Power and Water Corporation

NETWORK TECHNICAL CODE
and
NETWORK PLANNING CRITERIA

Version 4

30 March 2020

PowerWater

Table of Contents

INTRODUCTION

Transmission and *distribution network*s owned by *Power and Water* cover the major centres of the Northern Territory. The *NT NER* gives rights to private *Generator*s and *load customer*s to use the *network*s to enable contracted trade between *Generator Users* and *Customer Users*.

Structure of this document

This document comprises the following parts:

Part A The legislative requirements that apply to *Power and Water Network*s and to *customer*s seeking access to its regulated electrical *network*s.

Part B The ***Network Technical Code*** sets out technical requirements designed to ensure that the *network* and the *customer* installations and equipment *connect*ed to the *network* may be operated and maintained in a secure and *reliable* manner.

Part C The ***Network Planning Criteria*** are designed to ensure that new *load*s and *Generator*s *connect*ed to the *network* do not compromise the security and *reliability* of *supply* to all *Network Users*.

Part D Attachments, including, amongst other things, a Glossary of terms and Schedules of the information that is required to be provided by *customer*s seeking to *connect* to *Power and Water*'s regulated *network*s.

The *Network Technical Code* and *Network Planning Criteria* apply to *Power and Water*'s regulated *network*s.

Document nomenclature

Terms defined in the Glossary of this document are *italicised*.

Explanatory and contextual material is included in boxed sections that do not form part of the *Network Technical Code* or *Network Planning Criteria*.

Document amendment

This document is subject to amendment in accordance with the legislative provisions and users of the document are advised to obtain the current version from the Manager Regulation, Pricing and Economic Analysis, at the following address:

Power and Water Corporation
Level 7, Mitchell Centre, Darwin NT 0800
GPO Box 1921. Darwin NT 0801
Telephone: (08) 8985 8431
Facsimile: (08) 8923 9527

The document is also available from *Power and Water*'s Internet site at the following address: http://www.powerwater.com.au/.

Part A Legislative requirements

This document is prepared pursuant to the Northern Territory *Electricity Reform (Administration) Regulations*, as in force at 1 July 2019, which require Power and Water as a network provider to publish a Network Technical Code.

Network Technical Code

Regulation 25(4) of the *Electricity Reform (Administration) Regulations* states that the Network Technical Code must cover the requirements set out in Schedule 2, other than:

(a) matters dealt with in the National Electricity (NT) Rules; or

(b) matters appropriately dealt with in the System Control Technical Code.

Figure 1 sets out the matters listed in Schedule 2, together with their location in this Code or other instrument.

Figure 1 – Requirements of the *Network Technical Code*

***Code* requirement**		**clause**
(a)	performance standards in respect of service quality parameters in relation to the electricity network	2
(b)	the technical requirements that apply to the design or operation of plant or equipment connected to the electricity network	3
(c)	requirements relating to the operation of the electricity network (including the operation of the network in emergency situations)	4
(d)	obligations to test plant or equipment in order to demonstrate compliance with the Network Technical Code	5.1
(e)	procedures that apply if the network provider believes that an item of plant or equipment does not comply with the requirements of the Network Technical Code	5.6
(f)	requirements relating to the inspection of plant or equipment connected to the electricity network	5.7
(g)	requirements that relate to control and protection settings for plant or equipment connected to the electricity network	6
(h)	procedures that apply in the case of commissioning and testing of new plant or equipment connected to the electricity network	7
(i)	procedures that apply to the disconnection and reconnection of plant or equipment from the electricity network	8

Code requirement		clause
(j)	procedures relating to the operation of generating units connected to the electricity network (including the giving of *dispatch* instructions and compliance with those instructions)	9
(k)	*metering* requirements in relation to *connection*s	NT NER Chapter 7A
(l)	the information required to be provided to the Network Operator in relation to the operation of plant or equipment connected to the electricity network at a connection and how and when that information is to be provided.	11

Network Planning Criteria

Schedule 2 of the *Electricity Reform (Administration) Regulations* requires that the *Network Planning Criteria* must be consistent with the Network Technical Code, and lists the matters that shall be contained in the *Network Planning Criteria*. The relevant clauses of this document are referenced in Figure 2.

Figure 2 – Requirements of the Network Planning Criteria

Planning criterion			clause
(a)	contingency criteria;		14.6
(b)	steady-state criteria including:		15
	(i)	voltage limits;	15.2
	(ii)	thermal rating criteria; and	15.3
	(iii)	fault rating criteria;	15.4
(c)	stability criteria including:		16
	(i)	transient stability criteria; and	16.1
	(ii)	voltage stability criteria;	16.3
(d)	quality of supply criteria including:		17
	(i)	voltage fluctuation criteria;	17.1
	(ii)	harmonic voltage criteria;	17.2
	(iii)	harmonic current criteria;	17.2
	(iv)	voltage unbalance criteria; and	17.3
	(v)	electro-magnetic interference criteria;	17.4
(e)	construction standards criteria; and		18
(f)	environmental criteria.		18.1

Part B - Network Technical Code

1 INTRODUCTION

In this *Network Technical Code* (*Code*), unless otherwise stated, a reference to *Network Operator* or *Power System Controller* refers to the appropriate business unit of the *Power and Water Corporation*.

1.1 Persons to whom the Code applies

(a) *Power and Water Corporation* in its role as the operator of the *electricity network* (*Network Operator*);

(b) *Power and Water Corporation* in its role as the *Power System Controller*;

(c) Every person who seeks access to spare capacity or new capacity or makes an *Access Application* in order to establish a *connection* or modify an existing *connection*; and

(d) Every person to whom access to the *electricity network* is made available (including, without limitation, the *Power and Water Corporation* in its role as a trader of electricity and every person with whom the *Network Operator* has entered into an *Access Agreement*).

1.2 Plant and equipment to which the Code applies

(a) Equipment installed in the *Network Operator's electricity network*s; and

(b) Equipment installed by *Users* who are *connect*ed (either directly or indirectly) to the *electricity network*s.

1.3 Other documents

(a) This *Code* and the Network Planning Criteria at Part C shall be read in conjunction with the following *Power and Water Corporation* documents:

(1) Service Rules;

(2) Installation Rules;

(3) Metering Manual;

(4) Network Policies and Safe Working Procedures; and

(5) System Control Technical Code.

1.4 Commencement

(a) Version 1 of the *Code* came into operation on 1 April 2000 (*"Code commencement date"*).

(b) Amendment 2.0 of the *Code* was entitled the Network Connection Technical Code and was issued in April 2003.

(c) Amendment 3.1 of the *Network Technical Code* and *Network Planning Criteria* took effect from December 2013.

(d) This Version 4.0 amendment of the *Network Technical Code* and *Network Planning Criteria* has been made in accordance with the legislative provisions and takes effect from 30 March 2020.

1.5 Interpretation

(a) In this *Code*, words and phrases are defined in Attachment 1 and have the meanings given to them in Attachment 1, unless the contrary intention appears.

(b) This *Code* shall be interpreted in accordance with the rules of interpretation set out in Attachment 2, unless the contrary intention appears.

1.5.1 Conflict between Technical Codes

(a) A conflict exists when there is a difference in substance or interpretation of the provisions contained in the *Network Technical Code* and provisions contained in the *System Control Technical Code* relating to *power system*:

(1) *reliability*;

(2) safety;

(3) security;

(4) operational issues; or

(5) procedures.

(b) In the event of a conflict and to the extent of any inconsistency, the provisions of the System Control Technical Code will prevail over the *Network Technical Code.*

(c) Where a conflict cannot be resolved under sub clause (b), consultations will take place between:

(1) the *Power System Controller*;

(2) the *Network Operator*; and

(3) any affected *Users*.

(d) An affected *User* is a *User* who provides evidence to the *Power System Controller* and in the opinion of the *Power System Controller* the evidence proves the *User's* sufficient interest in consultations.

1.6 Dispute resolution

(a) Should a dispute arise between a *User* and the *Network Operator* concerning this *Code*, the *Network Operator* shall negotiate with the *User* to determine mutually acceptable agreed outcomes.

(b) If an agreement cannot be reached between these two parties, the Utilities Commissioner shall arbitrate the dispute.

1.7 Obligations

1.7.1 Obligations of the Network Operator

(a) The *Network Operator* shall comply with the *power system* performance and *quality of supply* standards:

(1) described in this *Code*; and

(2) in accordance with any *connection agreement* with a *User*.

(b) The *Network Operator* shall:

(1) ensure that to the extent that a *connection point* relates to the *electricity network*, every arrangement for *connection* with a *User* complies with all relevant provisions of this *Code*;

(2) permit and participate in inspection and testing of *facilities* and equipment in accordance with clause 5.1;

(3) permit and participate in commissioning of *facilities* and equipment which is to be *connect*ed to its *network* in accordance with clause 7;

(4) advise a *User* with whom there is a *connection agreement* of any expected interruption characteristics at a *connection point* on or with its *network* so that the *User* may make alternative arrangements for *supply* during such interruptions, including negotiating for an alternative or backup *connection*; and

(5) use its reasonable endeavours to ensure that modelling data used for planning, design and operational purposes is complete and accurate and order tests in accordance with clause 5.5 where there are reasonable grounds to question the validity of data.

(c) The *Network Operator* shall arrange for:

(1) management, maintenance and operation of the *electricity network* such that in the *satisfactory operating state*, electricity may be transferred continuously at a *connection point* up to the *agreed capability*;

(2) management, maintenance and operation of its *network* to minimise the number of interruptions to *agreed capability* at a *connection point* on or with that *network* by using *good electricity industry practice*; and

(3) restoration of the *agreed capability* as soon as reasonably practical following any interruption at a *connection point* on or with its *network*.

1.7.2 Obligations of Users

(a) All *Users* shall maintain and operate (or ensure their authorised *representatives* maintain and operate) all equipment that is part of their *facilities* in accordance with:

(1) relevant laws;

(2) the requirements of this *Code*; and

(3) *good electricity industry practice* and applicable *Australian Standards*.

(b) Each *User* shall:

(1) comply with the reasonable requirements of the *Network Operator* in respect of design requirements of equipment proposed to be *connected* to the *network* of the *Network Operator* in accordance with clause 3;

(2) permit and participate in inspection and testing of *facilities* and equipment in accordance with clause 5.1;

(3) permit and participate in commissioning of *facilities* and equipment which is to be *connected* to a *network* location for the first *time* in accordance with clause 7;

(4) operate *facilities* and equipment in accordance with any reasonable *direction* given by the *Network Operator* and *Power System Controller*; and

(5) give notice of intended voluntary *disconnection* in accordance with clause 8.

1.7.3 Obligations of Generator Users

(a) A *Generator User* shall comply at all times with applicable requirements and conditions of *connection* for *generating units*:

(1) as set out in clause 3.3; and

(2) in accordance with any *connection agreement* with the *Network Operator*.

1.7.4 Obligations of Generator Users with small generating systems

(a) A *Generator User* with a *Small Generator* shall comply at all times with applicable requirements and conditions of *connection* for a small *generating system*:

(1) as set out in clauses 3.2 and 3.4; and

(2) in accordance with any *connection agreement* with the *Network*

Operator.

1.7.5 Obligations of Users with Small Inverter Energy Systems

(a) A *User* with a *Small Inverter Energy System* shall comply at all times with applicable requirements and conditions of *connection* for *Small Inverter Energy Systems*:

(1) as set out in clauses 3.2 and 3.5; and

(2) in accordance with any *connection agreement* with the *Network Operator*.

1.7.6 Obligations of Users with loads

(a) Each *User* with a *load* shall ensure that all *facilities* which are owned, operated or controlled by it and are associated with a *connection point* at all times comply with applicable requirements and conditions of *connection* for *load*s:

(1) as set out in clauses 3.2 and 3.6; and

(2) in accordance with any *connection agreement* with the *Network Operator*.

1.7.7 Variations and exemptions from the Code

(a) Various clauses throughout this *Code* permit variations or exemptions from *Code* requirements to be granted to a *User* by reference to terms that include:

(1) the requirements may be varied, but only with the agreement of the *Network Operator*;

(2) unless otherwise agreed by the *Network Operator*;

(3) unless otherwise agreed; and

(4) except where specifically varied in a *connection agreement*.

(b) In all cases the *Network Operator* will notify in writing any such variation or exemption to *Users*.

1.8 Amendments to the Code

(a) Any *User* may propose an amendment to the *Code*.

(b) A proposal to amend the *Code* shall be made in writing by the *User* to the *Network Operator* and shall be accompanied by:

(1) the reasons for the proposed amendment to the *Code*; and

(2) an explanation of the effect on *Users* of the proposed amendment to the *Code*.

(c) Subject to paragraph (f) below, the *Network Operator* shall review the proposed amendment to the *Code* and within 30 days advise the *User* or electricity entity:

   (1) whether the proposed amendment to the *Code* is accepted or rejected; and

   (2) the reasons for the acceptance or rejection of the proposed amendment to the *Code*.

(d) The 30 day period in clause 1.9(c) is extended as reasonably required to allow any public consultation or consultation with the Utilities Commission required under the legislative provisions.

(e) The *Network Operator* shall review the operation of the *Code* at intervals of no more than 5 years and may seek submissions from *Users* and the Utilities Commission during the course of the review.

(f) Before amending the *Code* or *Network Planning Criteria* in a material way, the *Network Operator* must consult the Utilities Commission and undertake consultation in accordance with the legislative provisions.

2 Network performance standards

> Note - *Australian Standards* are defined in Attachment 1 as the most recent edition of a standard publication by Standards Australia. Historical standards referred to in this *Code* should be interpreted accordingly.

2.1 Introduction

This clause 2 describes the technical performance parameters and standards for the *power system*. These standards provide the basis for the technical requirements for equipment *connect*ed to the *electricity network*, covered in clause 3.

2.2 Power system operating frequency

(a) The nominal operating *frequency* of the *power system* is 50 Hz.

(b) The accumulated synchronous *time* error shall be less than 15 seconds for 99% of the *time*.

2.2.1 Frequency range under normal operating conditions

(a) The *frequency* ranges under normal operating conditions for the Northern Territory *regulated network*s are set out in Figure 3.

Figure 3 – *Frequency* range under normal operating conditions

***Power and Water* system**	***Frequency* range**
Darwin – Katherine	50 Hz ± 0.2 Hz
Alice Springs	50 Hz ± 0.2 Hz
Tennant Creek and isolated, *regional distribution networks*	50 Hz ± 0.4 Hz

2.2.2 Frequency range under abnormal operating conditions

(a) To cover for the loss of a *generating unit from* the *power system* two measures will be applied to arrest the fall in *frequency* following the loss of *generation* and to return the *frequency* to within normal operating levels as specified in clause 2.2.1:

(1) utilisation of available *spinning reserve* or C-FCAS as applicable in each regulated power system, under the *direction* of the *Power System Controller*; and

(2) *disconnection* of system *load* manually or by means of automatic *protection*.

(b) Under abnormal operating conditions, the *network frequency* may vary between 47 Hz and 52 Hz.

(b1) In the case of operation between 47 Hz and 52 Hz, the stabilisation time is 10 minutes, where stabilisation time means:

the longest time allowable for the *frequency* of the *power system* to remain outside the normal operating *frequency* band, for any condition (including an "island" condition) in the *frequency operating standards* that apply to each *region.*

(c) In the case of operation below 47 Hz but at or above 45 Hz, all *generating units* shall remain *connect*ed to the *Network Operator's network* for a period of at least 2 seconds.

(d) With sustained operation below 47 Hz, *under frequency load shedding* schemes may *disconnect load* on the *network* to restore *frequency* to the normal operating range, in accordance with clause 3.2.8.1.

(e) *Frequency* stability shall be satisfied under all credible *power system load* and *generation* patterns, and the most severe credible contingencies of *transmission plant* including the loss of *interconnect*ing *plant* leading to the formation of islands within the *power system*.

(f) Each island in the *power system* that contains *generation* shall have sufficient *load shedding facilities* in accordance with clause 16 of the *Network Planning Criteria* to aid recovery of *frequency* to the range 49.5 Hz to 50.5 Hz in the *network*.

(g) When islanding occurs the *Power System Controller* will determine which *power station* or *generating unit* in each isolated system will regulate the *frequency* in that system.

2.3 Power frequency voltage levels

2.3.1 Steady state voltage levels

(a) The requirements for steady-state *voltage* levels are set out in clause 15.2 of the *Network Planning Criteria*.

(b) The specifications for *voltage* levels in clause 15.2 shall apply in this Code.

(c) *Users'* equipment shall be designed to withstand these *voltage* levels.

(d) The power *frequency voltage* may vary outside the ranges set out in this clause 2.3.1 as a result of a *non-credible contingency event*.

2.3.2 Temporary over-voltages

(a) As a consequence of a *credible contingency event*, the *voltage* of *supply* at a *connection point* shall not rise above its *normal voltage* by more than the percentage specified in clause 17.1.1 of the *Network Planning Criteria*.

(b) *Users'* equipment shall also be designed to withstand these *voltage* levels.

(c) As a consequence of a *contingency event*, the *voltage* of *supply* at a *connection point* could fall to zero for any period.

2.3.3 Step changes in voltage levels

Step *changes* in the *power system voltage* levels may take place due to switching operations on the *network*. The step *changes* in *voltage* shall not exceed the limits set out in clause 17.1.2 of the *Network Planning Criteria*.

2.4 Quality of supply

2.4.1 Voltage fluctuations

A *voltage* disturbance is where the *voltage* shape is maintained but the *voltage* magnitude varies and may fall outside the steady state *supply voltage* range set out in clause 15.2 of the *Network Planning Criteria*. Short duration *voltage* disturbances of durations of up to one minute are termed *voltage* sags and swells.

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

Rapid *voltage* fluctuations cause *change*s to the luminance of lamps, which can create the visual phenomenon termed flicker.

(a) Under normal operating conditions, fluctuations in *voltage* on the *network* should be less than the *"*compatibility levels*"* defined in Table 1 of *Australian Standard* AS/NZS 61000.3.7 (2001).

(b) To facilitate the application of this standard *Power and Water* shall establish *"*planning levels*"* for its *network*s, as provided for in the *Australian Standard*.

(c) The *Network Operator* must allocate emission limits to a *connection applicant* that are no more onerous than the lesser of the acceptance levels determined in accordance with either of the stage 1 or the stage 2 evaluation procedures defined in AS/NZS 61000.3.7:2001.

2.4.2 Harmonic distortion

2.4.2.1 Harmonic voltage distortion

(a) Under normal operating conditions, the harmonic *voltage* in the *network* shall be less than the *"*compatibility levels*"* defined in Table 1 of *Australian Standard* AS/NZS 61000.3.6 (2001).

(b) To facilitate the application of this standard *Power and Water* shall establish *"*planning levels*"* of harmonic distortion for its *network*s as provided for in the *Australian Standard*.

(c) Planning levels for harmonic *voltage* distortion are specified in clause 17 of the *Network Planning Criteria*.

(d) The *Network Operator* must allocate emission limits to a *connection applicant* that are no more onerous than the lesser of the acceptance levels determined in accordance with either of the stage 1 or the stage 2 evaluation procedures defined in AS/NZS 61000.3.6:2001.

2.4.2.2 Non-integer harmonic distortion

Inter-harmonic or non-integer harmonic distortion may arise from large converters or power electronics equipment with Pulse Width Modulation (PWM) converters interfacing with the *power system*.

(a) Under normal operating conditions, the emission levels for inter-harmonic *voltage* in the *network* shall be less than the levels defined in section 9 of *Australian Standard* AS/NZS 61000.3.6 (2001).

(b) To facilitate the application of this standard *Power and Water* shall establish "planning levels" of inter-harmonic distortion for its *network*s as provided for in the *Australian Standard* AS/NZS 61000.3.6 (2001).

(c) Planning levels for inter-harmonic *voltage* distortion are specified in clause 17 of the *Network Planning Criteria*.

(d) The *Network Operator* must allocate emission limits to a *connection applicant* that are no more onerous than the lesser of the acceptance levels determined in accordance with either of the stage 1 or the stage 2 evaluation procedures defined in AS/NZS 61000.3.6:2001.

2.4.2.3 Voltage notching

Voltage notching may also arise from large convertors or power electronics equipment with Pulse Width Modulation (PWM) converters interfacing with the *power system*.

Voltage notching caused by a *User's facilities* is acceptable provided that:

(a) the limiting values of harmonic *voltage* distortion as described in clause 2.4.2.1 are not exceeded;

(b) the average of start notch depth and end notch depth shall not exceed 20% of the nominal fundamental peak *voltage*; and

(c) the peak amplitude of oscillations due to commutation at the start and end of the voltage notch shall not exceed 20% of the nominal fundamental peak voltage.

2.4.2.4 Harmonic current distortion

(a) The harmonic *voltage* distortion limits of clause 2.4.2 apply to each phase and are not to be exceeded by a *User* injecting harmonic currents at any of its *connection point*s.

(b) Any induced noise interference to telecommunications lines by a *User's load* due to harmonic currents is not acceptable and the *User* is required to reduce the level of harmonic currents so as to contain such interference to limits considered acceptable by the telecommunication *Network Operator*.

(c) The *User's load* shall not cause any harmonic resonance in other *Users'* systems or the *Network Operator's network*.

2.4.2.5 Direct current

(a) *Users' plant* and equipment shall comply with the requirements on direct current components as stipulated in clause 3.12 of *Australian Standard* AS/NZS 3100:2009. In particular, the direct current in the neutral caused by the *Users' plant* and equipment shall not exceed 120mA.h per *day*.

(b) *Users* shall ensure that all their *plant* and equipment is designed to withstand without damage or reduction in life expectancy the limits as specified in this clause 2.4.2.5.

(c) Responsibility of the *Network Operator* for direct current in the neutral outside the limits specified in this clause 2.4.2.5 shall be limited to direct current in the neutral caused by *network* assets.

(d) A *User* whose *plant* is identified by the *Network Operator* as not performing to the standards specified in this clause 2.4.2.5 shall take such measures as may be necessary to meet *Australian Standard* AS/NZS 3100:2009.

2.4.3 Voltage unbalance

(a) For normal system operation and for planned system *outage*s, the average *voltage* unbalance measured over a half hour at a *connection point* should not exceed the amount shown in Figure 4.

Figure 4 - *Voltage* unbalance limits

Nominal *supply voltage*	**Maximum negative sequence *voltage*** (% of *nominal voltage*)
132 kV	1.0
11-66 kV	1.5
Low voltage	2.0
An increase in the negative phase sequence *voltage* of up to 50% of the above is permissible for an aggregate of up to 5 minutes in any 30-minute period.	

2.5 Electromagnetic interference

Electromagnetic interference caused by equipment forming part of the *transmission* and *network* shall not exceed the limits set out in Tables 1 and 2 of *Australian Standard* AS2344 (1997).

2.6 Stability

2.6.1 [Deleted]

2.6.2 Dynamic stability

System oscillations originating from system electromechanical characteristics, electromagnetic effect or non-linearity of system components, and triggered by any small disturbance or large disturbance in the *power system*, shall remain within the small disturbance rotor angle stability criteria and the *power system* shall return to a stable operating state following the disturbance. The small disturbance rotor angle stability criteria are set out below.

(a) All electromechanical oscillations resulting from any small or large disturbance in the *power system* shall be well damped and the *power system* shall return to a stable operating state.

(b) The damping ratio of electromechanical oscillations shall be at least 0.1.

(c) For electromechanical oscillations as a result of a small disturbance, the damping ratio of the oscillation shall be at least 0.5.

(d) In addition to the requirements of clauses 2.6.2(a) and 2.6.2(b), the halving *time* of any electromechanical oscillations shall not exceed 5 seconds.

(e) If oscillations do not comply with clause 2.6.2(d), then appropriate measures shall be taken to *change* the *power system* configuration and/or *generation dispatch* so as to eliminate such oscillations. Such measures shall be taken by automatic means.

(f) *Users* who may cause subsynchronous or supersynchronous resonance oscillations shall provide appropriate measures at the planning and design stage to prevent the introduction of this problem to the *Network Operator's power system* or other *Users'* systems.

2.6.3 Short term voltage stability

(a) Short term *voltage* stability is concerned with the *power system* surviving an initial disturbance and reaching a satisfactory new steady state.

(b) Stable *voltage control* shall be maintained following the most severe *credible contingency event*.

2.7 Contingency criteria for the network

To a great extent, the contingency criteria used for the design of the *network* will determine the inherent *reliability* of *customer supply*. These criteria apply to the shared *network*, and not to *customer connection*s.

(a) The contingency levels to which the *network* and sub-clauses of the *network* are designed are set out in clause 14 of the *Network Planning Criteria*.

(b) The contingency criteria in this clause 2.7 apply only to the *electricity network*s and not to *customer connection*s to the *network*.

(c) The contingency criteria for a sub-clause of the *network* may be varied by *Power and Water* following a risk/benefit analysis and other considerations such as capital investment priorities, social needs, the environment and land use.

(d) Connection assets will be designed in accordance with a *User's* requirements and a *Network User* may choose a design configuration having a greater or lesser level of security for its dedicated *connection* to the shared *network*, subject to the approval of *Power and Water*.

(e) The contingency criteria to which the *network* has been designed shall be taken into account when assessing the impact of a *User's* installation on other *Users*, or the *power system*.

2.8 Equipment fault level ratings

(a) The *Network Operator* shall specify the minimum fault level ratings of equipment *connect*ed to the *network*.

(b) Unless otherwise agreed by the *Network Operator*, the equipment fault level ratings specified in clause 15.4 of the *Network Planning Criteria* shall apply.

2.9 Protection arrangements

2.9.1 Users' obligation to provide adequate protection

2.9.1.1 Safety of people

It is the *User's* responsibility to provide adequate *protection* (at the *User's* discretion) of all *User* owned *plant* to ensure the safety of the public and personnel, and to minimise damage.

2.9.1.2 System *reliability* and integrity

(a) The *Network Operator* and *Users* shall ensure that any new equipment *connect*ed to any part of the system is protected in accordance with the requirements of clause 2.9.

(b) Where the *connection* of new equipment would affect *critical fault clearance times*, the *protection* of both new and existing equipment throughout the *power system* shall meet the new *critical fault clearance times*.

(c) Where existing *protection* would not meet the new *critical fault clearance times*, that *protection* shall be upgraded.

(d) *Fault clearance time* requirements may not be established until all new *plant* data is available and the detailed design of a *User's connection* or *network* reinforcement has commenced.

(e) All faults of any type shall be cleared within the times specified in clause 2.9.5 unless it can be established by the *Network Operator* that a longer clearance *time* would not result in the *network* failing to meet the performance standards set out in clause 2.

2.9.1.3 Minimum standard of *protection* equipment

*Protection system*s shall be designed, installed and maintained in accordance with *good electricity industry practice*. In particular, the *Network Operator* shall ensure that all new *protection apparatus* including that installed on *User's* equipment complies with IEC Standard 60255 and that all new *current transformer*s and *voltage transformer*s comply with *Australian Standard* AS 60044.1 (2007) and *Australian Standard* AS 60044.2 (2007).

2.9.1.4 General requirements

(a) All *primary equipment* on the *network* shall be protected so that if an equipment fault occurs, the faulted equipment item is automatically removed from service by the operation of circuit breakers or fuses.

(b) *Protection system*s shall be designed and their settings coordinated so that, if there is a fault, unnecessary equipment damage is avoided and any reduction in *power transfer capability* or in the level of service provided to *Users* is minimised.

(c) Consistent with the requirement of clause 2.9.1.4(b), *protection system*s shall remove faulted equipment from service in a timely manner and ensure that, where practical, those parts of the *network* not directly affected by a fault remain in service.

2.9.2 Duplication of protection

To implement a "one out of two" arrangement, complete *secondary equipment* redundancy is required. This includes *CT* and *VT* secondaries, auxiliary supplies, cabling and wiring, circuit breaker trip coils and batteries and intertripping arrangements.

2.9.2.1 Equipment *connect*ed at *voltage*s of 66 kV and above

(a) *Primary equipment* shall be protected by a main *protection system* that shall remove from service only those items of *primary equipment* directly affected by a fault.

(b) The main *protection system* shall comprise *two fully independent protection schemes of differing principle*, *connect*ed to operate in a *"*one out of two*"* arrangement.

(c) One of the independent *protection scheme*s shall include earth fault *protection*.

(d) To maintain the integrity of the two *protection scheme*s, no electrical cross *connection*s shall be made between them.

(e) It shall be possible to test and maintain either *protection scheme* independently without affecting the other.

(f) Where both *protection scheme*s require end-to-end communications, independent *teleprotection signalling* equipment and communication channels shall be provided.

(g) Where failure of the *teleprotection signalling* would result in the failure of both *protection scheme*s to meet the requirements of this clause 2.9.2.1 independent communication bearers shall be provided.

(h) *Primary equipment* shall also be protected by a back-up *protection system* in addition to the main *protection system*. The back-up *protection system* shall isolate the faulted *primary equipment* if a circuit breaker fails to operate.

(i) The design of the main *protection system* shall make it possible to test and maintain either *protection scheme* without interfering with the other.

2.9.2.2 Equipment *connect*ed at *voltage*s of less than 66 kV

(a) Each item of *primary equipment* shall be protected by two independent *protection system*s.

(b) One of the independent *protection system*s shall be a main *protection system* that shall remove from service only the faulted item of *primary equipment*.

(c) At least one of the *protection scheme*s shall include earth fault *protection* so as to give additional coverage for low level earth faults and to provide some remote backup.

(d) The other independent *protection system* may be a back-up *protection system*.

(e) Notwithstanding the requirements of clause 2.9.2.2(a), where a part of the *distribution system* may potentially form a separate island the *protection system* that provides *protection* against islanding shall comprise *two fully independent protection schemes of differing principle*.

(f) Where appropriate, and with the approval of the *Network Operator*, a single set of high rupturing capacity (HRC) fuses may be used as a *protection scheme* for *plant* at 33 kV and below, in which case a second *protection scheme* would not be required to satisfy the requirements of this clause 2.9.2.2.

2.9.3 Availability of protection systems

All *protection scheme*s on the *network*, including any back-up or *circuit breaker failure protection scheme* and associated intertripping, shall be kept operational at all times except when maintenance is required.

2.9.4 Maximum total fault clearance times

(a) This clause 2.9.4 applies to short circuit faults of any type on *primary equipment* at nominal system *voltage*. Where *critical fault clearance times* exist, these times may be lower and take precedence over the times stated in this clause 2.9.4. *Critical fault clearance time* requirements are set out in clause 2.9.5.

(b) For *primary equipment* operating at *transmission system voltages* of 132 kV and 66 kV the maximum total fault clearance times in Figure 5 apply to the *nominal voltage* of the circuit breaker that clears a particular fault for both minimum and maximum *system* conditions. For *primary equipment* operating at *distribution system voltages* of 33 kV and below the maximum total fault clearance times specified in Figure 6 may be applied to all circuit breakers required to clear a fault for maximum system conditions, irrespective of the *nominal voltage* of the circuit breaker.

(c) For *primary equipment* operating at 132 kV and 66 kV:

(1) Both of the *protection schemes* of the main protection system must operate to achieve a total fault clearance time no greater than the "No CB Fail" time given in Figure 5. The backup protection system must achieve a total fault clearance time no greater than the "CB Fail" time in Figure 5, except that the second protection scheme that protects

against small zone faults must achieve a total fault clearance time no greater than 400 msec;

(2) For a small zone fault coupled with a circuit breaker failure, maximum total fault clearance times are not defined.

(3) In Figure 5, for voltages of 66 kV and above, the term "local" refers to the circuit breaker(s) of a protection system where the fault is located:

(i) within the same *substation* as the circuit breaker;

(ii) for a transmission line between two *substations*, at or within 50% of the line impedance nearest to the *substation* containing the circuit breaker, provided that the line is terminated at that *substation*; or

(iii) for a transmission line between more than two *substations*, on the same line section as the *substation* containing the circuit breaker, provided that the line is terminated at that *substation*.

(4) In Figure 5, for voltages of 66 kV and above, the term "remote" refers to all circuit breakers required to clear a fault, apart from those specified in clause 2.9.4(c)(3).

(d) In Figure 6, for *primary equipment* operating at *nominal voltage* of 33 kV and below, the term "local" refers only to faults located within the *substation* in which a circuit breaker is located.

Figure 5 – 132 kV and 66 kV *maximum total fault clearance times* (msec)

		No CB Fail	CB Fail
132 kV and 66 kV	Local	150	400
	Remote	200	450

Figure 6 – 33 kV and below *maximum total fault clearance times* (msec)

		No CB Fail	CB Fail
33 kV and below	Local	1160	1500
	Remote	Not defined	Not defined

2.9.5 Critical fault clearance times

One of the major factors affecting the transient stability of the *network* is the *fault clearance time*. The *critical fault clearance time* is the longest *time* that a fault can be allowed to remain on the *power system* to ensure that transient instability does not occur. Critical *fault clearance times* are established for the various fault types at key locations. *Protection* then shall be set to ensure that the *critical fault clearance times* are achieved.

2.9.5.1 *Critical fault clearance times*

Where a *critical fault clearance time* to p*reserve* system stability has been established by the *Network Operator* in a portion of the *network*:

(a) For *plant* operating at *voltage*s of 66 kV or higher, each of the two independent *protection schemes* shall be capable of detecting and clearing *plant* faults within the *critical fault clearance time*.

(b) Where a *critical fault clearance time* exists for *plant* operating at 33 kV and below:

   (1) one *protection scheme* shall be capable of detecting and clearing *plant* faults within the *critical fault clearance time*; and

   (2) the second *protection scheme* is required to meet the maximum acceptable *fault clearance times* set out in clause (c).

(c) Other *critical fault clearance time* requirements may be imposed by the *Network Operator* to limit system *voltage* and/or *frequency* disturbances resulting from faults.

2.9.6 Protection sensitivity

(a) Protection schemes must be sufficiently sensitive to detect fault currents in the *primary equipment* taken into account the errors in protection apparatus and *primary equipment* parameters under the system conditions in this clause 2.9.6.

(b) For minimum and maximum system conditions, all protection schemes must detect and discriminate all *primary equipment* faults within their intended normal operating zones.

(c) For abnormal equipment conditions involving two *primary equipment* outages, all *primary equipment* faults must be detected by one protection scheme and cleared by a protection system. Backup protection systems may be relied on for this purpose. Fault clearance times are not defined under these conditions.

2.9.7 Trip supply supervision

Where loss of power supply to its secondary circuits would result in protection scheme performance being reduced, all protection scheme secondary circuits must have trip supply supervision.

2.9.8 Trip circuit supervision

All protection scheme secondary circuits that include a circuit breaker trip coil must have trip circuit supervision, which monitor the health of the trip coil under both circuit breaker opened and closed positions.

2.9.9 Protection flagging, indication, fault and event records

All protective devices supplied to satisfy the protection requirements must contain such indicating, flagging, fault and event recording as is sufficient to enable the determination, after the fact, of which devices caused a particular trip.

Any failure of the tripping supplies, protection apparatus and circuit breaker trip oils must be alarmed and operating procedures must be put in place to ensure that prompt action is taken to remedy such failures.

2.10 Variation of service quality parameters

(a) In particular circumstances, the requirements in clause 2 of this *Code* may be varied.

(b) The *Network Operator* may vary the *Code* in accordance with the *derogation* provisions of clause 12.

(c) Where it is intended to vary the requirements set out in this *Code*, it shall be demonstrated that the variation will not adversely affect *Users* or *power system security*.

3 Technical requirements for equipment connected to the network

3.1 Introduction

(a) The objective of this clause 3 is to facilitate maintenance of the *power system* service quality parameters specified in clause 2, so that other *Users* are not adversely affected and that personnel and equipment safety are not put at risk.

(b) This clause sets out details of the technical requirements which *Users* shall satisfy as a condition of *connection* of any equipment to the *network* including, but not limited, to the following types of equipment:

(1) *Generating units connect*ed at all *voltage* levels of the *network*;

(2) Small *generating systems connect*ed at *voltage*s of 22 kV and below;

(3) *Small Inverter Energy System*s *connect*ed to the *low voltage network*; and

(4) *Load*s, including those with electronic switching systems, *connect*ed at all *voltage* levels of the *network*.

(c) The *Network Operator* shall determine the classification of equipment to be connected to the *network* and may alter the technical requirements of connection in this clause 3 in respect of a particular *connection* only as much as is necessary to ensure the *power system* service quality parameters specified in clause 2 are maintained.

(d) An exemption may be granted by the *Network Operator* to certain provisions in clause 3 in accordance with the *derogation*s in clause 12 of the *Code*.

3.2 Requirements for Network Users excluding Generator Users under clause 3.3

The requirements under this clause apply to all *Network Users* except *Generator Users* captured under clause 3.3, unless expressly referred to in a subclause within clause 3.3.

3.2.1 Network performance standards

A *User* shall ensure that each of its *facilities connect*ed to the *network* is capable of operation while the *power system* is operating within the parameters of the performance standards set out in clause 1.7.2.

3.2.1.1 *Voltage* fluctuations

A *User* shall maintain its contributions to flicker at the *connection point* to below the limits allocated by the *Network Operator* under clause 2.4.1.

3.2.1.2 Harmonic *voltage* distortion

(a) A *User* shall comply with any harmonic emission limits allocated by the *Network Operator* in accordance with clause 2.4.2 of the *Code*.

(b) A *User* shall ensure that the injection of harmonics or interharmonics from its equipment or *facilities* into the *network* does not cause the maximum system harmonic *voltage* levels at the point of *connection* to exceed the levels set out in clause 17.2 of the *Network Planning Criteria*.

3.2.1.3 Direct current injection

A *User* shall ensure that any DC component of current produced by its own equipment complies with the requirements of clause 17.2.2 of the *Network Planning Criteria*.

3.2.1.4 *Voltage* unbalance

A *User connect*ed to all three phases shall balance the current drawn in each phase at its *connection point* so as to achieve levels of negative sequence *voltage* at all *connection point*s that are equal to or less than the values specified in clause 2.4.3.

3.2.1.5 Stability

(a) *Users* shall cooperate with the *Network Operator* to achieve stable operation of the *network*s and shall install emergency controls as reasonably required by the *Network Operator*.

(b) The cost of installation, maintenance and operation of the emergency controls shall be borne by the *User*.

(c) The stability criteria stated in clause 2.6 shall be satisfied under the worst credible system *load* and *generation* pattern, and the most severe *credible contingency event* arising from either a single *credible contingency event* at up to 100% *peak load* or a double *credible contingency event* at up to 80% *peak load*.

(d) *Credible contingency event*s shall be considered in accordance with clause 2.7.

3.2.1.6 Electromagnetic interference

A *User* shall ensure that the electromagnetic interference caused by its equipment does not exceed the limits set out in clause 2.5.

3.2.1.7 Fault levels

(a) A *User connect*ed to the *network* may not install or *connect* equipment at the *connection point* that is rated for a *maximum fault current* lower than that specified in the *connection agreement* in accordance with clause 3.6.6.

(b) A *User connect*ed to the *network* shall not install equipment at the *connection point* that is rated for a *maximum fault current* lower than that specified in clause 15.4 of the *Network Planning Criteria* unless a lower *maximum fault current* is agreed with the *Network Operator* and specified in the *connection agreement*.

(c) Where a *User's* equipment increases the fault levels in the *transmission system*, responsibility for the cost of any upgrades to the equipment required as a result of the *change*d *power system* conditions will be dealt with by commercial arrangements between the *Network Operator* and the *Users*.

3.2.1.8 Main switch

A *User* shall be able to de-*energise* its own equipment without reliance on the *Network Operator*.

3.2.1.9 *Users'* power quality *monitoring equipment*

(a) The *Network Operator* may require a *User* to provide accommodation and *connection*s for the *Network Operator's* power quality monitoring and recording equipment within the *User's facilities* or at the *connection point*. In such an event the *User* shall meet the requirements of the *Network Operator* in respect of the installation of the equipment and shall provide access for reading, operating and maintaining this equipment.

(b) The key inputs that the *Network Operator* may require a *User* to provide to the *Network Operator's* power quality monitoring and recording equipment include:

(1) three phase *voltage* and three phase current and, where applicable, neutral *voltage* and current; and

(2) digital inputs for circuit breaker status and *protection* operate alarms hardwired directly from the appropriate devices. If direct hardwiring is

not possible and if the *Network Operator* agrees, then the *User* may provide inputs measurable to 1 millisecond resolution and GPS synchronised.

3.2.1.10 *Power system* simulation studies

(a) A *User* shall provide to the *Network Operator* such of the following information relating to any of the *User's facilities connect*ed or intended to be *connect*ed to the *transmission system* as is required to enable the undertaking of *power system* simulation studies:

(1) a set of functional block diagrams, including all transfer functions between feedback signals and *generating unit* output;

(2) the parameters of each functional block, including all settings, gains, *time constraint*s, delays, dead bands and limits; and

(3) the characteristics of non-linear elements.

(b) The *Network Operator* may provide any information it so receives to any *User* who intends to *connect* any equipment to the *transmission system* for the purposes of enabling that *User* to undertake any *power system* simulation studies it wishes to undertake, subject to that *User* entering into a confidentiality agreement with the *Network Operator*, to apply for the benefit of the *Network Operator* and any *User* whose information is so provided, in such form as the *Network Operator* may require.

3.2.1.11 Technical matters to be coordinated

(a) The *User* and the *Network Operator* shall use all reasonable endeavours to agree upon the following matters in respect of each new or altered *connection*:

(1) design at *connection point*;

(2) physical layout adjacent to *connection point*;

(3) *protection* and backup;

(4) control characteristics;

(5) communications, metered quantities and alarms;

(6) insulation co-ordination and lightning *protection*;

(7) fault levels and fault clearing times;

(8) switching and isolation *facilities*;

(9) interlocking arrangements;

(10) *metering* installations as described in the Chapter 7A of the NT NER;

(11) *synchronising facilities*;

(12) *under frequency load shedding* and islanding schemes;

(13) out of step/pole slip *facility*; and

(14) any special test requirements.

(b) Prior to *connection* to the *Network Operator's power system*, the *Users* shall have provided to the *Network Operator* a signed statement to certify that the equipment to be *connect*ed has been designed and installed in accordance with this *Code*, all relevant standards, all statutory requirements and *good electricity industry practice*.

3.2.2 Provision of information

(a) A *User* shall provide all data reasonably required by the *Network Operator*.

(b) Details of the kinds of data that may be required are included in clause 11 and Attachment 3 of this *Code*.

3.2.3 Protection requirements

Protection shall be provided to detect and clear faults, without system instability and without causing equipment damage, in accordance with clauses 2.6 and 2.9.

3.2.3.1 Transmission lines and other Plant operated at 66 kV and above

(a) *Protection* shall be by two fully independent *protection scheme*s as set out in clause 2.9.2.1.

(b) The *protection* arrangements shall be capable of clearing a fault within the clearance times set out in clause 2.9.5.

3.2.3.2 Interconnectors and ties operated at 33 kV and below

(a) *Protection* shall be by two fully independent *protection scheme*s as set out in clause 2.9.2.2.

(b) The *protection* arrangements shall be capable of clearing a fault within the clearance times set out in clause 2.9.5.

3.2.3.3 Feeders, reactors, capacitors and other plant operated at 33 kV and below

(a) The *protection* arrangements shall be capable of clearing a fault within the clearance times set out in clause 2.9.5.

(b) Where a *critical fault clearance time* exists, *protection* of these items will be by two independent *protection scheme*s of *differing principle*, each one discriminating with the *Network Operator power system* and capable of meeting the *critical fault clearance time*.

(c) At least one of these *protection scheme*s shall also include earth fault *protection* so as to give additional coverage for low level earth faults and to provide some remote backup.

(d) Where there is no *critical fault clearance time*, the following shall be the minimum *protection* requirement:

(1) three Phase Inverse Definite Minimum *Time* Overcurrent; and

(2) three Phase Instantaneous Overcurrent; and

(3) inverse Definite Minimum Time Earth Fault; and

(4) instantaneous Earth Fault.

(e) With the approval of the *Network Operator,* a single set of HRC fuses may be deemed to provide equivalent *protection* to subclause (c) of this clause3.2.3.3.

3.2.3.4 Transformers

> The composition of each of the two *protection scheme*s should be *complementary* such that, in combination, they provide dependable clearance of *transformer* faults within a specified *time*. With any single failure to operate of the *secondary plant*, fault clearance shall still be achieved by *transformer protection*, but may be delayed until the nature of the fault *change*s or evolves.
>
> *Protection* of *transformer*s larger than 3 MVA will require at least one of the *protection scheme*s to be a unit *protection* and provide high-speed fault clearance of *transformer* faults.

(a) For *transformer*s with a primary *voltage* of 66 kV and above, *protection* shall be by two fully independent *protection scheme*s as set out in clause2.9.2.1.

(b) For *transformer*s with a primary *voltage* of 33 kV and below, *protection* shall be by two *protection scheme*s which are *complementary*, as set out in clause 2.9.2.2.

(c) The *protection* arrangements shall be capable of clearing a fault within the clearance times set out in clause 2.9.5.

3.2.3.5 Protection discrimination

> Where the *Network Operator protection* is overcurrent, the maximum operate *time* will be 1 second at maximum fault level. Generally, *Network Operator* overcurrent and earth fault *protection* employs devices with standard inverse characteristics to BS142 with a 3 second curve at 10 times current and *time* multiplier of 1.0. Note that this is the specification of the characteristic rather than the device setting. Operating times for other types of *protection* will generally be lower and will be dependent upon location.

The *protection* in clauses 3.2.3.1, 3.2.3.2, 3.2.3.3and 3.2.3.4 is required to discriminate with the *Network Operator's protection* on the *power system*.

3.2.3.6 Backup protection

(a) The *protection* in clauses 3.2.3.1, 3.2.3.2, 3.2.3.3 and 3.2.3.4 is required to be backed up by an independent *protection* to ensure clearance of faults with a *protection* failure.

(b) *Backup protection* shall be provided to detect and clear faults involving small zones.

(c) *Protection* shall be provided to detect and clear faults involving *circuit breaker failure*.

(d) Where *critical fault clearance times* do not exist, or are greater than the times given in clause 2.9.5, the clearance times are to be as specified by the *Network Operator* in a *connection agreement*.

(e) Such *protection schemes* shall be capable of detecting and initiating clearance of uncleared or *small zone faults* under both normal and *minimum system conditions*.

(f) Under abnormal *plant* conditions, all primary system faults shall be detected and cleared by at least one *protection scheme* on the *User's* equipment. *Remote backup protection* or standby *protection* may be used for this purpose.

3.2.3.7 Protection alarm requirements

(a) Specific requirements and the interface point to which alarms shall be provided will be mutually decided during the detailed design phase. These alarms will be brought back to the *Network Operator's control centre* via the installed *SCADA system* supplied by the *User* in accordance with clause 3.2.5 or clause 1.1.1, as applicable.

(b) In addition, any failure of the *User's* tripping supplies, *protection apparatus* and circuit breaker trip coils shall be alarmed within the *User's* installation and operating procedures put in place to ensure that prompt action is taken to remedy such failures.

3.2.3.8 Islanding of a User's facilities from the power system

(a) Unless otherwise agreed by the *Network Operator,* a *User* shall ensure that islanding of its *generation plant* together with part of the *Network Operator power system*, cannot occur upon loss of *supply* from the *Network Operator's power system*.

(b) Clause 3.2.3.8(a) should not preclude a design that allows a *User* to island its own *generation* and *plant load*, thereby maintaining *supply* to that *plant*, upon loss of *supply* from the *Network Operator's power system*.

(c) Islanding shall only occur in situations where *Power and Water*'s *power system* is unlikely to recover from a major disturbance.

(d) Unless otherwise agreed by the *Network Operator*, the *User* shall provide *facilities* to initiate islanding in the event of their system drawing more than the agreed MW/MVAr demands from the *Network Operator power system* for a specified *time*.

(e) *Users* shall co-operate to agree with the *Network Operator* the type of initiating signal and settings to ensure compatibility with other *protection* settings on the *network* and to ensure compliance with the requirements of clause 2.2.

(f) Where a *User* does not wish to meet the requirements of clause 2.2, appropriate commercial arrangements will be required between the *User*, the *Network Operator* and/or another *User*(s) to account for the higher level of access service.

3.2.3.9 Automatic reclose equipment

The installation and use of *automatic reclose equipment* in a *User's facility* and in the *power system* shall only be permitted with the prior written agreement of *Network Operator*.

3.2.3.10 Maintenance of protection

(a) *Users* shall regularly maintain their *protection system*s at intervals of not more than 3 years. Records shall be kept of such maintenance and the *Network Operator* may review these. Refer also to clause 5.2.

(b) Each scheduled routine test, or any unscheduled tests that become necessary, shall include both a calibration check and an actual trip operation of the associated circuit breaker.

(c) All maintenance and testing of *User* owned *protection* shall be carried out by personnel suitably qualified and experienced in the commissioning, testing and maintenance of *primary plant* and *secondary plant* and equipment.

3.2.4 Design requirements for Users' substations

The following requirements apply to the design, station layout and choice of equipment for a *substation*.

(a) Safety provisions shall comply with requirements applicable and notified by the *Network Operator*.

(b) Where required by the *Network Operator* appropriate interfaces and accommodation shall be incorporated by the *Users* for *metering*, communication *facilities*, remote monitoring and *protection* of *plant* that is to be installed in the *substation* by the *Network Operator*.

(c) A *substation* shall be capable of *continuous uninterrupted operation* with the levels of *voltage*, harmonics, unbalance and *voltage* fluctuation from all sources as defined in clause 2 of this *Code*.

(d) Earthing of *primary plant* in the *substation* shall be in accordance with the Electricity Supply Association of Australia Substation Earthing Guide, and shall reduce step and touch potentials to safe levels.

(e) *Synchronisation facilities* or reclose blocking shall be provided if *generating units* are *connect*ed through the *substation*.

(f) Secure electricity supplies of adequate capacity to provide for the operation for at least eight hours of *plant* performing *metering*, communication, monitoring, and *protection* functions, on loss of AC supplies, shall be provided.

(g) *Plant* shall be tested to ensure that the *substation* complies with the design and specifications required by clause 3.2.3.10. Where appropriate, type test certificates provided by the manufacturer satisfy this clause.

(h) The *protection* equipment required would normally include *protection scheme*s for individual items of *plant*, back-up arrangements, auxiliary DC supplies and instrumentation *transformer*s.

(i) Insulation levels of *plant* in the *substation* shall co-ordinate with the insulation levels of the *network* to which the *substation* is *connect*ed without degrading the design performance of the *network*.

(j) Prior to *connection* to the *Network Operator's power system*, the *User* shall have provided to the *Network Operator* a signed written statement to certify that the equipment to be *connect*ed has been designed and installed in accordance with:

   (1) this *Code;*

   (2) all relevant standards;

   (3) all statutory requirements; and

   (4) *good electricity industry practice*.

   The statement shall have been certified by a Chartered Professional Engineer with NPER-3 standing with the Institution of Engineers, Australia, unless otherwise agreed.

3.2.5 Remote monitoring and control requirements

(a) The *Network Operator* may require the *User* to:

   (1) provide *remote monitoring equipment* (*RME*) to enable the *Network Operator* to remotely monitor status and indications of the *load facilities* where this is reasonably necessary in real *time* for control, planning or security of the *power system*; and

   (2) upgrade, modify or replace any *RME* already installed in a *power station* provided that the existing *RME* is, in the reasonable opinion of the *Network Operator*, no longer fit for purpose and notice is given in writing to the relevant *User*.

(b) The *RME* provided, upgraded, modified or replaced (as applicable) under subclause (a) shall conform to an acceptable standard as agreed by the *Network Operator* and shall be compatible with the *Network Operator's SCADA system*, including the requirements of clause 4.9 of this *Code*.

(c) Input information to *RME* may include, but not be limited to, the following:

(1) Status Indications

(i) relevant circuit breakers open/closed (double pole) within the *plant*

(ii) relevant isolators within the *plant*

(iii) *connection* to the *network*

(2) Alarms

(i) *protection* fail

(ii) battery fail - AC and DC

(iii) *Trip circuit supervision*

(iv) *Trip supply supervision*

(3) Measured Values

(i) *active power load*

(ii) *reactive power load*

(iii) *load* current

(iv) relevant *voltage*s throughout the *plant*

(4) Sequence-of-event (SOE) points

(i) *protection* operation

(ii) circuit breaker status

(5) Such other input information reasonably required by the *Network Operator*.

3.2.6 Communications equipment

(a) A *User* shall provide electricity supplies for any *RME* installed in relation to its *plant* capable of keeping these *facilities* available for at least eight hours following total loss of *supply* at the *connection point* for the relevant *plant*.

(b) A *User* shall provide communications paths (with appropriate redundancy) between any *RME* installed at its *plant* to a communications interface at the relevant *plant* and in a location reasonably acceptable to the *Network Operator*.

(c) Communications systems between this communications interface and the relevant *control centre* shall be the responsibility of the *Network Operator* unless otherwise agreed.

(d) The cost of the communications systems shall be met by the *User*, unless otherwise determined by the *Network Operator*.

3.2.7 Secure electricity supplies

Secure electricity supplies of adequate capacity to provide for the operation for at least eight hours of *plant* performing *metering*, communication, monitoring, and *protection* functions, on loss of AC supplies, shall be provided by a *User*.

3.2.8 Load shedding facilities

If reasonably required by the *Network Operator*, *Users* are to provide automatic *interruptible load* to the *Network Operator* in accordance with clause 2.2.2.

3.2.8.1 Load to be available for disconnection

(a) It is a requirement for *power system security* that 75% of the *power system load* at any *time* be available for *disconnection*:

(1) under the automatic control of *under frequency* relays; and

(2) under manual or automatic control from *control centre*s; and/or

(3) under the automatic control of *under voltage* relays.

(b) In some circumstances, it may be necessary to have up to 90% of the *power system load*, or up to 90% of the *load* within a specific part of the *network*, available for automatic *disconnection*. The *Network Operator* will advise *Users* if this additional requirement is necessary.

(c) Special *load shedding* arrangements may be required to be installed to cater for abnormal operating conditions.

(d) Subject to clauses 4.3.4(c) and 4.3.4(d), arrangements for *load shedding* shall be agreed between the *Network Operator* and *User* and can include the opening of circuits in a *network*.

(e) The *Network Operator* shall specify, in the *connection agreement*, control and monitoring requirements to be provided by a *User* for *load shedding facilities*.

3.2.8.2 Installation and testing of load shedding facilities

Users shall, if reasonably required by the *Network Operator*:

(a) Provide, install, operate and maintain *facilities* for *load shedding* in respect of any *connection point*.

(b) Co-operate with the *Network Operator* in conducting periodic functional testing of the *facilities*, which shall not require *load* to be *disconnect*ed, provided *facilities* are available to test the scheme without shedding *load*.

(c) Apply *under frequency* settings to relays as determined by the *Power System Controller*.

(d) Apply *under voltage* settings to relays as determined by the *Network Operator*.

3.2.9 Impact on power system performance

(a) Prior to a *User's facilities* being *connect*ed to the *power system*, the impact on *power system* performance due to the *Users' facilities* is to be determined by *power system* simulation studies as specified by the *Network Operator*.

(b) These studies may be performed by the *User* or a third party, in which case, the *Network Operator* will require full details of the studies performed including, without limitation:

(1) assumptions made;

(2) results;

(3) conclusions; and

(4) recommendations.

(c) The acceptance of studies performed by a *User* or a third party will be entirely at the *Network Operator's* discretion.

(d) Acceptance of *power system* studies by the *Network Operator* does not absolve *Users* of responsibility/liability for damages or losses incurred by others.

(e) The *Network Operator reserve*s the right to perform its own studies (at the *User's* cost) and will provide details of such studies to the *User*.

(f) The *Network Operator* will make the final determination on the suitability of a *User's facilities* and the requirements to be fulfilled prior to and after the *facilities* are *connect*ed, in accordance with this *Code*.

3.2.10 Safety criteria

(a) As part of the planning process the safety risk should be considered for any new developments and existing *facilities* which may have a significant impact on safety. The safety risk is to be assessed in the planning process. Relevant bodies should be informed, consulted and steps taken to ensure safety is maintained to industry standards.

(b) The ESAA National Electricity Network Safety (NENS) Code shall be applied and reference shall be made to the NENS Reference Guidelines.

3.2.11 Environmental criteria

(a) Environmental management of the *transmission* and *distribution network*s will be in keeping with the ESAA Code of Environmental practice. This applies in planning, construction, operation and *decommissioning*.

(b) *Users* shall inform and consult with relevant public bodies, community interest groups and the general public, and shall avoid where economically possible the use of land where conflicting uses or potential conflicting uses exist.

3.2.12 Construction criteria

3.2.12.1 Overhead lines

Overhead lines and cable systems shall be designed and constructed to *Australian Standard* HB C(b)1, "Guidelines for Design and Maintenance of Overhead Distribution and Transmission lines".

3.2.12.2 Underground cables

Cables shall be installed in a manner that takes into account the local environmental and service conditions, the location of other utilities' services and the risk of damage from excavation. Installation practices shall be in accordance with ESAA Code C(b)2, "Guide to the Installation of Cables Underground".

3.3 Requirements for connection of Generators

This clause 3.3 has been adapted from the National Electricity Rules v114 Schedule 5.2 for use in the Northern Territory.

3.3.1 Outline of requirements

(a) This clause 3.3 sets out details of additional requirements and conditions that *Generators* must satisfy as a condition of *connection* of a *generating system* to the *power system*.

(b) This clause 3.3 applies to *Generators* with a *generating system* that:

i. meets any materiality threshold established in a Northern Territory regulatory instrument for this purpose; or

ii. is connected or intended for use in a manner the *Network Operator* considers is likely to cause a material degradation in the quality of supply to other *Network Users*; or

iii. in the absence a materiality threshold referred to in subparagraph (i) above, has a rating of 2 MW or more.

Note: Generators that undertake the process under Chapter 5A or clause 5.3A of the NT NER may be assessed by the Network Operator in full or in part against the criteria under clause 3.3.5 of this Code.

(c) This clause 3.3 also sets out the requirements and conditions which, subject to clause 3.3.5, are obligations on *Generators*:

(1) to co-operate with the relevant *Network Operator* on technical matters when making a new *connection*; and

(2) to provide information to the *Network Operator* or *Power System Controller*.

(d) The equipment associated with each *generating system* must be designed to withstand without damage the range of operating conditions which may arise consistent with the system standards.

(e) *Generators* must comply with the performance standards and any attached terms or conditions of agreement agreed with the *Network Operator* or *Power System Controller* in accordance with a relevant provision of clauses 2.2 to 2.6 inclusive.

(f) This clause 3.3 does not set out arrangements by which a *Generator* may enter into an agreement or contract with the *Power System Controller* to:

  (1) provide additional services that are necessary to maintain *power system security*; or

  (2) provide additional services to facilitate management of the market.

(g) This clause 3.3 provides for *automatic access standards* and the determination of *negotiated access standard*s which once determined, must be recorded together with the *automatic access standards* in a *connection agreement* and registered with the *Power System Controller* as performance standards.

3.3.2 Application of settings

(a) A *Generator* must only apply settings to a control system or a protection system that are necessary to comply with performance requirements of this clause 3.3 if the settings have been approved in writing by the relevant *Network Operator* and, if the requirement is one that would involve the *Power System Controller* (being a *negotiated access standard*), also by the *Power System Controller*. A *Generator* must not allow its *generating unit* to supply electricity to the *power system* without such prior approval.

(b) If a *Generator* seeks approval from the *Network Operator* to apply or change a setting, then (except in the case of settings to be applied or changed by the *Generator* in connection with an emergency *frequency* control scheme) approval must not be withheld unless the *Network Operator* or, if the requirement is one that would involve the *Power System Controller* (being a *negotiated access standard*), the *Power System Controller*, reasonably determines that the changed setting would cause the *generating unit* to not comply with the relevant performance standard or cause an intra-regional power transfer capability to be reduced.

(c) If the *Network Operator* or, if the requirement is one that would involve the *Power System Controller* (being a *negotiated access standard*), the *Power System Controller*, reasonably determines that a setting of a generating unit's control system or protection system needs to change to comply with the relevant performance standard or to maintain or restore an intra-regional power transfer capability, the *Network Operator* or involve the *Power System Controller* (as applicable) must consult with the relevant *Generator*, and the

Network Operator may request in writing that a setting be applied in accordance with the determination.

(d) The *Network Operator* may also request a test to verify the performance of the relevant plant with the new setting. The *Network Operator* must provide the *Power System Controller* with a copy of its request to a *Generator* to apply a setting or to conduct a test.

(e) A *Generator* who receives such a request must arrange for the notified setting to be applied as requested and for a test to be conducted as requested. After the test, the *Generator* must, on request, provide both the *Power System Controller* and the *Network Operator* with a report of a requested test, including evidence of its success or failure. Such a report of a test is confidential information.

(f) A *Generator* must not change a setting requested by the *Network Operator* without its prior written agreement. If the *Network Operator* requires a *Generator* to change a setting within 18 months of a previous request, the *Network Operator* must pay the *Generator* its reasonable costs of changing the setting and conducting the tests as requested.

3.3.3 Technical matters to be co-ordinated

(a) A *Generator* and the relevant *Network Operator* must use all reasonable endeavours to agree upon relevant technical matters in respect of each new or altered connection of a *generating system* to a *network* including:

(1) design at the *connection point;*

(2) physical layout adjacent to the *connection point*;

(3) primary protection and *backup protection*;

(4) control characteristics;

(5) communications *facilities*;

(6) insulation co-ordination and lightning protection (paragraph (b));

(7) fault levels and fault clearance;

(8) switching and isolation *facilities*;

(9) interlocking and *synchronising* arrangements; and

(10) metering installations as described in Chapter 7A of the *NT NER*.

(b) A *Generator* must ensure that in designing a *generating system's* electrical plant, including any substation for the connection of the generating system to the network, to operate at the same *nominal voltage* as at the *connection point*:

(1) the *plant* complies with the relevant Australian Standards unless a provision of this *Code* allows or requires otherwise;

(2) the earthing of the *plant* complies with the ENA EG1-2006: Substation Earthing Guide to reduce step and touch potentials to safe levels;

(3) the *plant* is capable of withstanding, without damage the *voltage* impulse levels specified in the *connection agreement*;

(4) the insulation levels of the *plant* are co-ordinated with the insulation levels of the network to which the *generating system* is *connected* as specified in the *connection agreement*; and

(5) safety provisions in respect of the *plant* comply with requirements applicable to the participating jurisdiction in which the *generating system* is located, as notified by the *Network Operator*.

(c) If no relevant Australian Standard exists for the purposes of paragraph (b)(1), the *Generator* must agree with the *Network Operator* for the *Generator* to comply with another relevant standard.

(d) Prior to *connection* to the *Network Operator*'s power system, the *Users* shall have provided to the *Network Operator* a signed statement to certify that the equipment to be *connected* has been designed and installed in accordance with this *Code*, all relevant standards, all statutory requirements and good electricity industry practice.

3.3.4 Provision of information

Data to be provided by Generators

(a) A *Generator* shall provide the data specified in clause 11.2.

(b) The *Generator* shall provide all other data reasonably required by the *Network Operator*. This data shall include, without limitation, full Electromagnetic Transient (EMT) and Root Mean Square (RMS) models (and all model parameters) of:

(1) the *generating units*;

(2) the excitation *control systems*;

(3) turbine / engine governor systems;

(4) power system stabilisers; and

(5) inverter control systems;

to enable the *Network Operator* to conduct dynamic simulations.

(c) These models shall be in a form which is compatible with the power system analysis software used by the *Network Operator* (currently PSS/E from Siemens PTI and PowerFactory) and shall be inherently stable. These models shall be provided in both encrypted and unencrypted form (in circumstances required by the Generator Modelling Guidelines) and be supported by a separate *releasable user guide* for both the RMS and EMT models.

(d) Details of the kinds of data that may be required are included in Attachment 3 of this *Code*, specifically:

(1) Schedule S3.1 - Generating unit design data;

(2) Schedule S3.2 - Generating unit setting data;

(3) Schedule S3.5 - Network and plant technical data; and

(4) Schedule S3.6 - Network plant and apparatus setting data.

(e) Data provided by a *Generator* under this clause 3.3.4 may be shared by the *Network Operator* with other *Generators*, for the purposes of this *Code,* subject to the restrictions set out in the remainder of clause 3.3.4.

(f) The *Network Operator* must develop and publish Generator Modelling Guidelines and Generator Modelling Change Management Requirements for the purposes of this *Code*. The *Network Operator* must consult with the Utilities Commission and with Users before issuing or amending the guidelines or requirements.

Network modelling information for connection applicants

(g) A *connection applicant* for a new or modified *generating unit* or *generating system* seeking *connection* to the network, may request from the *Network Operator*:

(1) information that is reasonably required by the *connection applicant* to carry out power system simulation studies (including load flow and dynamic simulations) for planning and operational purposes; and

(2) operation and maintenance procedures and practices for network operation, sufficient to enable the *connection applicant* to carry out power system modelling under normal, outage and emergency conditions.

(h) If the *Network Operator* holds information requested under paragraph (g), the *Network Operator* must provide the requested information to the *connection applicant* as soon as practicable, subject to the following requirements:

(1) If the *Network Operator* holds and is required under this paragraph (h) to provide a *releasable user guide* that the *Network Operator* received from a *Generator*, the *Network Operator* must provide the *releasable user guide* to the *connection applicant* in an unaltered form.

(2) If the *Network Operator* holds and is required under this paragraph (h) to provide a form of the model source code that the *Network Operator* received from a *Generator* or from any other source, the *Network Operator* must provide that information:

(i) only in the form of, at the *Network Operator's* discretion:

(A) encrypted information; or

(B) a secured format agreed by the provider of the model source code,

unless the *Network Operator* has the written consent of the person who provided the information to the *Network Operator* to provide it in another form; and

(ii) in a form that can be interpreted by a software simulation product nominated by the *Network Operator*.

Confidentiality and use of information

(i) Any information provided by the *Network Operator* under paragraph (h) to a *connection applicant* must be treated as *confidential information*.

(j) A *connection applicant* who receives information under paragraph (h) may only use that information for the purpose of designing its *generating unit* or *generating system* and *connection* to the network, may only disclose such information to its employees and its external engineering advisers for use for such purpose and must not otherwise disclose or use the information

(k) A *connection applicant* who receives information under paragraph (h) must ensure any employees and engineering advisers to whom it discloses the information keep it confidential and only use it for the purpose referred to in paragraph (j).

3.3.5 Technical requirements

The following technical requirements describe the *automatic access standards* for new or modification of existing, *generating units* or *generating systems* seeking *connection* to the network. A *connection applicant* may propose an alternative *negotiated access standard* by applying the following:

(a) A *negotiated access standard* must:

(1) be set at a level that will not adversely affect *power system security*;

(2) be set at a level that will not adversely affect the *quality of supply* for other *Network Users*.

(b) When submitting a proposal for a *negotiated access standard*, a *connection applicant* must propose a standard that is as close as practicable to the corresponding *automatic access standard*, having regard to:

(1) the need to protect the *plant* from damage;

(2) *power system* conditions at the location of the proposed *connection*;

and

(3) the commercial and technical feasibility of complying with the *automatic access standard* with respect to the relevant technical requirement.

(c) When proposing a *negotiated access standard* under paragraph (b), the *connection applicant* must provide reasons and evidence to the *Network Operator* and *Power System Controller* as to why, in the reasonable opinion of the *connection applicant*, the proposed *negotiated access standard* is appropriate, including:

(1) how the *connection applicant* has taken into account the matters outlined in subparagraphs (b)(1), (b)(2) and (b)(3); and

(2) how the proposed *negotiated access standard* meets the requirements of paragraph (a).

(d) Within 30 business days following the later of:

(1) receipt of a proposed *negotiated access standard;* and

(2) receipt of all information required to be provided by the *connection applicant*,

the *Network Operator* must accept or reject a proposed *negotiated access standard.*

(e) The *Network Operator* must reject the proposed *negotiated access standard* where in the *Network Operator's* reasonable opinion, one or more of the requirements at subparagraphs (a)(1) and (a)(2) are not met.

(f) If the *Network Operator* rejects a proposed *negotiated access standard*, the *Network Operator* must, at the same time:

(1) subject to obligations in respect of *confidential information*, provide to the *connection applicant*:

(i) where the basis for the *Network Operator's* rejection is lack of evidence from the *connection applicant*, details of the additional evidence of the type referred to in paragraph (c) the *Network Operator* requires to continue assessing the proposed *negotiated access standard*;

(ii) detailed reasons in writing for the rejection, including the extent to which each of the matters identified at subparagraphs (a)(1) and (a)(2) contributed to the *Network Operator's* decision to reject the proposed *negotiated access standard*; and

(2) advise the *connection applicant* of a *negotiated access standard* that the *Network Operator* considers meets the requirements of subparagraphs (a)(1), and (a)(2).

(g) The *connection applicant* may in relation to a proposed *negotiated access standard* advised by the *Network Operator* in accordance with subparagraph (f)(2):

(1) accept the proposed *negotiated access standard*;

(2) reject the proposed *negotiated access standard*;

(3) propose an alternative *negotiated access standard* to be further evaluated in accordance with the criteria in paragraph (b); or

(4) elect to adopt the relevant *automatic access standard* or a corresponding *plant* standard.

(h) An *automatic access standard* or if the procedures in this clause 3.3.5 have been followed a *negotiated* access *standard*, that forms part of the terms and conditions of a *connection agreement*, is taken to be the performance standard applicable to the connected plant for the relevant technical requirement.

3.3.5.1 Reactive Power Capability

(a) The *automatic access standard* is a *generating system* operating at:

(1) any level of *active power* output not exceeding the *rated active power*; and

(2) any *voltage* at the *connection point* within the limits established under clause 15.2(a) without a *contingency event*,

must be capable of supplying and absorbing continuously at its *connection point* an amount of *reactive power* of at least the amount equal to the product of the *rated active power* of the *generating system* and 0.395.

(b) A performance standard must record the agreed value for *rated active power* and where relevant the method of determining the value.

(c) A performance standard for consumption of *energy* by a *generating system* when not supplying or absorbing *reactive power* under an *ancillary services agreement* is to be established under clause 3.6 as if the *Generator* were a load.

(d) If the *generating system* is not capable of the level of performance established under clause 3.3.5.1(a) the *Generator*, depending on what is reasonable in the circumstances, may request a *negotiated access standard* in accordance with clause 3.3.5(a) to (h), based on solutions including (without limitation):

(1) reaching a commercial arrangement with the *Network Operator* for the provision of the deficit of *reactive power* (supply and absorption) from within the *network*;

(2) installing additional equipment *connecting* at the *generating system's connection point* or another location, to provide the deficit of *reactive power* (supply and absorption), and such equipment is deemed to be part of the *generating system*;

(3) reaching a commercial arrangement with a *User* to provide the deficit of *reactive power* (supply and absorption); or

(4) if the inability to meet the performance level only occurs for particular operating conditions, agreeing to and documenting as part of the

proposed *negotiated access standard*, operational arrangements by which the *plant* can achieve an agreed level of performance for those operating conditions.

(e) The *Generator* may select one or more options referred to in paragraph (d).

3.3.5.2 Quality of Electricity Generated

(a) For the purpose of this clause 3.3.5.2 in respect of a *synchronous generating unit*, AS 1359.101 and IEC 60034-1 are *plant* standards for harmonic *voltage* distortion.

(b) The *automatic access standard* is a *generating system* when generating and when not generating must not produce at any of its *connection points* for *generation*:

(1) *voltage* fluctuation greater than the limits allocated by the *Network Operator* under clause 2.4.1;

(2) harmonic *voltage* distortion greater than the emission limits specified by a *plant standard* under paragraph (a) or allocated by the *Network Operator* under clause 2.4.2; and

(3) *voltage* unbalance greater than the limits allocated by the Network Operator in accordance with clause 2.4.3.

3.3.5.3 Generating Unit Response to Frequency Disturbance

(a) For the purposes of this clause 3.3.5.3:

normal operating frequency band and abnormal operating frequency excursion band are references to the widest range specified for those terms for any condition (including an "island" condition) in the *frequency operating standards* that apply to the *region* in which the *generating unit* is located.

stabilisation time means the longest times allowable for the *frequency* of the *power system* to remain outside the normal operating frequency band, for any condition (including an "island" condition) in the *frequency operating standards* that apply to the *region* in which the *generating unit* is located. The stabilisation time is 10 minutes.

transient frequency limit and transient frequency time mean the values of 45 Hz and 2 seconds respectively, or such other values determined by the *Power System Controller*.

(b) The *automatic access standard* is a *generating system* and each of its *generating units* must be capable of *continuous uninterrupted operation* for *frequencies* in the following ranges:

(1) the lower bound of the transient *frequency* limit for at least 2 seconds;

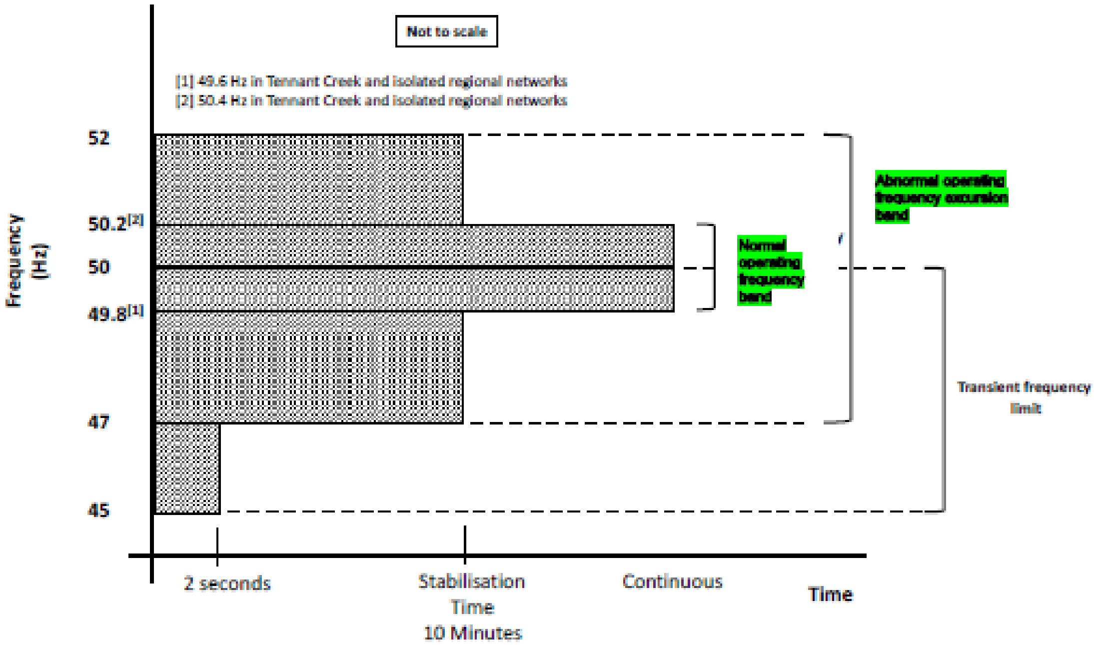
(2) the lower bound of the limits of the abnormal operating frequency excursion band specified in 2.2.2(b) to the lower bound of the *normal operating frequency band* for at least the stabilisation time;

(3) the *normal operating frequency band* for an indefinite period;

(4) the upper bound of the *normal operating frequency band* to the upper bound of the abnormal operating frequency excursion band for at least the stabilisation time,

unless the *rate of change of frequency* is outside the range of –4 Hz to 4 Hz per second.

The *automatic access standard* is illustrated in the following diagram reflecting the *frequency* standards outlined in clauses 2.2.1 and 2.2.2.



3.3.5.4 Generating System Response to Voltage Disturbances

(a) The *automatic access standard* is a *generating system* and each of its *generating units* must be capable of *continuous uninterrupted operation* where a *power system* disturbance causes the *voltage* at the *connection point* to vary within the following ranges:

(1) over 130% of *normal voltage* for a period of at least 0.02 seconds after T(ov);

(2) 125% to 130% of *normal voltage* for a period of at least 0.2 seconds after T(ov);

(3) 120% to 125% of *normal voltage* for a period of at least 2.0 seconds after T(ov);

(4) 115% to 120% of *normal voltage* for a period of at least 20.0 seconds after T(ov);

(5) 110% to 115% of *normal voltage* for a period of at least 20 minutes after T(ov);

(6) 90% to 110% of *normal voltage* continuously;

(7) 80% to 90% of *normal voltage* for a period of at least 10 seconds after T(uv); and

(8) 70% to 80% of *normal voltage* for a period of at least 2 seconds after T(uv),

where T(ov) means a point in time when the *voltage* at the *connection point* first varied above 110% of *normal voltage* before returning to between 90% and 110% of *normal voltage*, and T(uv) means a point in time when the voltage at the *connection point* first varied below 90% of *normal voltage* before returning to between 90% and 110% of *normal voltage*.

(b) The access standard must include any operational arrangements necessary to ensure the *generating system* and each of its *generating units* will meet its agreed performance levels under abnormal *network* or *generating system* conditions.

3.3.5.5 Generating System Response to Disturbances Following Contingency Events

(a) In this clause 3.3.5.5 a fault includes a fault of the relevant type having a metallic conducting path.

(b) The *automatic access standard* is:

(1) for a *generating system* and each of its *generating units*, the requirements of paragraphs (c) and (d);

(2) for a *generating system* comprised solely of *synchronous generating units*, the requirements of paragraph (e);

(3) for a *generating system* comprised solely of asynchronous *generating units*, the requirements of paragraphs (f) to (i); and

(4) for a *generating system* comprised of synchronous *generating units* and asynchronous *generating units*:

(i) for that part of the *generating system* comprised of *synchronous generating units*, the requirements of paragraph (e); and

(ii) for that part of the *generating system* comprised of asynchronous *generating units*, the requirements of paragraphs (f) to (i).

All generating systems

(c) A *generating system* and each of its *generating units* must remain in *continuous uninterrupted operation* for any disturbance caused by:

(1) a *credible contingency event*;

(2) a three phase fault in a *transmission system* cleared by all relevant primary protection systems;

(3) a two phase to ground, phase to phase or phase to ground fault in a *transmission system* cleared in:

(i) the longest time expected to be taken for a relevant *breaker fail protection* system to clear the fault; or

(ii) if a *protection system* referred to in subparagraph (i) is not installed, the greater of the time specified in clause 2.9.4 Figure 5 (or if none is specified, 450 milliseconds) and the longest time expected to be taken for all relevant primary *protection systems* to clear the fault; or

(4) a three phase, two phase to ground, phase to phase or phase to ground fault in a *distribution network* cleared in:

(i) the longest time expected to be taken for the *breaker fail protection* system to clear the fault; or

(ii) if a *protection system* referred to in subparagraph (i) is not installed, the greater of 1500 milliseconds and the longest time expected to be taken for all relevant primary *protection systems* to clear the fault,

provided that the event is not one that would disconnect the *generating unit* from the *power system* by removing *network* elements from service.

(d) A *generating system* and each of its *generating units* must remain in *continuous uninterrupted operation* for a series of disturbances within any five minute period caused by any combination of the events described in paragraph (c), without limitation on the time difference between successive disturbances unless any of the following conditions are exceeded first:

(1) more than six of the disturbances that cause the *voltage* at the *connection point* to drop below 50% of *normal voltage*;

(2) in parts of the network where three-phase automatic reclosure is permitted, more than two of the disturbances are three phase faults, and otherwise, more than one three phase fault where *voltage* at the *connection point* drops below 50% of *normal voltage*;

(3) more than one disturbance is cleared by a *breaker fail protection system* or similar back-up *protection system*;

(4) there are more than 15 disturbances;

provided that none of the events would result in:

(5) the islanding of the *generating system* or cause a material reduction in power transfer capability by removing network elements from service.

Synchronous generating systems

(e) Subject to any changed *power system* conditions or *energy* source availability beyond the *Generator's* reasonable control, a *generating system* comprised of *synchronous generating units,* in respect of the types of fault described in subparagraphs (c)(2) to (4), must supply to or absorb from the *network*:

(1) to assist the maintenance of *power system voltages* during the fault, capacitive reactive current of at least the greater of its pre-disturbance reactive current and 4% of the maximum continuous current of the *generating system* including all operating synchronous *generating units* (in

the absence of a disturbance) for each 1% reduction (from the level existing just prior to the fault) of *connection point voltage* during the fault;

(2) after clearance of the fault, *reactive power* sufficient to ensure that the *connection point* voltage is within the range for *continuous uninterrupted operation* under clause 3.3.5.4; and

(3) from 100 milliseconds after clearance of the fault, *active power* of at least 95% of the level existing just prior to the fault.

Asynchronous generating systems

(f) Subject to any changed *power system* conditions or *energy* source availability beyond the *Generator'*s reasonable control, a *generating system* comprised of asynchronous *generating units*, in respect of the types of fault described in subparagraphs (c)(2) to (4), must have *facilities* capable of supplying to or absorbing from the *network*:

(1) to assist the maintenance of *power system* voltages during the fault:

(i) capacitive reactive current in addition to its pre-disturbance level of at least 4% of the maximum continuous current of the *generating system* including all operating asynchronous *generating units* (in the absence of a disturbance) for each 1% reduction of *voltage* at the *connection point* below the relevant range in which a reactive current response must commence, as identified in subparagraph (g)(1), with the performance standards to record the required response agreed with the *Network Operator* and *Power System Controller*; and

(ii) inductive reactive current in addition to its pre-disturbance level of at least 6% of the maximum continuous current of the *generating system* including all operating asynchronous *generating units* (in the absence of a disturbance) for each 1% increase of voltage at the *connection point* above the relevant range in which a reactive current response must commence, as identified in subparagraph (g)(1), with the performance standards to record the required response agreed with the *Network Operator* and *Power System Controller*,

during the disturbance and maintained until *connection point voltage* recovers to between 90% and 110% of *normal voltage*, or such other range agreed with the *Network Operator* and *Power System Controller*, except for voltages below the relevant threshold identified in paragraph (h); and

(2) from 100 milliseconds after clearance of the fault, *active power* of at least 95% of the level existing just prior to the fault.

(g) For the purpose of paragraph (f):

(1) the *generating system* must commence a response when the *voltage* is in an under-voltage range of 85% to 90% or an over-voltage range of 110% to 115% of *normal voltage*. These ranges may be varied with the agreement of the *Network Operator* and *Power System Controller*

(provided the magnitude of the range between the upper and lower bounds remains at Δ5%); and

(2) the reactive current response must have a rise time of no greater than 40 milliseconds and a settling time of no greater than 70 milliseconds and must be adequately damped.

(h) Despite paragraph (f), a *generating system* is not required to provide a capacitive reactive current response in accordance with subparagraph (f)(1)(i) where:

(1) the *generating system* is directly connected to the *power system* with no step-up or connection transformer; and

(2) voltage at the *connection point* is 5% or lower of *normal voltage*.

(i) Subject to paragraph (h), despite the amount of reactive current injected or absorbed during *voltage* disturbances, and subject to thermal limitations and *energy* source availability, a *generating system* must make available at all times:

(1) sufficient current to maintain rated apparent power of the *generating system* including all operating *generating units* (in the absence of a disturbance), for all *connection point* voltages above 115% (or otherwise, above the over-voltage range agreed in accordance with subparagraph (g)(1)); and

(2) the maximum continuous current of the *generating system* including all operating *generating units* (in the absence of a disturbance) for all *connection point voltages* below 85% (or otherwise, below the under-voltage range agreed in accordance with subparagraph (g)(1)),

except that the *Network Operator* and *Power System Controller* may agree limits on active current injection where required to maintain *power system security* and/or the *quality of supply* to other *Network Users*.

General requirement

All generating systems

(j) The performance standard must include any operational arrangements to ensure the *generating system* including all operating *generating units* will meet its agreed performance levels under abnormal network or *generating system* conditions.

(k) When assessing multiple disturbances, a fault that is re-established following operation of automatic reclose equipment shall be counted as a separate disturbance.

(l) The performance standard must specify the cumulative time thresholds for which the *generating system* can remain in continuous operation for a sequence of disturbances consistent with 3.3.5.5(c) and (d). The standard must record the cumulative time with voltage at the *connection point* lower than 80% of *normal voltage* and the cumulative time with voltage at the *connection point* lower than 90% of *normal voltage*.

Asynchronous generating systems

(m) For the purpose of paragraph (f):

(1) the reactive current contribution may be limited to the maximum continuous current of a *generating system*, including its operating asynchronous *generating units*;

(2) the reactive current contribution and *voltage* deviation described may be measured at a location other than the *connection point* (including within the relevant *generating system*) where agreed with the *Network Operator* and *Power System Controller*, in which case the level of injection and absorption will be assessed at that agreed location;

(3) the reactive current contribution required may be calculated using phase to phase, phase to ground or sequence components of *voltages*. The ratio of the negative sequence to positive sequence components of the reactive current contribution must be agreed with the *Network Operator* and *Power System Controller* for the types of disturbances listed in this clause 3.3.5.5; and

(4) the performance standards must record all conditions (which may include temperature) considered relevant by the *Network Operator* and *Power System Controller* under which the reactive current response is required.

Synchronous generating systems and units

(n) For a *generating system* comprised solely of synchronous *generating units*, the reactive current contribution may be limited to 250% of the maximum continuous current of the *generating system*.

(o) For a *synchronous generating unit* within a *generating system* (other than a *generating system* described in paragraph (m)), the reactive current contribution may be limited to 250% of the maximum continuous current of that *synchronous generating unit*.

3.3.5.6 Quality of Electricity Generated and Continuous Uninterrupted Operation

The *automatic access standard* is a *generating system* including each of its operating *generating units* and reactive plant, must not *disconnect* from the *power system* as a result of *voltage* fluctuation, harmonic *voltage* distortion and *voltage* unbalance conditions at the *connection point* within the levels specified in clauses 2.4.1, 2.4.2 and 2.4.3.

3.3.5.7 Partial Load Rejection

The *automatic access standard* is a *generating system* shall be capable of *continuous uninterrupted operation*, during and following a *load* reduction which occurs in less than 0.5 seconds, from a fully or partially loaded condition provided that the *load* reduction is less than 50% of the generating system's *nameplate rating* and the *load* remains above minimum *load* or as otherwise agreed between the *Network Operator* and the relevant *User* and stated in the *connection agreement* between them.

3.3.5.8 Protection of Generating Units from Power System Disturbances

(a) The *automatic access standard* is:

(1) Subject to paragraph (d), for a *generating system* or any of its *generating units* that is required by a *Generator* or *Network Operator* to be automatically *disconnected* from the *power system* in response to abnormal conditions arising from the *power system*, the relevant *protection system* or *control system* must not *disconnect* the *generating system* for:

(i) conditions for which it must remain in *continuous uninterrupted operation*; or

(ii) conditions it must withstand under this *Code*.

(2) A *generating system*, connected to a *network* must have facilities to automatically and rapidly reduce its generation:

(i) by at least half, if the frequency at the *connection point* exceeds a level nominated by the *Network Operator* (not less than the upper limit of the *operational frequency tolerance band*) and the duration above this *frequency* exceeds a value nominated by the *Network Operator* where the reduction may be achieved:

(A) by reducing the output of the *generating system* within 3 seconds, and holding the output at the reduced level until the *frequency* returns to within the *normal operating frequency band*; or

(B) by disconnecting the *generating system* from the *power system* within 1 second; or

(ii) in proportion to the difference between the *frequency* at the *connection point* and a level nominated by the *Network Operator* (not less than the upper limit of the *operational frequency tolerance band*), such that the generation is reduced by at least half, within 3 seconds of the *frequency* reaching the upper limit of the *operational frequency tolerance band*.

(b) The *Network Operator* or *Power System Controller* may require that an access standard include a requirement for the *generating system* to be automatically *disconnected* by a local or remote control scheme whenever the part of the *network* to which it is *connected* has been *disconnected*, forming an island that supplies a *customer*.

(c) The access standard must include specification of conditions for which the *generating unit* or *generating system* must trip and must not trip.

(d) Notwithstanding clauses 3.3.5.3, 3.3.5.4, 3.3.5.5, 3.3.5.6 and 3.3.5.7, a *generating system* may be automatically *disconnected* from the *power system* under any of the following conditions:

(1) in accordance with an *ancillary services agreement* between the *Generator* and the *Network Operator* or *Power System Controller*;

(2) where a *load* that is not part of the *generating system* has the same *connection point* as the *generating system* and the *Network Operator* and *Power System Controller* agree that the *disconnection* would in effect be under-frequency load shedding;

(3) where the *generating system* is automatically *disconnected* under paragraph (a), clause 3.3.5.9 or by an emergency *frequency* control scheme;

(4) where the *generating system* is automatically *disconnected* under clause 3.3.5.10; or

(5) in accordance with an agreement between the *Generator* and the *Network Operator* (including an agreement in relation to an emergency control scheme under clause 3.2.1.5 to provide a service that is necessary to maintain or restore *power system security* in the event of a specified contingency event.)

(e) The *Network Operator* or *Power System Controller* is not liable for any loss or damage incurred by the *Generator* or any other person as a consequence of a fault on either the *power system*, or within the *Generator's facility*.

3.3.5.9 Protection Systems that Impact on Power System Security

(a) The *automatic access standard* is:

(1) primary *protection systems* must be provided to *disconnect* from the *power system* any faulted element in a *generating system* and in protection zones that include the *connection point* within the applicable fault clearance time determined under clause 2.9.4 and 2.9.5;

(2) each primary *protection system* must have sufficient redundancy to ensure that a faulted element within its protection zone is *disconnected* from the power system within the applicable fault clearance time with any single protection element (including any communications *facility* upon which that *protection system* depends) out of service; and

(3) breaker fail *protection systems* must be provided to clear faults that are not cleared by the circuit breakers controlled by the primary *protection system* within the applicable fault clearance time determined under clause 2.9.4 and 2.9.5

(b) In relation to an *automatic access standard* under this clause 3.3.5.9, the *Generator* must provide redundancy in the primary *protection systems* under paragraph (a)(2) and provide breaker fail *protection systems* under paragraph (a)(3) if the *Network Operator* and *Power System Controller* consider that a lack of these *facilities* could result in:

(1) a material adverse impact on *power system security* or *quality of supply* to other *Network Users*; or

(2) a reduction in intra-regional *power transfer capability*,

through any mechanism including:

(3) consequential tripping of, or damage to, other *network* equipment or *facilities* of other *Network Users,* that would have a *power system security* impact; or

(4) instability that would not be detected by other *protection systems* in the *network*.

(c) The *Network Operator* and the *Generator* must cooperate in the design and implementation of *protection systems* to comply with this clause 3.3.5.9, including cooperation on:

(1) the use of current transformer and *voltage* transformer secondary circuits (or equivalent) of one party by the *protection system* of the other;

(2) tripping of one party's circuit breakers by a *protection system* of the other party; and

(3) co-ordination of protection system settings to ensure inter-operation.

(d) The *protection system* design referred to in paragraphs (a) must:

(1) be coordinated with other *protection systems*;

(2) avoid consequential *disconnection* of other *Network Users' facilities*; and

(3) take into account existing obligations of the *Network Operator* under *connection agreements* with other *Network Users*.

3.3.5.10 Protection to Trip Plant for Unstable Operation

(a) The *automatic access standard* is a *generating system* must have:

(1) for its *synchronous generating units*, a *protection system* to *disconnect* it promptly when a condition that would lead to pole slipping is detected, to prevent pole slipping or other conditions where a *generating unit* causes *active power*, *reactive power* or *voltage* at the *connection point* to become unstable as assessed in accordance with the *power system* stability criteria established under clause 16; and

(2) for its asynchronous *generating units*, a *protection system* to *disconnect* it promptly for conditions where the *active power*, *reactive power* or *voltage* at the *connection point* becomes unstable as assessed in accordance with the guidelines for *power system* stability established under clause 16.

3.3.5.11 Frequency Control

(a) For the purpose of this clause 3.3.5.11:

(1) **Droop** means, in relation to frequency response mode, the percentage change in *power system frequency* as measured at the *connection point*, divided by the percentage change in power transfer of the *generating system* expressed as a percentage of the maximum operating level of the *generating system*. Droop must be measured at *frequencies* that are outside the deadband and within the limits of

power transfer.

(2) **Maximum operating level** means in relation to:

(i) a *generating unit*, the maximum sent out *generation* consistent with its *nameplate rating* to which it may be dispatched*;* and

(ii) a *generating system*, the combined maximum sent out *generation* to which its in-service *generating units* may be dispatched.

(3) **Minimum operating level** means in relation to:

(i) a *generating unit*, its minimum sent out *generation* for continuous stable operation;

(ii) a *generating system*, the combined minimum sent out *generation* of its in-service *generating units*.

(b) The *automatic access standard* is:

(1) subject to energy source availability a *generating system's* power transfer to the *power system* must not:

(i) increase in response to a rise in the *frequency* of the *power system* as measured at the *connection point*; or

(ii) decrease in response to a fall in the *frequency* of the *power system* as measured at the *connection point*; and

(2) subject to energy source availability a *generating system* must be capable of operating in *frequency* response mode such that it automatically provides a proportional:

(i) decrease in *power transfer* to the *power system* in response to a rise in the *frequency* of the *power system* as measured at the *connection point;* and

(ii) increase in power transfer to the *power system* in response to a fall in the f*requency* of the *power system* as measured at the *connection point,*

sufficiently rapidly and sustained for a sufficient period for the *Generator* to be in a position to offer measurable amounts of all *ancillary services* for the provision of *power system frequency control*.

(c) Each control system used to satisfy this clause 3.3.5.11 must be adequately damped.

(d) The amount of a relevant market *ancillary service* for which the plant may be registered must not exceed the amount that would be consistent with the performance standard registered in respect of this requirement.

(e) For the purposes of subparagraph (b)(2):

(1) the change in *power transfer* to the *power system* must occur with no delay beyond that required for stable operation, or inherent in the *plant* controls, once the *frequency* of the *power system* as measured at the *connection point* leaves a deadband around 50 Hz;

(2) a *generating system* must be capable of setting the deadband and droop within the following ranges:

(i) the deadband referred to in subparagraph (1) must be set within the range of 0 to ± 1.0 Hz. Different deadband settings may be applied for a rise or fall in the *frequency* of the *power system* as measured at the *connection point*; and

(ii) the droop must be settable within the range of 1% to 6%, or such other settings as agreed with the *Network Operator* and *Power System Controller*;

(3) nothing in subparagraph (b)(2) is taken to require a *generating system* to operate below its minimum operating level in response to a rise in the *frequency* of the *power system* as measured at the *connection point*, or above its maximum operating level in response to a fall in the *frequency* of the *power system* as measured at the *connection point*; and

(4) the performance standards must record:

(i) agreed values for maximum operating level and minimum operating level, and where relevant the method of determining the values, and the values for a *generating system* must take into account its in-service *generating units*; and

(ii) for the purpose of subparagraph (b)(2), the market *ancillary services,* including the performance parameters and requirements that apply to each such market *ancillary service*.

3.3.5.12 Impact on Network Capability

(a) The *automatic access standard* is a *generating system* must have *plant* capabilities and control systems that are sufficient so that when *connected* it does not reduce any intra-regional *power transfer capability* below the level that would apply if the *generating system* were not *connected*.

A *negotiated access standard* under this clause 3.3.5.12 must detail the *plant* capabilities, *control systems* and operational arrangements that will be maintained by the *Generator*, notwithstanding that change to the *power system*, but not changes to the *generating system*, may reduce the efficacy of the *plant* capabilities, *control systems* and operational arrangements over time.

3.3.5.13 Voltage and Reactive Power Control

(a) For the purposes of this clause 3.3.5.13:
static excitation system means in relation to a *synchronous generating unit*, an *excitation control system* that does not use rotating machinery to produce the field current.

(b) The *voltage* and *reactive power* control *automatic access standard* is:

(1) The *excitation control system* of a *synchronous generating unit* shall be capable of:

(i) limiting *generating unit* operation at all *load* levels to within *generating unit* capabilities for continuous operation;

(ii) controlling the *generating unit* output to maintain the short-time average *generating unit* output voltage at highest rated level (which shall be from a maximum of 5% below the nominal output *voltage* to at least 5% above the nominal output *voltage* and is usually 10% above the nominal output *voltage*);

(iii) ensuring that *plant* capabilities and control systems are sufficient such that:

A. *power system* oscillations, for the frequencies of oscillation of the *generating unit* against any other *generating unit,* are adequately damped;

B. operation of the *generating system* does not degrade the damping of any critical mode of oscillation of the *power system*; and

C. operation of the *generating system* does not cause instability (including hunting of tap-changing transformer control systems) that would adversely impact other *Users.*

(iv) in the case of a rotating *synchronous generating unit*, the five second ceiling excitation *voltage* shall be at least twice the excitation *voltage* required to achieve maximum continuous rating at *nominal voltage*; and

(v) providing reactive current compensation settable for boost or droop unless otherwise agreed by the *Network Operator*.

(2) The *control system* of a *generating unit* shall be capable of:

(i) New *synchronous generating units* shall be fitted with fast acting *excitation control systems*. AC exciter, rotating rectifier or static excitation systems shall be provided for any new *generating units* with a rating greater than 10 MW or for new smaller *generating units* within a *power station* totalling in excess of 10 MW. *Excitation control systems* shall provide *voltage* regulation to within 0.5% of the selected set point value.

(ii) New non-synchronous *generating units* must be fitted with fast acting *voltage* and / or reactive power control systems, which must utilise modern technology and be approved by the *Network Operator*. Control systems must provide regulation to within 0.5% of the selected set point value.

(iii) Unless agreed by the *Network Operator*, new *synchronous generating units* shall incorporate *power system* stabiliser circuits that modulate *generating unit* field *voltage* in response to changes in power output and/or shaft speed and/or any other equivalent input signal approved by the *Network Operator*. The stabilising circuits shall be responsive and adjustable over a *frequency* range that shall include *frequencies* from 0.1 Hz to 2.5 Hz.

(iv) The *Network Operator* may require *power system* stabiliser circuits on *synchronous generating units* with ratings less than or equal to 10 MW or smaller *synchronous generating units* within a *power station* with a total active power output capability less than or equal to 10 MW (if *power system* simulations indicate a need for such a requirement). Before commissioning of any *power system stabiliser*, the *Generator* must propose preliminary settings for the *power system stabiliser*, which must be approved by the *Network Operator*.

(v) *Power system stabilisers* may also be required for non-synchronous *generating units*. The performance characteristics of these *generating units* with respect to *power system* stability must be similar to those required for *synchronous generating units*. The requirement for a *power system stabiliser* and its structure and settings will be determined by the *Network Operator* from *power system* simulations.

(vi) Before commissioning of any *power system stabiliser*, its preliminary settings shall be agreed by the *Network Operator*. The User shall propose these preliminary settings that should be derived from system simulation studies and the study results reviewed by the *Network Operator*.

(vii) The performance characteristics set out in Figure 7 are required for AC exciter, rotating rectifier and static excitation systems.

Figure 7 – *Synchronous Generator* excitation system performance requirements

Performance Item	Units	Static Excitation	A.C. Exciter or Rotating Rectifier	Notes
Sensitivity: A sustained 0.5% error between the *voltage* reference and the sensed *voltage* will produce an excitation *change* of not less than 1.0 per unit.	Open loop gain (ratio)	200 minimum	200 minimum	1
Field *voltage* rise *time*: *Time* for field *voltage* to rise from rated *voltage* to excitation ceiling *voltage* following the application of a short duration impulse to the *voltage* reference.	second	0.05 maximum	0.5 maximum	2
Settling *time* with the *Generator synchronised* following a disturbance equivalent to a 5% step *change* in the sensed *Generator* terminal *voltage*.	second	2.5 maximum	5 maximum	3
Settling *time* with the *Generator unsynchronised* following a disturbance equivalent to a 5% step *change* in the sensed *Generator* terminal *voltage*. Shall be met at all operating points within the *Generator* capability.	second	1.5 maximum	2.5 maximum	3
Settling *time* following any disturbance that causes an excitation limiter to operate.	second	5 maximum	5 maximum	3

Notes:

1. One per unit is that field *voltage* required to produce nominal *voltage* on the air gap line of the *Generator* open circuit characteristic (Refer IEEE Standard 115-1983 – Test Procedures for Synchronous Machines).
2. Rated field *voltage* is that *voltage* required to give nominal *Generator* terminal *voltage* when the *Generator* is operating at its maximum continuous rating. Rise *time* is defined as the *time* taken for the field voltage to rise from 10% to 90% of the increment value.
3. Settling time is defined as the time taken for the Generator terminal voltage to settle and stay within an error band of ±10% of its increment value.

(viii) The performance characteristics required for the *voltage* or *reactive power* control systems of all non-synchronous *generating units* are specified in Figure 8.

Figure 8 – Non-synchronous Generator voltage or reactive power control system performance requirements

Performance Item	Units	Limiting Value	Notes
Sensitivity: A sustained 0.5% error between the reference *voltage* and the sensed *voltage* must produce an output change of not less than 100% of the *reactive power generation* capability of the *generating unit,* measured at the point of control.	Open loop gain (ratio)	200 minimum	1
Rise time: Time for the controlled parameter (*voltage* or *reactive power* output) to rise from the initial value to 90% of the change between the initial value and the final value following the application of a 5% step change to the *control system* reference.	second	1.5 maximum	2
Small disturbance settling time Settling time of the controlled parameter with the *generating unit* connected to the *transmission or distribution network* following a step change in the *control system* reference that is not large enough to cause saturation of the controlled output parameter. Must be met at all operating points within the *generating unit's* capability.	second	2.5 maximum	3
Large disturbance settling time Settling time of the controlled parameter following a large disturbance, including a *transmission or distribution network* fault, which would cause the maximum value of the controlled output parameter to be just exceeded.	second	5 maximum	3

Notes:

1. A control system with both proportional and integral actions must be capable of achieving a minimum equivalent gain of 200.
2. The controlled parameter and the point where the parameter is to be measured must be agreed and included in the relevant *connection agreement*.
3. Settling time is defined as the time taken for the controlled parameter to settle and stay within an error band of ±10% of its increment value.

(ix) The *Network Operator* shall approve the structure and parameter settings of all components of the *excitation control system*, including the *voltage* regulator, *power system stabiliser*, power amplifiers and all excitation limiters.

(x) The structure and settings of the *excitation control system* shall not be changed, corrected or adjusted in any manner without prior written notification to the *Network Operator*. The *Network Operator* may require *generating unit* tests to demonstrate compliance with the requirements of Figure 7 or Figure 8. The *Network Operator* may witness such tests.

(xi) Settings may require alteration from time to time as advised by the *Network Operator or Power System Controller*. The cost of altering the settings and verifying subsequent performance shall be borne by the User, provided alterations are not made more than once in each 18 months for each *generating unit*. If more frequent changes are requested the person making that request shall pay all costs on that occasion.

(xii) Excitation limiters shall be provided for under excitation and over excitation and may be provided for *voltage* to *frequency* ratio. The *generating unit* shall be capable of stable operation for indefinite periods while under the control of any excitation limiter. Excitation limiters shall not detract from the performance of any *power system stabiliser* or power oscillation damping capability and shall have settings applied which are co-ordinated with all *protection systems*.

(3) a *control system* must have:

(i) for the purposes of disturbance monitoring and testing, permanently installed and operational, monitoring and recording *facilities* for key variables including each input and output; and

(ii) *facilities* for testing the *control system* sufficient to establish its dynamic operational characteristics.

3.3.5.14 Active Power Control

(a) Subject to energy source availability, the *active power* control *automatic access standard* is a *generating system* must have an *active power* control system capable of:

(1) Maintaining and changing its *active power* output in accordance with its *dispatch* instructions to the accuracy specified in paragraph (f); and

(2) Receiving and automatically responding to AGC signals as updated (nominal update rate of once per four seconds)

(b) Each control system used to satisfy the requirements of paragraph (a) must be adequately damped.

(c) Settings may require alteration from time to time as advised by the *Network Operator or Power System Controller*. The cost of altering the settings and verifying subsequent performance shall be borne by the *User*, provided alterations are not made more than once in each 18 months for each *generating unit*. If more frequent changes are requested the person making that request shall pay all costs on that occasion.

(d) A *generating system* must be capable of ramping its active power output linearly at a rate not slower than 5% of *nameplate rating* per minute.

(e) *Active power* output of the *generating system* may differ from *dispatch* instructions as a result of actions to correct system *frequency* in accordance with other provisions of this *Code.*

(f) The *active power* output of the *generating system* must be within +/-0.5% of the *dispatch* instructions subject to clause 3.3.5.14(e), the firm offer in clause 3.3.5.17 and *plant* ramp rates.

3.3.5.15 Inertia and Contingency FCAS

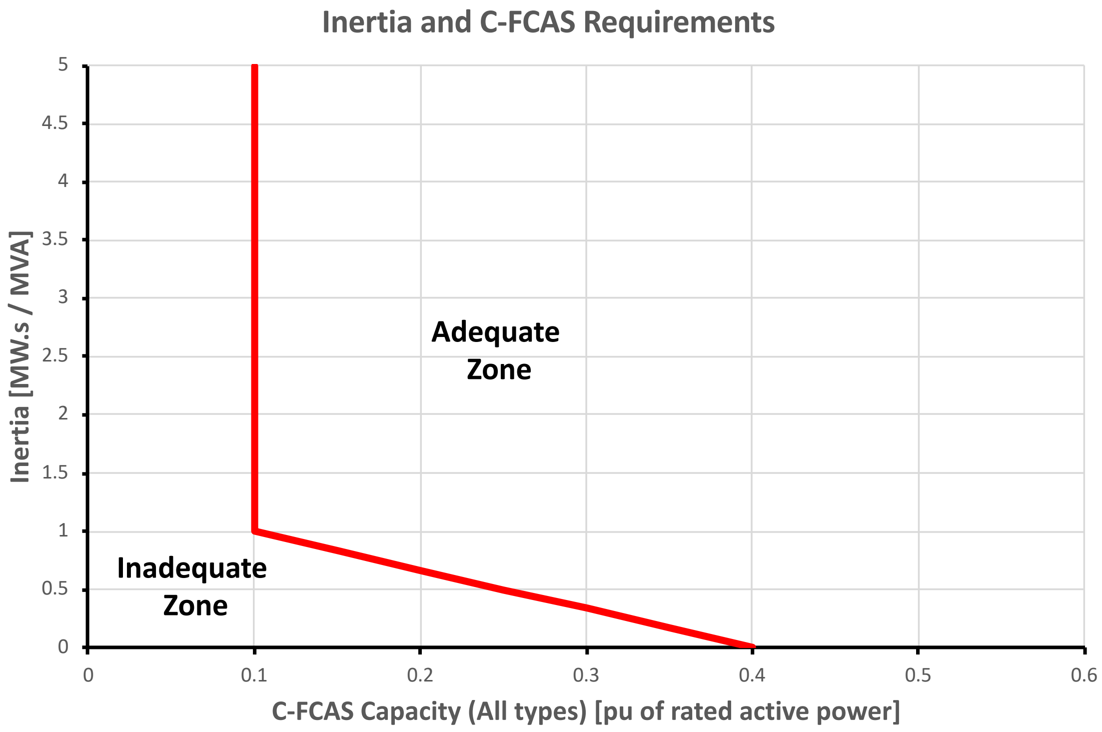
(a) The *inertia* and *contingency FCAS automatic access standard* is:

(1) A *generating system* must have an adequate *inertia* and *contingency FCAS* capability as defined by the characteristic below. Subject to energy source availability, the *generating system* must be able to operate at a real power output that will deliver *inertia* and *contingency FCAS* capability within the adequate zone as shown. The required capability can be achieved by any combination of partially loaded *generating unit(s)*, and/or additional plant (e.g. *synchronous condensers*, energy storage system, etc.), to achieve the required capability.

(2) *Inertia* offered or provided from non-synchronous (emulated) sources needs to be assessed and accepted by the *Power System Controller* and *Network Operator*.

(3) The *inertia* and *FCAS* capabilities will be accredited by the *Power System Controller* using the specifications and evaluation framework outlined in the System Secure Guidelines.

Figure 9 – Inertia vs C-FCAS Trade Off Requirements for New Generators



3.3.5.16 System Strength

(a) The *Network Operator* must prepare *system strength impact assessment guidelines*. In preparing the first version of the guidelines, the *Network Operator* must review the AEMO System Strength Impact Assessment Guidelines v1.0 July 2018 and adopt those aspects of that document that are appropriate to apply in the Northern Territory together with any other provisions the *Network Operator* considers appropriate. The *Network Operator* may amend the guidelines at any time, and must assess the need to amend the guidelines when any changes are made to the AEMO guidelines. The *Network Operator* must consult with *Users* before issuing or amending the guidelines.

(a1) Until the *Network Operator* has developed and published the first version of its *system strength impact assessment guidelines*, it may undertake assessments based on the relevant provisions of AEMO's System Strength Impact Assessment Guidelines v1.0 July 2018.

(b) The system strength *automatic access standard* is a *generating system* must not cause an adverse impact on system strength as defined in the *system strength impact assessment guidelines* and following an assessment by the *Network Operator*.

Subject to paragraph (a):

(1) a *Network Operator* must undertake system strength *connection* works at the cost of the *connection applicant* if the full assessment undertaken in accordance with the system strength impact assessment guidelines indicates that the *connection applicant's* proposed new *connection* of a *generating facility* or the *Generator*'s proposed alteration to a *generating system* will have an adverse system strength impact, or

(2) to the extent that the *adverse system strength impact* referred to in paragraph (a) is or will be avoided or remedied by a system strength remediation scheme agreed or determined under this clause and implemented by the *connection applicant* in accordance with its *connection agreement*.

(c) A *connection applicant* proposing to install *plant* as part of a system strength remediation scheme must include a description of the *plant*, the ratings of the proposed *plant* (in MVA) and other information (including models) reasonably required by the *Network Operator* and *Power System Controller* to assess the system strength remediation scheme.

3.3.5.17 Capacity Forecasting

(a) In this clause 3.3.5.17, the following terms apply:

(1) ‘t’ is time.

(2) ‘t=0’ refers to the moment when a forecast is updated.

(3) ‘t=[numeral]’ refers to the number of minutes elapsed since t=0.

(4) ‘capacity’ means the minimum capability of a *generating system* to deliver an active power output at a continuous steady level over the relevant 5 minute interval.

(5) ‘firm offer’ means the capacity forecast provided at t=0 for the interval commencing t=0 for 5 minutes.

(b) The capacity forecasting *automatic access standard* is:

(1) Subject to paragraph (f), a *Generator* must supply to the *Power System Controller* a forward forecast of the capacity of its *generating system*.

(2) The forecast in 3.3.5.17(b)(1) must:

(i) include a 24 hour ahead forecast for capacity for every 5 minute interval, updated at 5 minute intervals; and

(ii) have an accuracy such that in any rolling 24 hour period, at least 90% of the non-zero forecasts for the intervals commencing from t=5 to t= 30 do not exceed the firm offer for the time for which the forecast was made.

(3) For the forecast updates that do not meet paragraph (2)(ii) above, that exceed the firm offer, the forecast must not exceed the firm offer by a margin greater than:

(i) 5% of the *generating unit's nameplate rating*; or

(ii) 1 MW,

whichever is the lesser.

(4) The firm offer must be the capacity of the generating system for the interval and therefore the generating system must follow a *dispatch* instruction up to the firm offer in accordance with the requirements in clause 3.3.5.14.

Note: When issuing dispatch instructions*, the System Controller will respect plant limits such as firm offers and ramp rates of plant.*

(c) A *Generator* must provide forecasts to the *Power System Controller* in a format specified by the *Power System Controller*.

(d) The *generating system* owner will be required to report compliance against the above requirements in a format and timeframe determined by the *Power System Controller*.

(e) In the event of non-compliance with the *automatic access standard* by a *Generator*, the *Power System Controller* may adjust that *Generator's* subsequent forecasts and firm offers accordingly.

(f) The *System Controller* must publish a procedure that specifies the process the *System Controller* will use to detect any non-compliance with the capacity forecasting performance standard and the process that will be used to determine the action taken in response to any non-compliance with that performance standard. In formulating this process the *System Controller* shall publish a proposed draft process and then consult with, and consider the input from interested parties, including the Utilities Commission and *Users*. The draft procedure must be published by 30 March 2020. Following the required consultation, the final procedure must be published by 8 May 2020.

3.3.6 Monitoring and Control Requirements

3.3.6.1 Remote Monitoring and Control

(a) The remote monitoring standard is:

(1) The *Network Operator* will require *Users* to provide remote monitoring equipment ("RME") to enable the *Network Operator* and the *Power System Controller* to remotely monitor performance of a *generating unit* (including its dynamic performance) where this is reasonably necessary in real time for control, planning or security of the *power system*; and

(2) Any RME provided, upgraded, modified or replaced (as applicable) shall conform to an acceptable standard as agreed by the *Network Operator* and shall be compatible with the *Network Operator*'s SCADA system and the *nomenclature standards* of the *Network Operator* and as agreed to by the *Power System Controller*

(3) Input information to RME may include, but not be limited to, the following:

(i) Status indications:

a. Generating Unit Circuit Breaker Open/Closed
b. Remote Generation Load Control on/off
c. Generating Unit Operating Mode
d. Governor Limiting Operation
e. Connection to the network

(ii) Alarms:

a. Generating Unit Circuit Breaker Tripped by Protection
b. Prepare to off load

(iii) Protection Defective Alarms

(iv) Measure Values:

a. Gross active power output of each *generating unit*
b. Net station active power import or export at each connection point
c. Gross reactive power output of each *generating unit*
d. Net station reactive power import or export at each connection point
e. *Generating unit* stator voltage
f. *Generating unit* transformer tap position
g. Net station output of active energy (impulse)
h. *Generating unit* remote *Generation* control high limit value
i. *Generating unit* remote *Generation* control low limit value
j. *Generating unit* remote *Generation* control rate limit value
k. For energy storage devices the available energy (in MWh)
l. *Generating unit* present maximum active capacity
m. *Generating unit* forecasted maximum active capacity

(v) Such other input information as is reasonably required by the *Network Operator or Power System Controller*.

(4) A *User* is required to install *remote control equipment* ("RCE") that is adequate to enable the *Power System Controller* to remotely control:

(i) The *active power* output of any *generating unit*; and

(ii) The reactive power output of any *generating unit*.

(5) Unless agreed otherwise, the relevant *User* will be responsible for the following actions at the request of the *Network Operator* or the *Power System Controller*:

(i) Activating and de-activating RCE installed in relation to any *generating unit*; and

(ii) Setting the minimum and maximum levels to which, and a maximum rate at which, the *Power System Controller* will be able to adjust the performance of any *generating unit* using RCE.

(6) A User shall provide electricity supplies for the RME and RCE installed in relation to its *generating unit* capable of keeping these *facilities* available for at least eight hours following total loss of supply at the *connection point* for the relevant *generating unit*.

(7) The performance of the RME and RCE in terms of accuracy and reliability shall meet the requirements of the *Network Operator* and *Power System Controller*.

3.3.6.2 Communications Equipment

(a) The communications equipment standard is:

(1) A *User* shall provide communications paths (with appropriate redundancy) between RME or RCE installed at any of its *generating units* to a communications interface at the relevant *power station* and in a location reasonably acceptable to the *Network Operator*.

(2) Communications systems between this communications interface and the relevant control centre shall be the responsibility of the *Network Operator* unless otherwise agreed,

(3) The *User* shall meet the cost of the communications systems, unless otherwise determined by the *Network Operator*.

(4) Telecommunications between the *Power System Controller* and *Generators* shall be established in accordance with the requirements set down below for *operational communications*.

(i) Primary Speech Facility

(A) Each *User* shall provide and maintain equipment by means of which routine and emergency control telephone calls may be established between the *User's* responsible Engineer/ Operator and the *Power System Controller*.

(B) The *facilities* to be provided, including the interface requirement between the *Power System Controller*'s equipment and the User's equipment shall be specified by the *Network Operator*.

(ii) Back-up Speech Facility

(A) Where the *Network Operator* advises a *User* that a back-up speech *facility* to the primary *facility* is required, the *Network Operator* will provide and maintain a separate telephone link or radio installation. The costs of the equipment shall be recovered through the charge for *connection*.

(B) The *Network Operator* shall be responsible for radio system planning and for obtaining radio licenses for equipment used in relation to the *Network Operator* networks.

3.3.7 Power station auxiliary supplies

In cases where a *generating system* takes its auxiliary supplies via a *connection point* through which its *generation* is not transferred to the *network*, the access standards for the auxiliaries must be established under clause 3.6 as a *load customer*.

3.3.8 Fault current

(a) The fault current standard is:

(1) The contribution of the *generating system* to the fault current on the connecting network through its *connection point* must not exceed the contribution level that will ensure that the total fault current can be safely interrupted by the circuit breakers of the connecting network and safely carried by the connecting network for the duration of the applicable breaker fail protection system fault clearance times, as specified for the relevant *connection point* by the *Network Operator*;

(2) A *generating system's connected plant* must be capable of withstanding fault current through the *connection point* up to the higher of:

(i) The level specified by the *Network Operator*; or

(ii) The highest level of current at the *connection point* that can be safely interrupted by the circuit breakers of the connecting network and safely carried by the connecting network for the duration of the applicable breaker fail *protection system* fault clearance times, as specified by the *Network Operator*.

(3) A circuit breaker provided to isolate a *generating unit* or *generating system* from the *network* must be capable of breaking, without damage or restrike, the maximum fault currents that could reasonably be expected to flow through the circuit breaker for any fault in the *network* or in the *generating unit* or *generating system*, as specified in the *connection agreement*.

3.4 Requirements for connection of Small Generators

3.4.1 Scope

(a) This clause 3.4 addresses the requirements for the *connection* of *Small Generation Unit*s and groups of *Small Generation Unit*s.

(b) This clause 3.4 does not apply to the *connection* of *Small Inverter Energy System*s, in respect of which clause 3.5 applies.

3.4.2 Objectives

(a) The issues addressed by this clause 3.4 are:

(1) the possibility that *Small Generation Unit*s embedded in *network*s may affect the *quality of supply* to other *Users*, cause reverse *power transfer*, use up *network* capacity, create a *network* switching hazard and increase risks for operational personnel;

(2) the possibility that a *Small Generation Unit connect*ed to a *network* could become islanded on to a de-*energise*d part of the *network* resulting in safety and *quality of supply* concerns; and

(3) a simplified *connection* process for *Small Generator*s.

3.4.3 Categorisation of facilities

(a) This clause 3.4 covers *Small Generation Unit*s of all types, whether using renewable or non-renewable *energy* sources.

(b) Unless otherwise specified, technical requirements for *Small Generation Unit*s will apply at the *connection point*, rather than at the *Generator* machine terminals, except that the *reactive power* requirements for *synchronous Small Generation Unit*s will apply at the *Generator* machine terminals.

(c) *Connection point*s for small *power stations* are characterised as:

(1) high *voltage connect*ed: 3 phase, 11 kV or 22 kV; or

(2) *low voltage connect*ed: 1, 2 or 3 phase plus neutral, 230 V or 400 V.

(3) Where a *Small Generation Unit* is the only *facility connect*ed to a *low voltage network* the *Generator* may choose to have the *power station* assessed for compliance as if the *power station* was high *voltage connect*ed. Prior to another *User* subsequently *connect*ing to the same *low voltage network* the *Network Operator* shall reassess the *power station* for compliance with the requirements for *low voltage connect*ed *power stations* and the *Small Generator* shall rectify any noncompliance identified in the reassessment.

(d) The mode of operation of a *Small Generation Unit* in a small *power station* is characterised as being in:

(1) continuous parallel operation with the *network*, and either exporting electricity to the *network* or not exporting electricity to it;

(2) occasional parallel operation with the *network*, and either exporting electricity to the *network* or not exporting electricity to it, including *generating units* participating in peak lopping and system *peak load* management for up to 200 hours per year;

(3) short term test parallel operation with the *network*, and either exporting electricity to the *network* or not exporting electricity to it, and having a maximum duration of parallel operation 2 hours per event and 24 hours per year; or

(4) bumpless (make before break) transfer operation, being:

(i) operation in rapid transfer mode where, when *load* is transferred between the *Small Generation Unit* and the *network* or vice versa, the *Small Generation Unit* is *synchronise*d for a maximum of one second per event; or

(ii) operation in gradual transfer mode where, when *load* is transferred between the *Small Generation Unit* and the *network* or vice versa, the *Small Generation Unit* is *synchronise*d for a maximum of 60 seconds per event.

3.4.4 Information to be provided by a Small Generator

(a) A *Small Generator* shall provide all information in relation to the design, construction, operation and configuration of that small *power station* as is required by the *Network Operator* to ensure that the operation and performance standards of the *network*, or other *Users*, are not adversely affected by the operation of the *power station*.

(b) Details of the kinds of information that may be required for *Small Generator*s are included in clause 11.

3.4.5 Safety and reliability

The requirements imposed on a *Small Generator* by this clause 3.4.5 are intended to provide minimum safety and *reliability* standards for the *network* and other *Users*.

(a) A *Small Generator* shall design its *facilities* in accordance with applicable standards and regulations, *good electricity industry practice* and the manufacturers' recommendations.

(b) The safety and *reliability* of the *network* and the equipment of other *Users* are paramount and *connection* applications shall be evaluated accordingly.

(c) A *Small Generator* shall not *connect* or re*connect* to the *network* if the safety and *reliability* of the *network* or *Users* would be placed at risk.

(d) Where it is apparent that the operation of equipment installed in accordance with the requirements of this clause may have an adverse impact on the operation, safety or performance of the *network* or on the *quality of supply* to other *Users*, the *Network Operator* shall consult with the *Users* to reach an agreement on an acceptable solution.

(e) Pursuant to clause 3.4.5(d), the *Network Operator* may require the *Small Generator* to test or modify its relevant equipment.

(f) Unless otherwise agreed in the relevant *connection agreement*, the *Network Operator* may require a *Small Generator* not to operate equipment in abnormal *network* operating conditions.

(g) Equipment directly *connect*ed to the *connection point* of a small *power station* shall be rated for the *maximum fault current* at the *connection point* specified in clause 2.8.

(h) A *Small Generator* shall ensure that the *maximum fault current* contribution from a *Small Generation Unit* or small *power station* is not of a magnitude that will allow the total fault current at the *connection point* to exceed the levels specified in clause 2.8 for all normal operating conditions.

3.4.6 Small Generation Unit characteristics

(a) To assist in controlling *network* fault levels, *Small Generator*s shall ensure that *generating units* comply with the *Network Operator's* requirements relating to *minimum fault current* and *maximum fault current* contribution through a *connection point*.

(b) If the *connection* or *disconnection* of a *User's* small *power station* causes or is likely to cause excessively high or low fault levels, this shall be addressed by other technical measures specified in the relevant *connection agreement*.

3.4.7 Connection and operation

3.4.7.1 Main switch

(a) Each *facility* at which a *Small Generation Unit* in a small *power station* is *connect*ed to the *network* shall contain one main switch provided by the *User* for each *connection point* and one main switch for each *Small Generation Unit*, where a *Small Generation Unit* shares a *connection point* with other *Small Generation Unit*s or *load*s. For larger installations, additional *connection point*s and main switches or a dedicated feeder may be required.

(a) Switches shall be automatically operated, fault current breaking and making, ganged switches or circuit breakers. The relevant *facility* may also contain similarly rated interposed paralleling switches for the purpose of providing alternative *synchronise*d switching operations.

(b) At each relevant *connection point* there shall be a means of visible and lockable isolation and test points accessible to the *Network Operator's* operational personnel. This may be a withdrawable switch, a switch with visible contacts, a set of removable links or other approved means. It shall be possible for the *Network Operator's* operational personnel to fit safety locks on the isolation point. *Low voltage Small Generation Unit*s with moulded case circuit breakers and fault limiting fuses with removable links are acceptable for isolation points in accordance with this sub clause.

3.4.7.2 Synchronising

(a) For a synchronous *Small Generation Unit* in a small *power station*, a *Small Generator* shall provide automatic *synchronising* equipment at each *Small Generation Unit* circuit breaker.

(b) Check *synchronising* shall be provided on all *Small Generation Unit* circuit breakers and any other switching devices that are capable of *connect*ing the *User's* generating equipment to the *network* unless otherwise interlocked to the satisfaction of the *Network Operator*.

(c) Prior to the initial *synchronisation* of the *Small Generation Unit*(s) to the *network*, the *Small Generator* and the *Network Operator* shall agree on written operational procedures for *synchronisation*.

3.4.7.3 Safe shutdown without external supply

A *Small Generation Unit* shall be capable of being safely shut down without electricity *supply* being available from the *network*.

3.4.8 Power quality and voltage change

(a) A *Small Generator* shall ensure that the *network* performance standards of clause 2 are met when a small *power station* is *connect*ed by it to the *network*.

(b) The step *voltage change* at the *connection point* for *connection* and *disconnection* shall comply with the requirements of clause 2.3.3. These requirements may be achieved by *synchronising* individual *generating units* sequentially. On *low voltage* feeders, *voltage change*s up to 5% may be allowed in some circumstances with the approval of the *Network Operator*.

(c) The steady state *voltage* rise at the *connection point* resulting from export of power to the *network* shall not exceed 2% and shall not cause the *voltage* limits specified in clause 2.3.1 to be exceeded.

(d) When operating *unsynchronised*, a synchronous *Small Generation Unit* in a small *power station* shall generate a constant *voltage* level with balanced phase *voltage*s and harmonic *voltage* distortion equal to or less than permitted in accordance with either *Australian Standard* AS 1359 (1997) "General Requirements for Rotating Electrical Machines" or a recognised relevant international standard, as agreed between the *Network Operator* and the *User*.

3.4.9 Remote control, monitoring and communications

(a) For *Small Generation Unit*s exporting 1 MW or more to the *network* the *Generator* shall provide for:

(1) tripping of the *Small Generation Unit* remotely from the *Network Operator's control centre*;

(2) a close-enable interlock operated from the *Small Network Operator's control centre*; and

(3) remote monitoring at the *control centre* of (signed) MW, MVAr and *voltage*.

(b) For *Small Generation Units* exporting less than 1 MW monitoring may not be required.

(c) Where concerns for safety and *reliability* arise that are not adequately addressed by automatic *protection system*s and interlocks, the *Network Operator* may require the *Small Generator* to provide remote monitoring and remote control of some functions in accordance with this clause 3.4.9.

(d) A *Small Generator* shall provide a continuous communication link with the *Network Operator's control centre* for monitoring and control for *Small Generation Unit*s exporting 1 MW and above to the *network*. For *Small Generation Unit*s exporting below 1 MW, non-continuous monitoring and control may be required e.g. a bi-*direction*al dial up arrangement.

(e) A *Small Generator* shall have available at all times a telephone link or other communication channel to enable voice communications between a small *power station* and the *Network Operator*'s *control centre*.

(f) For *Small Generation Unit*s exporting above 1 MW, a dedicated telephone link or other dedicated communication channel may be required.

3.4.10 Protection

3.4.10.1 General

(a) A *Small Generator* shall provide, as a minimum, the *protection* functions specified in this clause in accordance with the aggregate rated capacity of *Small Generation Unit*s in a small *power station* at the *connection point*.

(b) A *Small Generator*'s proposed *protection system* and settings shall be approved by the *Network Operator*, who shall assess their likely effect on the *network* and may specify modified or additional requirements to ensure that:

(1) the *network* performance standards specified in clause 2 are met;

(2) the *power transfer capability* of the *network* is not reduced; and

(3) the *quality of supply* to other *Users* is maintained. Information that may be required by the *Network Operator* prior to giving approval is specified in clause 11.

(c) A *Small Generator’*s *protection system* shall clear internal *plant* faults and coordinate with the *Network Operator’s protection system*.

(d) The design of a *Small Generator’*s *protection system* shall ensure that failure of any *protection* device cannot result in the *network* being placed in an unsafe operating mode or lead to a disturbance or safety risk to the *Network Operator* or to other *Users*. This may be achieved by providing back-up *protection scheme*s or designing the *protection system* to be fail-safe, e.g. to trip on failure.

(e) All *protection apparatus* shall comply with the IEC 60255 series of standards. Integrated control and *protection apparatus* may be used provided that it can be demonstrated that the *protection* functions are functionally independent of the control functions, i.e. failure or maloperation of the control features will not impair operation of the *protection system*.

(f) All *Small Generators* shall provide under and over *voltage*, under and over *frequency* and overcurrent *protection scheme*s in accordance with the equipment rating.

(g) All *Small Generators* shall provide earth fault *protection* for earth faults on the *network*. All small *power station*s *connect*ed at high *voltage* shall have a sensitive earth fault *protection scheme*.

(h) The earth fault *protection scheme* may be:

(1) earth fault; or

(2) neutral *voltage* displacement

depending on the *connection* type).

(i) No *Small Generator* may *supply* a de-*energise*d *network* and all small *power station*s shall provide *protection* against abnormal *network* conditions, as specified in clause3.2.3, on one or more phases. This *protection* against loss of external *supply* may be:

(1) loss of mains;

(2) *rate of change of frequency* (ROCOF);

(3) vector surge;

(4) reverse power; or

(5) *direction*al over current.

(j) All *Small Generators* that have an export limit shall have reverse power or *direction*al current limits set appropriate to the export limit.

(k) All *Small Generators* shall have loss of AC and DC auxiliary *supply protection*, which shall immediately trip all switches that depend on that *supply* for operation of their *protection*.

(l) Where *synchronisation* is *time* limited, the *Small Generator* shall be *disconnect*ed by an independent timer.

(m) *Small Generation Unit*s that are only operated in parallel with the *network* during rapid bumpless transfer shall be protected by an independent *time*r that will *disconnect* the *Small Generation Unit* from the *network* if the bumpless transfer successfully completed. Automatic transfer switches shall comply with Australian Standard AS 60947.6.2 (2004). For the avoidance of doubt *Small Generation Unit*s covered by sub-clause 3.4.10.1(m) need not comply with sub sub-clauses (f) to (l) of clause 3.4.10.1. This exemption recognises that the rapid bumpless transfer will be completed or the *Small Generation Unit* will be *disconnect*ed by the *disconnection* timer before other *protection scheme*s operate. *Protection* of the *Small Generation Unit* when it is not operating in parallel with the *network* is at the discretion of the *Small Generator*.

3.4.10.2 Pole slipping

Where it is determined that the disturbance resulting from loss of synchronism is likely to exceed that permitted in clause 2.6, the *Small Generator* shall install a pole slipping *protection scheme*.

3.4.10.3 Islanding protection and intertripping

(a) For sustained parallel operation (which excludes rapid or gradual bumpless transfer), islanding *protection scheme*s of two different functional types shall be provided to prevent a *Small Generation Unit* energising a part of the *network* that has become isolated from the remainder of the *transmission* or *network* under all operating modes. The *Small Generator* shall demonstrate that two different functional types of islanding *protection scheme*s have been provided.

(b) *Small Generation Unit*s designed for gradual bumpless transfer shall be protected with at least one functional type of islanding *protection scheme*.

(c) Islanding *protection* shall operate within 2 seconds to ensure *disconnection* before the first *network* reclosing attempt (typically 5 seconds). Relay settings are to be agreed with the *Network Operator*. It should be assumed that the *Network Operator* will always attempt to auto-reclose to restore *supply* following transient faults.

(d) In cases where, in the opinion of the *Network Operator*, the risk of undetected islanding of part of the *network* and the *Small Generator*'s *facility* remains significant, the *Network Operator* may also require the installation of an intertripping link between the *Small Generator*'s main switch(es) and the feeder circuit breaker(s) in the zone *substation* or other upstream *protection* device nominated by the *Network Operator*.

3.4.10.4 Protection of Small Generator's equipment

(a) This clause 3.4.10.4 applies only to *protection* necessary to maintain *power system security*. A *Small Generator* shall design and specify any additional *protection* required to guard against risks within the *Small Generator*'s *facility*.

(b) Any failure of the *Small Generator*'s tripping supplies, *protection apparatus* or circuit breaker trip coils required under clause 3.4.10 shall be alarmed within the *Small Generator*'s *facility* and operating procedures put in place to ensure that prompt action is taken to remedy such failures. As an alternative to alarming, *Small Generation Unit* main switches may be tripped automatically.

3.4.11 Commissioning and testing

The *Small Generator* shall comply with the testing and commissioning requirements for *Small Generation Unit*s *connect*ed to the *network* specified in clause 7.

3.4.12 Technical matters to be coordinated

As an alternative to *network augmentation*, the *Network Operator* may require a *Generator* to provide additional *protection scheme*s to ensure that operating limits and agreed import and export limits are not exceeded.

3.5 Requirements for connection of Small Inverter Energy Systems

The *Network Operator* is not able to enter an *energy* buyback agreement directly. A *User* wishing to enter into such an agreement shall apply to a participating retailer. It should also be noted that whereas this clause 3.5 covers *connection* issues for *Small Inverter Energy Systems* of up to 30 kVA, the maximum capacity that a retailer may be prepared to enter into an *energy* buyback agreement may be less than this amount.

3.5.1 Scope

(a) Clause 3.5 addresses the particular requirements for the *connection* of *Small Inverter Energy Systems* to the *Network Operator's low voltage network*.

(b) For similarly rated non-Inverter *Energy* systems, the requirements of clause 3.4 for *Small Generator*s apply.

(c) The scope of clause 3.5 is limited to technical conditions of *connection*.

3.5.2 Relevant standards

(a) The installation of primary *energy* systems shall comply with the relevant *Australian Standard*s and international standards.

(b) Inverter systems shall satisfy the requirements of *Australian Standard* AS 4777 *"*Grid connection of energy systems via inverters*"* as published and revised. The following parts of this standard apply:

(1) AS 4777.1 – 2005 Part 1 Installation requirements.

(2) AS 4777.2 – 2005 Part 2 Inverter requirements.

(3) AS 4777.3 – 2005 Part 3 Grid protection requirements.

(c) The term *'*Inverter *Energy* system*'* in these Rules has the same meaning as in *Australian Standard* AS 4777.

(d) A type-test report or type-test certificate from an independent and recognised certification body showing compliance of inverter *plant* with *Australian Standard* AS 4777.2 (2005) shall be supplied to the *Network Operator*.

(e) Should it be necessary to *change* any parameter of the equipment as installed and contracted, approval shall be sought from the *Network Operator*. Subsequently, the *Network Operator* shall determine whether a revised application is required.

3.5.3 Metering installation

The *User* shall make provision for import and export *metering* in accordance with the requirements of the NT NER Chapter 7A.

3.5.4 Safety

(a) Installations shall comply with the relevant *Australian Standard*s and all statutory requirements including Australian Standards AS/NZS 3000, AS/NZS 5033 and *Power and Water'*s Power Networks Service Rules and Power Networks Installation Rules.

(b) All electrical installation, commissioning and maintenance work wherever required shall be carried out by an electrical contractor licensed under the *Northern Territory Electrical Workers and Contractors Act*, as in force at 4 July 2016.

3.5.5 Security of operational settings

Where operational settings are applied via a keypad or switches, adequate security shall be employed to prevent tampering or inadvertent/unauthorised *change*s to these settings. A suitable lock or password system shall be used. The *Network Operator* shall approve *change*s to settings prior to implementation.

3.5.6 Circuit arrangements

3.5.6.1 Schematic diagram

A durable single sided schematic-wiring diagram of the installation showing all equipment and switches shall be affixed on the site adjacent the inverter system.

3.5.7 Protection

(a) A *Small Inverter Energy System connect*ed to the *network* shall be approved by the *Network Operator* and meet the requirements of relevant standards in accordance with clause 3.5.2 and the following requirements below.

(b) The *User* shall provide the information required by the *Network Operator* prior to approval being given.

3.5.7.1 Islanding *protection*

The islanding function shall be automatic and shall physically remove the *Small Inverter Energy System* from the *network*. The Islanding *protection* shall be capable of detecting loss of *supply* from the *network* and *disconnect* the *Small Inverter Energy System* from the *network* within 2 seconds.

3.5.7.2 *Synchronising*

Connection to the *network* shall be automated. The protective apparatus shall be capable of confirming that the *supply voltage* and *frequency* is within limits for no less than one minute prior to *synchronisation*.

3.5.7.3 Re*connection* to *network*

Re*connection* to the *network* shall be automated. The protective apparatus shall be capable of confirming that the *supply voltage* and *frequency* are within limits for no less than one minute prior to *synchronisation*.

3.5.7.4 Overcurrent *protection*

Overcurrent *protection* shall be provided at the isolating switch of a *Small Inverter Energy System* in accordance with the equipment rating, unless otherwise agreed with the *Network Operator*.

3.5.7.5 *Voltage* limits

(a) The Inverter *voltage* limits shall be set according to equipment capability and *Australian Standard* AS 4777.

(b) The *Small Inverter Energy System* shall remain *connect*ed for *voltage* variations within the limits of Figure 10 unless otherwise agreed with the *Network Operator*. The *network voltage* range is based on 5-minute averages of the RMS value.

Figure 10 - *Low voltage* limits for *Small Inverter Energy Systems*

Nominal *voltage*	Lower limit	Upper limit
230 V	226 V	254 V
400 V	390 V	440 V

(c) The *Network Operator* is not responsible for failure of the *Small Inverter Energy System* to remain *connect*ed for the full range of *voltage* on the *network* set out in Figure 10.

3.5.7.6 *Frequency* limits

(a) The Inverter *frequency* limits shall be set according to the equipment capability and *Australian Standard* AS 4777.

(b) The *Small Inverter Energy System* shall remain *connect*ed for *frequency* variations between 47.5 Hz and 52 Hz unless otherwise agreed with *Network Operator*.

3.5.8 Commissioning and testing

3.5.8.1 Commissioning

(a) Commissioning may occur only after the installation of the *metering equipment*.

(b) In commissioning equipment installed under clause 3.5.8, a *User* shall verify that:

(1) The approved schematic has been checked and accurately reflects the installed electrical system.

(2) All required switches present and operate correctly as per the approved schematic.

(3) Signage and labelling comply with that specified in *Power and Water*'s Service Rules.

(4) The installation is correct and fit for purpose.

(5) Operational settings are secure as specified.

(6) The islanding *protection* operates correctly and *disconnect*s the Inverter *Energy* system from the *network* within 2 seconds.

(7) The delay in re*connection* following restoration of normal *supply* is greater than 1 minute.

(c) Subsequent modifications to the inverter installation shall be submitted to the *Network Operator* for approval.

3.5.8.2 Re-confirmation of correct operation

(a) The *Network Operator* may elect to inspect the proposed *Small Inverter Energy System* from *time* to *time* to ensure continued compliance with these requirements. In the event that the *Network Operator* considers that the installation poses a threat to safety, to *quality of supply* or to the integrity of the *network* it may *disconnect* the generating equipment.

(c) *Small Inverter Energy System protection systems* shall also be tested for correct functioning at regular intervals not exceeding 5 years. The *User* shall arrange for a suitably qualified person to conduct the tests. Results of tests shall be certified by a competent person and supplied to the *Network Operator*.

3.6 Requirements for connection of loads

The following requirements apply to the *connection* of *loads* to *networks*.

(a) These requirements and particular provisions may be waived for smaller *Users* and *Users* that have no potential to affect other *Users*, at the discretion of the *Network Operator*.

(b) Nothing in this clause 3.6 waives the requirements for all installations to comply with the *Network Operator's* Service and Installation Rules, *Metering* Manual, Contractor's Bulletins, and any requirement included in a *connection agreement*.

3.6.1 Connection point for a User

Connection points between a *User's facility* and a *network* will be defined in the *connection agreement*.

3.6.2 Information

Before any new or additional equipment is *connected*, the *User* may be required to submit information to the *Network Operator* in accordance with clause 11.

3.6.3 Design standards

Changes to the *power system* may result in the requirements for *connected* equipment changing. For example, as additional *plant* is *connected* to the *power system* fault levels will increase and the *User's plant* may no longer be suitable for *connection* to the system.

(a) A *User's* installation shall comply with the relevant *Australian Standards* as applicable at the *time*, *good electricity industry practice* and this *Code*, including, but not limited to, the *quality of supply* standards as specified in clause 2.4.

(b) All *plant* ratings shall co-ordinate with the equipment installed on the *Network Operator power system*.

(c) *Users* will be responsible for ensuring that *plant* capabilities and ratings are monitored on an ongoing basis to ensure continued suitability as conditions on the *power system change*.

(d) A *User* will be responsible for the cost of any *plant* upgrades required at its *facilities* as a result of changing *power system* conditions.

(e) If, after installation of a *User's facilities*, it is found that the installation is adversely affecting:

(1) the security or *reliability* of the *power system*;

(2) the *quality of supply*; or

(3) the installation does not comply with the *Code* or the relevant *connection agreement*;

the *User* shall be responsible for remedying the problem at the *User's* cost, and within a *time* frame reasonably required by the *Network Operator*.

3.6.4 Users' protection systems that impact on power system security

(a) Where a *User connection* to the *network* may affect *power system security*, the *protection system*s of the *User's connection* shall comply with the requirements of clause 3.2.3.

(b) *Protection* of the *connection* equipment solely for the *User's* risks is at the *User's* discretion.

3.6.5 Thermal limits

The thermal ratings of the *network* components shall comply with the specifications set out in clause 15.3 of the *Network Planning Criteria*.

3.6.6 Fault limits

The calculated fault levels in the *network*s shall not exceed 95% of the equipment fault ratings set out in clause 15.4 of the *Network Planning Criteria*.

3.6.7 Power factor requirements

The *power factor* of a *load connection* affects the required capacity of the *network* to *supply* the *load* and the management of *voltage* conditions on the *network*.

Power factor improvement may be achieved by installing additional *reactive plant* or reaching a commercial agreement with the *Network Operator* to install, operate and maintain equivalent *reactive plant* as part of *connection asset*s.

(a) *Power factor* ranges to be met by *Users* for their *load*s are shown in Figure 11.

Figure 11 - *Power factor* requirements (*Loads*)

Supply Voltage (nominal)	**Permissible *Power factor* Range** (half-hour average, unless otherwise specified by the *Network Operator*)
132 kV / 66 kV	0.95 lagging to unity
<66 kV	0.9 lagging to 0.9 leading

(b) The *Network Operator* may permit a lower lagging or leading *power factor* where this will not reduce system security and/or *quality of supply*, or require a higher lagging or leading *power factor* to achieve required *power transfer*s.

(c) If the *power factor* falls outside the range in the table over any critical loading period nominated by the *Network Operator*, the *User* shall, where required by the *Network Operator* in order to economically achieve required *power transfer* levels, take action to ensure that the *power factor* falls within range as soon as reasonably practical.

(d) A *User* who installs *static var compensator* systems for either *power factor* or *quality of supply* requirements shall ensure its *control system* does not interfere with other normal control functions on the *electricity network*. Adequate filtering *facilities* shall be provided if reasonably required by the *Network Operator* to absorb any excessive harmonic currents.

4 Power system operation support

This section 4 of the *Network Technical Code* establishes requirements relating to the operation of the electricity network (including the operation of the network in emergency situations). It applies to the *Network Operator* and all *Network Users*.

4.1 [Deleted]

4.2 [Deleted]

4.3 Responsibilities

4.3.1 [Deleted]

4.3.2 Network Operator

(a) The *Network Operator* shall use its reasonable endeavours, including through the provision of appropriate information to *Users* to the extent permitted by law and under this *Code*, to ensure that:

(1) the power system;

(2) *network* equipment;

(3) *network* connections; and

(4) *User* equipment;

are specified, planned and developed in accordance with *power system security* principles and *good electricity industry practice*.

(b) Where an obligation is imposed on the *Network Operator* under this clause of the *Code* to arrange or control any act, matter or thing or to ensure that any other person undertakes or refrains from any act, that obligation is limited to a requirement for the *Network Operator* to use reasonable endeavours, including to give such *direction*s as are within its powers, to comply with that obligation.

(c) If the *Network Operator* fails to arrange or control any act, matter or thing or the acts of any other person notwithstanding the use of the *Network Operator's* reasonable endeavours, the *Network Operator* will not be taken to have breached such obligation.

(d) The *Network Operator* shall make accessible to *Users* such information as:

(1) the *Network Operator* considers appropriate;

(2) the *Network Operator* is permitted to disclose in order to assist *Users* to make appropriate market decisions related to open access to the *Network Operator's network*s; and

(3) the *Network Operator* is able to disclose to enable *Users* to consider initiating procedures to manage the potential risk of any necessary action by the *Network Operator* to restore or maintain *power system security*.

(e) In making information available in accordance with clause 4.3.2(d), the *Network Operator* shall use reasonable endeavours to ensure that such information is available to those *Users* who request the information on an equivalent basis.

(f) In the event that the *Network Operator*, in its reasonable opinion for reasons of safety to the public, the *Network Operator* personnel, *Users'* equipment or the *Network Operator* equipment, needs to interrupt *supply* to any *User*, the *Network Operator* will (*time* permitting) consult with the relevant *User* and as applicable, the *Power System Controller* prior to executing that interruption.

(g) The *Network Operator* in consultation with the *Power System Controller* shall arrange controls, monitoring and secure communication systems which are appropriate in the circumstances to facilitate a manually initiated, rotational *load shedding* and restoration process.

4.3.3 [Deleted]

4.3.4 Users

(a) All *Users* shall co-operate with and assist the *Power System Controller* in the proper discharge of the *Power System Controller's power system security responsibilities*.

(b) All *Users* shall operate their *facilities* and equipment in accordance with any reasonable *direction* given by the *Power System Controller*.

(c) All *Users* shall provide automatic *interruptible load* of the type described in clause 3.2.8. The level of this automatic *interruptible load* will be a minimum of 75% of their expected *demand*, or such other minimum *interruptible load* level as may be periodically determined by the *Network Operator* in accordance with clause 3.2.8.

(d) *Users* shall provide their *interruptible load* in manageable blocks spread over a number of steps within *under frequency* bands from 49.25 Hz down to 48.50 Hz as nominated by the *Power System Controller*.

4.4 [Deleted]

4.5 Voltage control

4.5.1 Network voltage control

(a) The *Network Operator* shall determine the adequacy of the capacity to produce or absorb *reactive power* in the control of the *network voltages*.

(b) The *Network Operator* shall assess and determine the limits of the operation of the *network* associated with the avoidance of *voltage* failure or collapse under *credible contingency event* scenarios.

(c) The limits of operation of the *network* shall be translated by the *Network Operator,* into key location operational *voltage* settings or limits, power line capacity limits, *reactive power* production (or absorption) capacity or other appropriate limits to enable their use by the *Power System Controller* in the maintenance of *power system security*.

(d) The determination referred to in clause 4.5.1(b) shall include a review of the dynamic stability of the *voltage* of the *transmission network*.

(e) The limits determined in paragraph (c) shall be, subject to consultation, included in the System Secure Guidelines.

(f) The *Network Operator* shall use its reasonable endeavours to arrange the provision of *reactive power facilities* and *power system voltage* stabilising *facilities* through:

(1) contractual arrangements for *ancillary services* with appropriate *Users*;

(2) obligations on the part of *Users*; or under their *connection agreements*;

(3) provision of such *facilities* by the *Network Operator*.

(g) Without limitation, such *reactive power facilities* may include:

(1) *synchronous Generator voltage control*s usually associated with *tap-changing transformer*s; or *Generator* AVR set point control (rotor current adjustment);

(2) *synchronous condensers* (compensators);

(3) *static var compensator*s (SVC);

(4) shunt capacitors;

(5) shunt *reactor*s;

(6) series capacitors.

4.5.2 [Deleted]

4.6 Network operations and power system security support

4.6.1 Network operations

(a) [Deleted]

(b) *Users* shall operate their equipment interfacing with the *network* in accordance with the requirements of:

(1) this *Code;*

(2) any applicable *connection agreement* or *ancillary services agreement;*

(3) the requirements of the System Control Technical Code and the *Network Operator's* Electrical Safety Manual; and

(4) the relevant *power system operating procedures*.

(c) *Users* shall ensure that *network* operations performed on their behalf are undertaken by competent persons.

4.6.2 Switching of reactive power facilities

(a) [Deleted]

(b) Where a User and the *Network Operator* have made prior arrangements in relation to matters associated with *power system security* support, the *User* shall use reasonable endeavours to comply with relevant instructions given by the *Network Operator* or its authorised agent.

4.6.3 [Deleted]

4.7 Other system security support measures

4.7.1 [Deleted]

4.7.2 [Deleted]

4.7.3 [Deleted]

4.7.4 [Deleted]

4.7.5 Managing electricity supply shortfall events

(a) If, at any *time*, there are insufficient *supply* options available to securely *supply* total *load* in a *region*, as advised by the *Power System Controller*, the *Network Operator* shall direct a *User* to take such steps as are reasonable to immediately reduce its *load*.

(b) A *User* shall use all reasonable endeavours to comply with a direction given under clause 4.7.5(a).

4.7.6 Directions by the Network Operator

(a) If the *Network Operator,* acting in response to a *direction* from the *Power System Controller*, requires a *User* to do any act or thing which is considered reasonably necessary to ensure the security of the *power system* and compliance with this *Code*, a *User* shall use all reasonable endeavours to comply within a reasonable period of *time* with any such *direction*s given to it by the *Network Operator*.

(b) If a *User* does not comply with a *direction* within a reasonable period of time and as such a *satisfactory operating state* cannot be re-established, the *Network Operator* may *disconnect* the *User* without further recourse.

4.7.7 Disconnection of generating units and/or associated loads

(a) Where, under this *Code* or the relevant *connection agreement* the *Network Operator* has the authority or responsibility to *disconnect* either a *generating unit* or its *associated load*, then it may do so as described in clause 8.

(b) The relevant *User* and *associated load* shall provide all reasonable assistance to the *Network Operator* for the purpose of such *disconnection*.

4.7.8 Emergency black start-up facilities

Generator Users shall ensure they have sufficient *facilities* available and operable for their own black start-up requirements.

4.7.9 [Deleted]

4.7.10 Black system start-up

If a *User* is providing *black start-up facilities* under an *ancillary services agreement* with another *User*, then the *local black system procedures* for that *User* shall be consistent with this *Code* and their *connection agreement*.

4.7.11 [Deleted]

4.8 Agent communications

(a) A *User* may appoint an agent (called a *"User* Agent*"*) to coordinate operations of one or more of its *facilities* on its behalf, but only with the prior written consent of the *Power System Controller*.

(b) A *User* who has appointed a *User* Agent may replace that *User* Agent but only with the prior written advice to and consent of the *Power System Controller*.

(c) The *Power System Controller* may only withhold its consent to the appointment of a *User* Agent under clause 4.8(a), if it reasonably believes that the relevant person is not suitably qualified or experienced to operate the relevant *facility* at the interface with a *network*.

(d) For the purposes of this *Code* and any applicable *connection agreement,* acts or omissions of a *User* Agent are deemed to be acts or omissions of the relevant *User*.

(e) The *Power System Controller* and its *representative*s (including authorised agents) may:

(1) rely upon any communications given by a *User* Agent as being given by the relevant *User*; and

(2) rely upon any communications given to a *User* Agent as having been given to the relevant *User*.

(f) The *Power System Controller* is not required to consider whether any instruction has been given to a *User* Agent by the relevant *User* or the terms of those instructions.

4.9 Nomenclature standards

The *Network Operator* and *Users* are to comply with clause 6.14 of the SCTC in regard to nomenclature standards.

5 Testing of *plant* and equipment

The testing of *plant* and equipment is required before *connection* to the *network* and periodically thereafter to ensure that the *network* and *connection*s can continue to operate within the parameters of the *network* performance standards set out in clause 2 and that equipment meets the requirements to be *connect*ed to the *network* set out in clause 3.

5.1 Obligations to test plant or equipment

5.1.1 Network Operator obligations

(a) The *Network Operator* shall arrange, co-ordinate and supervise the conduct of such appropriate tests as may be necessary to ensure that:

(1) the equipment at new *connection*s to the *network* meets the requirements set out in clause 3.

(2) the *protection* of the *network* is adequate to protect against damage to *power system plant* and equipment. Such tests shall be performed according to the requirements of clause 5.2.

(3) the *power system* capability and performance is adequate to meet forecast operating conditions and power flows, as set out in clause 5.5.

(4) adequate *reactive power* devices are provided and available to control and maintain *power system voltage*s under both *satisfactory operating state* and *contingency event* conditions;

(5) adequate devices are installed and available to maintain *power system* stability.

(6) *Users* continue to comply with the conditions set out in *connection agreements* and that all *Users' connection* equipment meets the requirements to set out in clause 3 and 5.4.

(7) the testing of *metering* installations is carried out in accordance with the NT NER.

5.1.2 Network Users' obligations

(a) All *Network Users* shall cooperate to permit the testing of their *connection* equipment as required under clause 5.1.1.

(b) A *Generator* shall provide evidence that each *generating unit* complies with the technical requirements of clause 3.3 and the relevant *connection agreement* as required by clause 5.4

5.2 Routine testing of protection equipment

(a) Subject to clause 3.2.3.10, a *User* shall cooperate with the *Network Operator* to test the operation of equipment forming part of a *protection scheme* relating to a *connection point* at which that *User* is *connect*ed to a *network* and the *User* shall conduct these tests:

(1) prior to the *plant* at the relevant *connection point* being placed in service; and

(2) at intervals specified in the *connection agreement* or in accordance with an asset management plan agreed between the *Network Operator* and the *User*.

(b) A *User* shall, on request from the *Network Operator,* demonstrate to the *Network Operator's* satisfaction the correct calibration and operation of the *User'* s protective devices.

(c) Each *User* shall pay the *Network Operator's* reasonable costs and shall bear its own costs of conducting tests under this clause 5.2.

5.3 Testing by Users of their own plant requiring changes to agreed operation

(a) A *User* proposing to conduct a test on equipment related to a *connection point*, which requires a *change* to the operation of that equipment as specified in the *connection agreement*, shall give notice in writing to the *Network Operator* of at least 15 *business day*s except in an emergency.

(b) The notice to be provided under clause 5.3(a) is to include:

(1) the nature of the proposed test;

(2) the estimated, start and finish *time* for the proposed test;

(3) the identity of the equipment to be tested;

(4) the *power system* conditions required for the conduct of the proposed test;

(5) details of any potential adverse consequences of the proposed test on the equipment to be tested;

(6) details of any potential adverse consequences of the proposed test on the *power system*; and

(7) the name of the person responsible for the coordination of the proposed test on behalf of the *Users*.

(c) The *Network Operator* shall review the proposed test to determine whether the test:

(1) could adversely affect the normal operation of the *power system*;

(2) could cause a threat to *power system security*;

(3) requires the *power system* to be operated in a particular way which differs from the way in which the *power system* is normally operated; or

(4) could affect the normal *metering* of *energy* at a *connection point*;

(d) If, in the *Network Operator's* reasonable opinion, a test could threaten public safety, damage or threaten to damage equipment or adversely affect the operation of the *power system*, the *Network Operator* may direct that the proposed test procedure be modified or that the test not be conducted at the *time* proposed.

(e) The *Network Operator* shall advise any other *User* who will be adversely affected by a proposed test and consider any reasonable requirements of those *Users* when approving the proposed test.

(f) The *User* who conducts a test under this clause 5.3 shall ensure that the person responsible for the coordination of a test promptly advises *Network Operator* when the test is complete.

(g) If the *Network Operator* approves a proposed test, the *Network Operator* shall use its reasonable endeavours to ensure that *power system* conditions reasonably required for that test are provided as close as is reasonably practical to the proposed start *time* of the test and continue for the proposed duration of the test.

(h) Within a reasonable period after any such test has been conducted, the *User* who has conducted a test under this clause 5.3 shall provide the *Network Operator* with a report in relation to that test including test results where appropriate.

5.4 Tests to demonstrate Generator compliance

(a) Each *User* shall provide evidence to the *Network Operator* that each of its *generating units* complies with the technical requirements of clause 3.3 and the relevant *connection agreement*.

(b) Each *User* shall provide facilities to carry out *power system* tests prior to commercial operation in order to verify acceptable performance of each *generating unit*, and provide information and data necessary for computer model validation. These test requirements are detailed in Attachment 5.

(c) Other tests, if reasonably necessary, may be specified by the *Network Operator,* and *Users* will be advised accordingly.

(d) Each *User* shall negotiate in good faith with the *Network Operator* to agree on a compliance monitoring program, including an agreed method, for each of its *generating units* to confirm ongoing compliance with the applicable technical requirements of clause 3.3 and the relevant *connection agreement*.

(e) If a performance test or monitoring of in-service performance demonstrates that a *generating unit* is not complying with one or more technical requirements of clause 3.3 and the relevant *connection agreement* then the *User* shall:

(1) promptly notify the *Network Operator* of that fact; and

(2) promptly advise the *Network Operator* of the remedial steps it proposes to take and the *time*table for such remedial work; and

(3) diligently undertake such remedial work and report at *month*ly intervals to the *Network Operator* on progress in implementing the remedial action; and

(4) conduct further tests or monitoring on completion of the remedial work to confirm compliance with the relevant technical requirement.

(f) From the *Code commencement date* or from the date of access, whichever is the later, Each *User* shall maintain records and retain them for a minimum of 7 years (from the date of creation of each record) for each of its *generating units* and *power stations* setting out details of the results of all technical performance and monitoring conducted under this clause 5.4 and make these records available to *Network Operator* on request.

5.4.1 Tests of generating units requiring changes to agreed operation

(a) The *Network Operator* may, at intervals of not less than 12 *month*s per *generating unit*, require the testing by a *User* of any *generating unit connect*ed to the *network* of the *Network Operator* in order to determine analytic parameters for modelling purposes or to assess the performance of the relevant *generating unit*. The *Network Operator* is entitled to witness such tests and the *Network Operator* shall have reasonable grounds for requiring such tests.

(b) Adequate notice of not less than 15 *business day*s shall be given by the *Network Operator* to the *User* before the proposed date of a test under clause 5.4.1(a).

(c) The *Network Operator* shall use its reasonable endeavours to ensure that tests permitted under this clause 5.4.1 are to be conducted at a *time* which will minimise the departure from the *commitment* that is due to take place at that *time*.

(d) If not possible beforehand, a *User* shall conduct a test under this clause 5.4.1 at the next scheduled *outage* of the relevant *generating unit* and in any event within 9 *month*s of the request.

(e) A *User* shall provide any reasonable assistance requested by the *Network Operator* in relation to the conduct of tests.

(f) Tests conducted under this clause 5.4.1 shall be conducted in accordance with test procedures agreed between the *Network Operator* and the relevant *User, who* shall not unreasonably withhold agreement to the test procedures proposed for this purpose by the *Network Operator*.

(g) The *Network Operator* shall provide to a *User* such details of the analytic parameters of the model derived from the tests referred to in this clause 5.4.1

for any of that *User's generating units* as may reasonably be requested by the *User*.

(h) Each *User* shall bear its own costs associated with tests conducted under this clause 5.4.1 and no compensation is to be payable for financial losses incurred as a result of these tests or associated activities.

5.5 Power system tests

(a) Tests conducted for the purpose of either verifying the magnitude of the *power transfer capability* of *network*s or investigating *power system* performance shall be coordinated and approved by the *Network Operator*. The *Network Operator* or a *User* requesting such tests shall have reasonable grounds for requiring such tests.

(b) The tests described in clause 5.5(a) may be conducted whenever:

(1) a new *generating unit* or *facility* of a *customer*, *User* or a *network* development is commissioned that is calculated or anticipated to substantially alter *power transfer capability* through the *network*;

(2) setting *change*s are made to any *governor system* and *excitation control system*, including *power system stabiliser*s; or

(3) a test is required to verify the performance of the *power system* or to validate computer models.

(c) The *Network Operator* shall notify all *Users* who could reasonably be expected to be affected by the proposed test at least 15 *business day*s before any test under this clause 5.5 may proceed and to consider any reasonable requirements of those *Users* when approving the proposed test.

(d) Operational conditions for each test shall be arranged by the *Network Operator* and the test procedures shall be coordinated by an officer nominated by the *Network Operator* who has authority to stop the test or any part of it or vary the procedure within pre-approved guidelines if it considers any of these actions to be reasonably necessary.

(e) Each *User* shall cooperate with the *Network Operator* when required in planning, preparing for and conducting *network* tests to assess the technical performance of the *network*s and if necessary conduct co-ordinated activities to prepare for *power system* wide testing or individual, on-site tests of the *User's facilities* or *plant*, including *disconnection* of a *generating unit*.

(f) The *Network Operator* may direct operation of *generating units* by *Users* during *power system* tests if this is necessary to achieve operational conditions on the *network*s that are reasonably required to achieve valid test results.

(g) The *Network Operator* shall plan the timing of tests so that the variation from *dispatch* that would otherwise occur is minimised and the duration of the tests is as short as possible consistent with test requirements and *power system security*.

(h) Each *User* is to bear its own costs of conducting tests under this clause 5.5 and no compensation is to be payable for financial losses incurred as a result of these tests or associated activities.

(i) If the *Network Operator* has initiated the tests as part of a series of periodic *power system* performance assessment studies, then the costs of the studies will be borne by the *Network Operator*. If the tests demonstrate the need for a *User* to install additional equipment in order to maintain or enhance *power system* performance in accordance with this *Code*, then the *User* will be responsible for the cost of installing the additional equipment.

5.6 Compliance with the Network Technical Code

5.6.1 Right of inspection and testing

(a) If the *Network Operator* has reasonable grounds to believe that equipment owned or operated by a *User* may not comply with this *Code* or the *connection agreement*, the *Network Operator* may require testing of the relevant equipment by giving notice in writing to the *User*.

(b) If a notice is given under clause 5.6.1(a) the relevant test is to be conducted at a *time* agreed by the *Network Operator*.

(c) The *User* who receives a notice under clause 5.6.1(a) shall co-operate in relation to conducting tests requested under clause 5.6.1(a).

(d) The cost of tests requested under clause 5.6.1(a) shall be borne by the *Network Operator,* unless the equipment is determined by the tests not to comply with the relevant *connection agreement*, and/or this *Code* in which case all reasonable costs of such tests shall be borne by the owner of that equipment.

(e) Tests conducted in respect of a *connection point* under this clause 5.6.1 shall be conducted using test procedures agreed between the relevant *User*, which agreement is not to be unreasonably withheld or delayed.

(f) Tests under this clause 5.6.1 shall be conducted only by persons with the relevant skills and experience.

(g) If the *Network Operator* requests a test under this clause 5.6.1, the *Network Operator* may appoint a *representative* to witness a test and the relevant *User* shall permit a *representative* appointed under this clause 5.6.1(g) to be present while the test is being conducted.

(h) Subject to clause 5.6.1(i), a *User* who conducts a test shall submit a report to the *Network Operator* within a reasonable period after the completion of the test and the report is to outline relevant details of the tests conducted, including but not limited to the results of those tests.

(i) If a performance test or monitoring of in-service performance demonstrates that equipment owned or operated by a *User* does not comply with this *Code* or the relevant *connection agreement* then the *User* shall:

(1) promptly notify the *Network Operator* of that fact; and

(2) promptly advise the *Network Operator* of the remedial steps it proposes to take and the *time*table for such remedial work; and

(3) diligently undertake such remedial work and report at *month*ly intervals to the *Network Operator* on progress in implementing the remedial action; and

(4) conduct further tests or monitoring on completion of the remedial work to confirm compliance with the relevant technical requirement.

(j) The *Network Operator* may attach test equipment or *monitoring equipment* to *plant* owned by a *User* or require a *User* to attach such test equipment or *monitoring equipment*, subject to the provisions of clause 5.7.1 regarding entry and inspection.

(k) In carrying out monitoring under clause 5.6.1 (j), the *Network Operator* shall not cause the performance of the monitored *plant* to be *constrained* in any way.

5.6.2 Generator compliance with the Code

(a) If the *Network Operator* reasonably believes that a *Generator* is not complying with one or more technical requirements of clause 3.3 and the relevant *connection agreement*, the *Network Operator* may instruct the *User* to conduct tests within 25 *business day*s to demonstrate that the relevant *generating unit* complies with those technical requirements.

(b) If the tests provide evidence that the relevant *generating unit* continues to comply with the technical requirement(s) *Network Operator* shall reimburse the *User* for the reasonable expenses incurred as a direct result of conducting the tests.

(c) If the *Network Operator*:

(1) is satisfied that a *generating unit* does not comply with one or more technical requirements; and

(2) does not have evidence demonstrating that a *generating unit* complies with the technical requirements set out in clause 3.3; or

(3) holds the reasonable opinion that there is or could be a threat to *power system security*,

the *Network Operator* may direct the relevant *User* to operate the relevant *generating unit* at a particular *generated* output or in a particular mode until the relevant *User* submits evidence reasonably satisfactory to the *Network Operator* that the *generating unit* is complying with the relevant technical requirement.

(d) A *direction* under clause 5.6.2(c) shall be recorded by the *Network Operator*.

5.7 Inspection of plant and equipment

5.7.1 Right of entry and inspection

(a) The *Network Operator* or any of its *representative*s (including authorised agents) may, in accordance with this clause 5.7.1, inspect a *facility* of a *User* and the operation and maintenance of that *facility* in order to:

(1) assess compliance by the relevant *User* with its operational obligations under this *Code*, or a *connection agreement*, or an *ancillary services agreement*; or

(2) investigate any possible past or potential threat to *power system security*; or

(3) conduct any periodic familiarisation or training associated with the operational requirements of the *facility*.

(b) If the *Network Operator* wishes to inspect the *facilities* of a *User* under clause 5.7.1(a), the *Network Operator* shall give that *User* at least 2 *business day*s' notice in writing of its intention to carry out an inspection. In the case of an emergency condition affecting the *power system* which the *Network Operator* reasonably considers requires access to the *User's facility*, prior notice is not required, however, the *Network Operator* shall notify the *User* as soon as practical after deciding to enter the *User's facility* of the nature and extent of the *Network Operator's* activities at the *User's facility*.

(c) A notice given under clause 5.7.1(b) shall include the following information:

(1) the name of the *representative* who will be conducting the inspection on behalf of the *Network Operator;*

(2) subject to clause 5.7.1(h), the *time* when the inspection will commence and the expected *time* when the inspection will conclude; and

(3) if associated with clause 5.7.1(a)(1) then the nature of the suspected non-compliance with the *Code* or *connection agreement* or *ancillary services agreement*, or if associated with clauses 5.7.1(a)(2) or 5.7.1(a)(3) then the relevant reasons for the inspection.

(d) The *Network Operator* may not carry out an inspection under clause 5.7.1 within 6 *month*s of any previous inspection except for the purpose of verifying the performance of corrective action claimed to have been carried out in respect of a non-conformance observed and documented on the previous inspection or for the purpose of investigating an operating incident in accordance with the NT NER .

(e) At any *time* when the *representative* of the *Network Operator* is in a *Users' facility*, that *representative* shall:

(1) cause no damage to the *facility*;

(2) only interfere with the operation of the *facility* to the extent reasonably necessary and approved by the relevant *User* (such approval not to be unreasonably withheld or delayed);

(3) observe *"*permit to test*"* access to sites and clearance protocols of the operator of the *facility*, provided that these are not used by the *facility* solely to delay the granting of access to site and inspection;

(4) observe the requirements of the operator of the *facility* in relation to occupational health and safety and industrial relations matters, which requirements are of general application to all invitees entering on or into the *facility*, provided that these are not used by the *facility* solely to delay the granting of access to site and inspection; and

(5) not ask any question other than as reasonably necessary for the purpose of such inspection or give any *direction*, instruction or advice to any person involved in the operation or maintenance of the *facility* other than the operator of the *facility* or unless approved by the operator of the *facility*.

(f) Any *representative* of the *Network Operator* conducting an inspection under this clause 5.7.1 shall be appropriately qualified and experienced to perform the relevant inspection. If so requested by the *User*, the *Network Operator* shall procure that a *representative* of *Network Operator* (other than an employee) gaining access under this *Code* or an *connection agreement* enters into a confidentiality undertaking in favour of the *User* in a form reasonably acceptable to the *User* prior to gaining such access.

(g) The costs of inspections under this clause 5.7.1 shall be borne by the *User* if the suspected non-compliance is later proved by tests.

(h) Any inspection under clause 5.7.1(a) shall not take longer than one *day* unless the *Network Operator* seeks approval from the *User* for an extension of *time* (such approval not to be unreasonably withheld or delayed).

(i) Any equipment or goods installed or left on land or in premises of a *User* after an inspection conducted under this clause 5.7.1 do not become the property of the relevant *User* (notwithstanding that they may be annexed or affixed to the relevant land or premises).

(j) In respect of any equipment or goods left on land or premises of a *User* during or after an inspection, a *User*:

(1) shall not use any such equipment or goods for a purpose other than as contemplated in this *Code* without the prior written approval of the owner of the equipment or goods;

(2) shall allow the owner of any such equipment or goods to remove any such equipment or goods in whole or in part at a *time* agreed with the relevant *User* with such agreement not to be unreasonably withheld or delayed;

(3) shall not create or cause to be created any mortgage, charge or lien over any such equipment or goods; and

(4) shall reimburse the owner of any such equipment or goods for reasonable costs and expenses suffered or incurred by the owner due to loss or damage to any such equipment or goods caused by the *User*.

6 Control and *protection* settings

6.1 *Protection* of *power system* equipment

It is important to note that the requirements of this clause 6 are designed to adequately protect the *Network Operator's power system*. The requirements are not necessarily adequate to protect *Users' plant* and equipment.

6.1.1 Scope

(a) The requirements of clause 6.1 apply only to a *User's protection*, which is necessary to maintain *power system security*.

(b) *Users' protection schemes* shall be located on *Users'* equipment.

(c) *Protection* installed solely to cover risks associated with a *User's plant* and equipment is at the *User's* discretion.

(d) The extent of a *User's plant* and equipment that will need to conform to the requirements of clause 6.1 will vary from installation to installation.

(e) The *Network Operator* will assess each *User's* installation individually. *Users* will be advised accordingly.

6.1.2 Power system fault levels

(a) The *Network Operator* shall determine the fault levels at all *busbar*s of the *Network Operator's network* as described in clause 6.1.2(b);

(b) The *Network Operator* shall ensure that there is information available about the *network* that will allow the determination of fault levels for normal operation of the *power system*. The *Network Operator* will make available on request the *credible contingency event*s which the *Network Operator* considers may affect the configuration of the *power system* so that the *Network Operator* and *Users* can identify their *busbar*s which could potentially be exposed to a fault level which exceeds the fault *current rating*s of the circuit breakers and other equipment associated with that *busbar*.

6.1.3 Power system protection co-ordination

The *Network Operator* shall use its reasonable endeavours to co-ordinate the *protection* settings for equipment *connect*ed to the *network*. *Users* with *protection system*s that impact *power system security* and *reliability* shall ensure their settings co-ordinate with the *Network Operator's protection*. Such *Users* may not adjust settings without the *Network Operator's* approval. Specific requirements are described in clauses 6.1.6.4 and 11.2.2.

6.1.4 Short-term thermal ratings of the power system

(a) The *Network Operator* may act so as to use, or require or recommend actions which use the full extent of the thermal ratings of *network* elements to maintain *power system security*, including the short-term ratings (being *time* dependent ratings), as defined by the *Network Operator* from *time* to *time*.

(b) The *Power System Controller* shall use its reasonable endeavours not to exceed the *network* element ratings and not to require or recommend action that causes those ratings to be exceeded.

6.1.5 Availability of protection

(a) All elements of *protection scheme*s, including *backup protection* and associated intertripping, shall be maintained so as to be available for service at all *time*s.

(b) For maintenance or repair purposes, one *protection scheme* forming part of a *protection system* can be taken out of service for period of up to 24 hours every 6 *month*s.

(c) At the discretion of the *Network* Controller, longer periods of unavailability may require the associated *primary plant* to be taken out of service in accordance with clause 6.1.6.

(d) Except in an emergency, a *User* shall notify the *Network Operator* at least 5 *business day*s prior to taking a *protection scheme* out of service.

6.1.6 Partial outage of power protection systems

(a) Where there is an *outage* of one *protection* of a *network* element, the *Power System Controller* shall determine, the most appropriate action. Depending on the circumstances the determination may be:

(1) to leave the *network* element in service for a limited duration;

(2) to take the *network* element out of service immediately;

(3) to install or direct installation of a temporary *protection*;

(4) to accept a degraded performance from the *protection*, with or without additional operational measures or temporary *protection* measures to minimise *power system* impact; or

(5) to operate the *network* element at a lower capacity.

(b) If there is an *outage* of both *protection scheme*s on a *network* element and the *Power System Controller* determines this to be an unacceptable risk to *power system security*, the *Power System Controller* shall take the *network* element out of service as soon as possible and advise any affected *User* immediately this action is undertaken.

(c) Any affected *User* shall accept a determination made by the *Network Operator* under this clause 6.1.6.

6.1.6.1 *Sensitivity* of *protection*

(a) All *protection scheme*s shall have sufficient *sensitivity* to detect and correctly clear all *primary plant* faults within their intended normal operating zones, under both normal and *minimum system conditions*.

(b) *Protection scheme*s shall discriminate with the *Network Operator's protection*.

(c) Under abnormal *plant* conditions, all primary system faults shall be detected and cleared by at least one *protection scheme* on the *User's* equipment. *Remote backup protection* or standby *protection* may be used for this purpose.

(d) The *protection* will be considered to have sufficient *sensitivity* if it will detect and correctly clear a fault when there is half the fault current that will flow for the above conditions.

(e) In rural areas where the earth return impedance is high, sensitive earth fault *protection* may also be required, in addition to the above backup and primary *protection*.

6.1.6.2 Clearance of *small zone fault*s

*Small zone fault*s shall be detected and cleared by *backup protection* as specified in clause3.2.3.6.

6.1.6.3 Clearance of faults under circuit breaker fail conditions

Failure of a circuit breaker, due to either a mechanical or electrical fault, to clear a fault shall, when reasonably required by the *Network Operator*, be detected and the primary fault current shall be cleared by *backup protection* as specified in the clause 3.2.3.6.

6.1.6.4 Details of proposed *Users' protection* settings

Unless agreed otherwise, *Users* shall provide the *Network Operator* with full details of proposed *protection* settings and setting calculations on all *plant* that may impact on the *Network Operator's power system* a minimum of 65 *business day*s prior to *energisation* of the protected *primary plant*. Refer to clause 7.1.3.

6.1.6.5 Coordination of *protection* settings

(a) The *User* shall ensure that all their *protection* settings coordinate with existing *Network Operator protection* settings. Where this is not possible, the *User* will be responsible for the cost of revising *Network Operator* settings and upgrading *Network Operator* or other *Users'* equipment, where required.

(b) Generally, *Network Operator protection* which discriminates on the basis of *time* employs devices with standard inverse characteristics to BS EN 60255-6:1995 with a 3 second curve at 10 times current and *time* multiplier of 1.0.

Note that this is the specification of the characteristic rather than the device setting. Distance relay Zone 2 *time* is generally set to 400 msec and Zone 3 *time* to 1000 msec.

(c) Specific details of *Network Operator protection* are available on request.

6.2 *Power system* stability co-ordination

(a) The *Network Operator* shall use its reasonable endeavours to ensure that all necessary calculations associated with the stable operation of the *power system* as described in clause 2.6 and for the determination of settings of equipment used to maintain that stability are carried out and to co-ordinate these calculations and determinations.

(b) The *Network Operator* shall facilitate establishment of the parameters and endorse the installation of *power system* devices that are approved by the *Network Operator* to be necessary to assist the stable operation of the *power system*.

7 Commissioning and testing procedures

7.1 Commissioning

7.1.1 Requirement to inspect and test equipment

(a) A *User* shall ensure that any of its new or replacement equipment is inspected and tested to demonstrate that it complies with relevant *Australian Standard*s, relevant international standards, this *Code* and any relevant *connection agreement* prior to or within an agreed *time* after being *connect*ed to a *network*, and the *Network Operator* is entitled to witness such inspections and tests.

(b) The *User* shall produce test certificates on request by the *Network Operator* showing that the equipment has passed the tests and complies with the standards set out in clause 7.1.1(a) before *connection* to the *power system*, or within an agreed *time* thereafter.

7.1.2 Co-ordination during commissioning

A *User* seeking to *connect* to a *network* shall cooperate with the *Network Operator* to develop procedures to ensure that the commissioning of the *connection* and *connect*ed *facility* is carried out in a manner that:

(a) Does not adversely affect other *Users* or affect *power system security* or *quality of supply* of the *power system*; and

(b) Minimises the threat of damage to any other *Users'* equipment.

7.1.3 Control and protection settings for equipment

(a) Not less than 65 *business day*s prior to the proposed commencement of commissioning of any new or replacement equipment that could reasonably be expected to alter performance of the *power system*, the *User* shall submit to the *Network Operator* sufficient design information including proposed parameter settings to allow critical assessment including analytical modelling of the effect of the new or replacement equipment on the performance of the *power system*.

(b) The *Network Operator* shall:

(1) consult with other *Users* as appropriate; and

(2) within 20 *business day*s of receipt of the design information under clause 7.1.3(a), notify the *User* of any comments on the proposed parameter settings for the new or replacement equipment.

(c) If the *Network Operator's* comments include alternative parameter settings for the new or replacement equipment, then the *User* shall notify the *Network Operator* within 20 *business day*s that it either accepts or disagrees with the alternative parameter settings suggested by the *Network Operator*.

(d) The *Network Operator* and the *User* shall negotiate parameter settings that are acceptable to them both.

(e) The *User* and the *Network Operator* shall co-operate with each other to ensure that adequate grading of *protection* is achieved so that faults within the *User's facility* are cleared without adverse effects on the *power system*.

(f) The *User* shall pay the *Network Operator's* reasonable costs associated with the assessment of the parameter settings under this clause 7.1.3.

7.1.4 Commissioning program

(a) Not less than 65 *business day*s prior to the proposed commencement of commissioning by a *User* of any new or replacement equipment that could reasonably be expected to alter performance of the *power system*, the *User* shall advise the *Network Operator* in writing of the commissioning program including test procedures and proposed test equipment to be used in the commissioning.

(b) The *Network Operator* shall, within 20 *business day*s of receipt of such advice under clause 7.1.4(a), notify the *User* either that it:

(1) agrees with the proposed commissioning program and test procedures; or

(2) requires *change*s in the interest of maintaining *power system security*, safety or *quality of supply*.

(c) If the *Network Operator* requires *change*s, then the parties shall co-operate to reach agreement and finalise the commissioning program within a reasonable period.

(d) A *User* shall not commence the commissioning until the commissioning program has been finalised and the *Network Operator* shall not unreasonably delay finalising a commissioning program.

(e) The *User* shall pay the *Network Operator's* reasonable costs associated with the assessment of the commissioning program under this clause 7.1.4.

7.1.5 Commissioning tests

(a) The *Network Operator* has the right to witness commissioning tests relating to new or replacement equipment that could reasonably be expected to alter performance of the *power system* or the accurate *metering* of *energy*, including SCADA equipment.

(b) Prior to *connection* to the *Network Operator's power system*, the *User* shall have provided to the *Network Operator* a signed written statement to certify that the equipment to be *connect*ed has been installed in accordance with:

(1) this *Code*;

(2) the relevant *connection agreement*;

(3) all relevant standards;

(4) all statutory requirements; and

(5) *good electricity industry practice*.

(c) The statement shall have been certified by a professional engineer, as approved by the *Network Operator*.

(d) The *Network Operator* shall, within a reasonable period of receiving advice of commissioning tests, notify the *User* whose new or replacement equipment is to be tested under this clause 7.1.5 whether or not it:

(1) wishes to witness the commissioning tests; and

(2) agrees with the proposed commissioning times.

(e) A *User* whose new or replacement equipment is tested under this clause 7.1.5 shall submit to the *Network Operator* the commissioning test results demonstrating that a new or replacement item of equipment complies with this *Code* or the relevant *connection agreement* or both to the satisfaction of the *Network Operator*.

(f) If the commissioning tests conducted in relation to a new or replacement item of equipment demonstrates non-compliance with one or more requirements of this *Code* or the relevant *connection agreement* then the *User* whose new or replacement equipment was tested under this clause7.1.5 shall promptly meet with the *Network Operator* to agree on a process aimed at achievement of compliance of the relevant item with this *Code*.

(g) The *Network Operator* may direct that the commissioning and subsequent *connection* of the *User's* equipment should not proceed if the relevant equipment does not meet the technical requirements specified in clause 7.1.1.

(h) All commissioning and testing of *User* owned equipment shall be carried out by personnel experienced in the commissioning of *power system primary plant* and *secondary plant*.

(i) The *User* shall pay the *Network Operator's* reasonable costs associated with the witnessing of commissioning tests under this clause 7.1.5.

7.1.5.1 Commissioning of *protection*

(a) The *Network Operator reserve*s the right to witness the commissioning tests on any of the *User's protection* that it deems to be important or critical for the *reliable* operation and integrity of the *Network Operator power system*.

(b) The *User* shall pay *Network Operator's* reasonable costs associated with the witnessing of the commissioning tests.

(c) All commissioning and testing of *User* owned *protection* shall be carried out by personnel suitably qualified and experienced in the commissioning, testing and maintenance of *primary plant* and *secondary plant* and equipment.

8 Disconnection and reconnection of plant and equipment

8.1.1 Voluntary disconnection

(a) Unless agreed otherwise and specified in a *connection agreement*, a *User* shall give to the *Network Operator* notice in writing of its intention to permanently *disconnect* a *facility* from a *connection point*.

(b) A *User* is entitled, subject to the terms of the relevant *connection agreement*, to require voluntary permanent *disconnection* of its equipment from the *power system* in which case appropriate operating procedures necessary to ensure that the *disconnection* will not threaten *power system security* shall be implemented in accordance with clause 8.1.2.

(c) The *User* shall pay all costs directly attributable to the voluntary *disconnection* and *decommission*ing.

8.1.2 Decommissioning procedures

(a) In the event that a *User's facility* is to be permanently *disconnect*ed from the *power system*, whether in accordance with clause 8.1.1 or otherwise, the *Network Operator* and the *User* shall, prior to such *disconnection* occurring, follow agreed procedures for *disconnection*.

(b) The *Network Operator* shall notify other *Users* if it believes, in its reasonable opinion, the terms and conditions of such a *connection agreement* will be affected by procedures for *disconnection* or proposed procedures agreed with any other *Users* The parties shall negotiate any amendments to the procedures for *disconnection* or the *connection agreement* that may be required.

(c) Any *disconnection* procedures agreed to or determined under clause 8.1.2(a) shall be followed by the *Network Operator* and all *Users*.

8.1.3 Involuntary disconnection (refer also to clause 4.7)

(a) The *Network Operator* may *disconnect* a *User's facilities* from a *network*:

(1) during an emergency in accordance with clause 8.1.5;

(2) in accordance with relevant laws; or

(3) in accordance with the provisions of the *User's connection agreement*.

(b) In all cases of *disconnection* by the *Network Operator* during an emergency in accordance with clause 8.1.5, the *Network Operator* is required to undertake a review and the *Network Operator* shall then provide a report to the *User* advising of the circumstances requiring such action.

8.1.4 Disconnection due to breach of a connection agreement

(a) Subject to the relevant provisions the *Network Operator* may *disconnect* a *User's facilities* from a *network* if in the *Network Operator's* reasonable opinion, the *User* has breached a term of the *connection agreement* and such breach poses a threat to *power system security*. In such circumstances the *Network Operator* will not be liable in any way for any loss or damage suffered or incurred by the *User* by reason of the *disconnection* and the *Network Operator* will not be obliged for the duration of the *disconnection* to fulfil any agreement to convey electricity to or from the *User's facility*.

(b) A *User* shall not bring proceedings against the *Network Operator* to seek to recover any amount for any loss or damage described in clause 8.1.4(a).

(c) A *User* whose *facilities* have been *disconnect*ed under this clause 8.1.4 shall pay charges in accordance with the *Network* Pricing and Charges Schedule as if any *disconnection* had not occurred.

8.1.5 Disconnection during an emergency

Where the *Network Operator* may *disconnect* a *User's facilities* during an emergency under this *Code* or otherwise, then the *Network Operator* may:

(a) Request the relevant *User* to reduce the *power transfer* at the proposed point of *disconnection* to zero in an orderly manner and then *disconnect* the *User's facility* by automatic or manual means; or

(b) Immediately *disconnect* the *User's facilities* by automatic or manual means where, in the *Network Operator's* reasonable opinion, it is not appropriate to follow the procedure set out in clause 8.1.5(a) because action is urgently required as a result of a threat to safety of persons, hazard to equipment or a threat to *power system security*.

8.1.6 Obligation to reconnect

The *Network Operator* shall re*connect* a *User's facilities* to a *network* at a reasonable cost to the *User* as soon as practical if:

(a) *Disconnection* of the *User* during an emergency has taken place in accordance with clause 8.1.5.

(b) A breach of this *Code* or *connection agreement* giving rise to *disconnection* has been remedied; or

(c) Where the breach is not capable of remedy, compensation has been agreed and paid by the *User* to the affected parties or, failing agreement, the amount of compensation payable has been determined in accordance with the dispute resolution process described in clause 1.6 and that amount has been paid; or

(d) Where the breach is not capable of remedy and the amount of compensation has not been agreed or determined, assurances for the payment of reasonable compensation have been given to the satisfaction of the *Network Operator* and the parties affected; or

(e) The *User* has taken all necessary steps to prevent the re-occurrence of the breach and has delivered binding undertakings to the *Network Operator* that the breach will not reoccur.

9 Operation of *Generator*s *connect*ed to the *network*

9.1 *Power system security* related market operations

9.1.1 Dispatch related limitations

A *User* shall not, unless in the *User's* reasonable opinion public safety would otherwise be threatened or there would be a material risk of damaging equipment or the environment:

(a) *Dispatch* any *energy* from a *generating unit* except:

(1) in accordance with the procedures specified in this *Code* and its Technical Requirements for *connection*; or

(2) in accordance with an instruction from the *Power System Controller*; or

(3) as a consequence of operation of the *generating unit'*s automatic *load* following scheme approved by the *Network Operator;* or

(4) in accordance with a procedure agreed with the *Network Operator*; or

(5) in *connection* with a test conducted in accordance with the requirements of this *Code* or a procedure agreed with by the *Network Operator*.

(b) Adjust the *transformer tap position* or *excitation control system voltage* set-point of a *scheduled generating unit* except:

(1) in accordance with an instruction from or by agreement with the *Network Operator;* or

(2) in response to remote control signals given by the *Network Operator* or its agent; or

(3) if, in the scheduled *User's* reasonable opinion, the adjustment is urgently required to prevent material damage to the *User's plant* or associated equipment, or in the interests of safety; or

(4) in *connection* with a test agreed with the *Network Operator* and conducted in accordance with this *Code* or procedures agreed with the *Network Operator*.

(c) *Energise* a *connection point* in relation to a *User's generating unit* without prior approval from the *Network Operator*. This approval shall be obtained immediately prior to *energisation*;

(d) *Synchronise* a *scheduled generating unit* to, or de-*synchronise* a *scheduled generating unit* from, the *power system* without prior approval from the *Power System Controller* except *de-synchronisation* as a consequence of the operation of automatic *protection* equipment or where such action is urgently required to prevent material damage to *plant* or equipment or in the interests of safety;

(e) *Change* the *frequency response mode* of a *scheduled generating unit* without the prior approval of the *Network Operator;* or

(f) Remove from service or interfere with the operation of any *power system* stabilising equipment installed on that *generating unit*.

See also clauses 3.3 and 4.2 of Version 4.0 of the System Control Technical Code.

9.1.2 [Deleted]

9.1.3 [Deleted]

9.2 Users' plant changes

A *User* shall, without delay, notify the *Power System Controller* of any event which has *change*d or is likely to *change* the operational availability or *load* following capability of any of its *generating units*, whether the relevant *generating unit* is *synchronise*d or not, as soon as the *User* becomes aware of the event.

9.3 Operation, maintenance and extension planning

Operation, maintenance and *extension* planning and co-ordination shall be performed in accordance with this *Code* and any applicable *connection agreement*.

9.4 [Deleted]

10 [Deleted]

11 Information requirements for network connection

11.1 Scope

(a) The following information requirements apply to the *connection* of *Users* to the *Power and Water networks*.

(b) The *Network Operator* is obliged to obtain sufficient information in respect of a *network connection* to enable the *Network Operator* to ensure that the relevant *User connection* will not prevent the *network* performance standards in clause 2 of the *Code* from being met.

(c) If, in the opinion of the *Network Operator*, additional information for a particular *User connection* is required to ensure the *network* performance standards in clause 2 of the *Code* are met, the *User* shall *supply* the additional information.

(d) The *User* shall provide all data reasonably required by the *Network Operator*.

(e) Particular provisions may be waived for smaller *Users* and *Users* that have no potential to affect other *Users*, at the discretion of the *Network Operator*, in accordance with the *derogation* provisions of clause 12.

(f) Nothing in this section waives the requirements for all installations to comply with the *Network Operator's* Service and Installation Rules, *Metering* Manual, Contractor's Bulletins, and any requirement included in a *connection agreement*.

11.2 Information to be provided by all Network Users

11.2.1 Information on connected plant

(a) Before any new or additional equipment is *connect*ed, the *User* may be required to submit the following kinds of information to the *Network Operator*:

(1) a single line diagram with the *protection* details;

(2) *metering* system design details for equipment being provided by the *User*;

(3) a general arrangement locating all the equipment on the site;

(4) a general arrangement for each new or altered *substation* showing all exits and the position of all electrical equipment;

(5) type test certificates for all new switchgear and *transformer*s, including measurement *transformer*s to be used for *metering* purposes in accordance with Chapter 7A of the NT NER;

(6) the proposed methods of earthing cables and other equipment to comply with the Electricity Supply Association of Australia Substation Earthing Guide, or *Australian Standard* AS3000, or both, as appropriate;

(7) *plant* and earth grid test certificates from approved test authorities;

(8) a primary/secondary injection test of *protection* and trip test certificates on all circuit breakers;

(9) certification that all new equipment has been inspected before being *connect*ed to the *supply*;

(10) operational procedures;

(11) calculated maximum *demand* of the installation;

(12) details of potentially disturbing *load*s; and

(13) SCADA arrangements.

(b) Details of the kinds of data that may be required are included in Attachment 3.

11.2.2 Details of proposed Users' protection

(a) Unless otherwise agreed by the *Network Operator, Users* shall provide the *Network Operator* with full details of proposed *protection* designs, together with all relevant *plant* parameters, a minimum of 12 *month*s prior to *energisation* of the protected *primary plant*.

(b) The *Network Operator* shall provide comments on a *User's* proposed *protection* designs within 65 *business day*s, unless otherwise agreed.

11.2.3 Requirements where a critical fault clearance time exists

(a) Where a *critical fault clearance time* exists, *Users* shall maintain a record of design *fault clearance times* for all circuit breakers within their *plant*.

(b) Records of design *fault clearance times* shall be made available to the *Network Operator* on request.

11.3 [Deleted]

11.4 Information to be provided by *Users* with *Small Generator*s

(a) A *User* with a *Small Generator* shall provide the data specified in clause 11.2.

(b) A *Small Generator* shall provide all information in relation to the design, construction, operation and configuration of that small *power station* as is required by the *Network Operator* to ensure that the operation and performance standards of the *network*, or other *Users*, are not adversely affected by the operation of the *power station*.

(c) In order to assess the impact of the equipment on the operation and performance of the *network* or on other *Users*, the *Network Operator* may require a *Small Generator* to provide data on:

(1) *power station* and *generating unit* aggregate real and *reactive power*; and

(2) flicker coefficients and harmonic profile of the equipment, where applicable and especially for wind power and inverter *connect*ed equipment. Data on power quality characteristics, including flicker and harmonics, in accordance with IEC 61400- 21 shall be provided for all wind turbines.

(d) Net import / export data shall be provided in the form of:

(1) a typical 24 hour power curve measured at 15 minute intervals (or better if available); and

(2) details of the maximum kVA output over a 60 second interval, or such other form as specified in the relevant *connection agreement*.

(e) When requested by the *Network Operator*, a *Small Generator* shall provide details of the proposed operation of the equipment during start-up, shut-down, normal daily operation, intermittent fuel or wind variations and under fault or emergency conditions.

(f) Details of the kinds of data that may be required are included in Attachment 3 of this Code, specifically:

(1) Schedule S3.3 - *Generator* data for small *generating systems*;

(2) Schedule S3.5 - *Network* and *plant* technical data; and

(3) Schedule S3.6 - *Network plant* and apparatus setting data.

11.5 Information to be provided by *Users* with *Small Inverter Energy System*s

A *Small Inverter Energy System* may be installed as an addition to an existing *load connection*, in conjunction with a new *load connection* or as a stand-alone *Generation* system.

(a) A *User* with a *Small Inverter Energy System* shall provide the data specified in clause 11.2.

(b) Details of the kinds of data that may be required from a *User* with a *Small Inverter Energy System* are included in Attachment 3 of this *Code*, specifically:

(1) Schedule S3.4 - Technical data for *Small Inverter Energy System*s;

(2) Schedule S3.5 - *Network* and *plant* technical data;

(3) Schedule S3.6 - *Network plant* and apparatus setting data; and

(4) Schedule S3.7 - *Load* characteristics at *connection point*.

11.6 Information to be provided by *Users* with *load*s

(a) A *User* with a *load* shall provide the data specified in clause 11.2.

(b) Details of the kinds of data that may be required from a *User* with a *Load* are included in Attachment 3 of this *Code*, specifically:

(1) Schedule S3.5 - *Network* and *plant* technical data;

(2) Schedule S3.6 - *Network plant* and apparatus setting data; and

(3) Schedule S3.7 - *Load* characteristics at *connection point*.

12 Transitional arrangements and derogations from the *Code*

12.1 Purpose and application

(a) This clause 12 prevails over all other clauses of this *Code*.

(b) *Derogation*s of *Users* are:

(1) those provisions of the other clauses of the *Code* which shall not apply either in whole or part to particular *Users* or potential *Users* or others in relation to their *facilities* for a fixed or indeterminate period;

(2) any provisions which substitute for those provisions which are not to apply; and

(3) applicable only to that particular *User* or potential *User*.

(c) *Derogation*s are for the purpose of:

(1) enabling *Users* to effect an orderly transition to the provisions of the *Code* from those provisions currently applying (including extension of a grace period set out in Schedule S4);

(2) providing specific exemptions from the *Code* for pre-existing arrangements which the *Network Operator* determines shall continue beyond a specific transition period; and

(3) providing specific exemptions from the *Code* for future arrangements (implemented after the introduction of a new version of this *Code*) that the *Network Operator* determines to be acceptable.

(d) The *Network Operator* is not required to grant a *derogation* if doing so will adversely affect *network capability*, *power system security*, quality or reliability of *supply*, *intra-regional power transfer capability* or the use of a *network* by another *User.*

(e) An applicant for a *derogation* must submit that application in such form reasonably required by the *Network Operator* which application must outline:

(1) the nature of the *derogation* sought;

(2) why the *derogation* should be granted;

(3) why granting of the *derogation* will not have the effect referred to in clause 12.1(d).

(f) Applications for *derogations* under clause 12.1(b)(1) and (2) may be granted if the *Network Operator* in good faith forms the view that the *derogation* is appropriate given the pre-existing arrangements to which the *User* is party and having regard to the criteria in clause 12.1(d).

(g) In considering applications under clause 12.1(b)(3) the *Network Operator* must apply the principle that *Users* first applying to *connect* to the *electricity* *network* after the commencement of Version 4 of this *Code* should comply with the standards in this *Code* and that *derogations* should only be granted to small *Users* who have only minor impact upon the *electricity network* (including when their impact is aggregated with other small *Users*) or where there are otherwise compelling reasons for granting the *derogation*.

(h) Applications for *derogation*s shall be submitted to and processed by the *Network Operator* in accordance with any requirement of applicable laws.

12.2 *Pre 1 April 2019 plant and equipment*

(a) This clause applies to *plant* of a *Generator User connected* to the *electricity network* prior to 1 April 2019 (such *plant and equipment* being ***Existing Connection Plant***).

(b) A *Generator User* to whom this clause applies must, in respect of the *Existing Connection Plant*:

(i) comply with the technical standards applicable to such *Existing Connection Plant* under Version 3 of this *Code* (as in force immediately prior to the date Version 4 of this *Code* came into effect); and

(ii) comply with clause 3 of this *Code* (Technical requirements for equipment *connected* to the *network*) including the *automatic access standards* set out in that clause 3 to the extent the *Existing Connection Plant* is able (without requiring modification, alteration or enhancement) to comply with that clause and those *automatic access standards*.

(c) A *Generator User* to whom this clause applies must, if required by the *Network Operator*, conduct such tests as required by the *Network Operator* to determine the extent to which the *Existing Connection Plant* of the *Generator User* is able to comply with clause 3, including the *automatic access standards*. Such tests must be conducted at the times and otherwise in accordance with the requirements reasonably determined by the *Network Operator*.

(d) The *Generator User* must report the results of the tests to the *Network Operator* in such manner specified by the *Network Operator* acting reasonably.

(e) The *Generator User* must bear its own costs of undertaking the tests required by the *Network Operator* and must reimburse the *Network Operator*, at such times reasonably determined by the *Network Operator*, the *Network Operator's* reasonable costs of conducting and overseeing such tests.

(f) If a *Generator User* materially modifies, alters or enhances *Existing Connection Plant*, then it must do so, if required by the *Network Operator*, in accordance with any applicable provisions of the *NT NER* and this *Code* (including where required by this *Code* complying with the *automatic access standards* or such *negotiated access standards* as may be agreed).

12.3 Post 1 April 2019 plant and equipment

(a) This clause applies to a *Generator User* who has entered into a *connection agreement* with the *Network Operator* prior to Version 4 of this Code coming into effect but had not completed the *connection* of *plant and equipment* to the *electricity network* prior to 1 April 2019.

(b) Subject to this clause 12.3, such *Generator User* must ensure all *plant and equipment connected* to the *electricity network* pursuant to that *connection agreement* complies with the requirements of this *Code* including (subject to paragraph (c) below) the *automatic access standards.* However where a grace period for a technical requirement is specified in Schedule S4 a *Generator User* will not be regarded as in breach of this *Code* if:

(i) within 30 days of commencement of version [4] of this *Code* it submits to the *Network Operator* a written communication confirming each *automatic access standard* that is met, and for each individual *automatic access standard* that is not met, a plan setting out the procedures, consistent with *good electricity industry practice*, which will be followed by the *Generator User* to ensure it complies with that technical requirement from the end of the applicable grace period; and

(ii) it complies with that plan; and

(iii) it ensures it complies with that technical requirement as soon as reasonably practicable and in any event from the end of the relevant applicable grace period.

(c) A plan submitted under clause 12.3(b):

(i) may include a process for negotiating a *negotiated access standard*; and

(ii) must include the testing and commissioning procedures which will be followed by the *Generator User* to establish it has achieved compliance with each relevant technical requirement.

(d) A *Generator User* must make such changes to a plan submitted under clause 12.3(b) as reasonably required by the *Network Operator*.

(e) A *Generator User* to whom this clause applies may request the *Network Operator* to agree with it a *negotiated access standard* in substitution for an *automatic access standard* and, if so, the *Network Operator* will negotiate in good faith with the *Generator User* to agree such *negotiated access standard* in accordance with the criteria set out in clause 3.3.5. Until such time as a *negotiated access standard* is agreed, any *connected plant* of the *Generator User* must, subject to clause 12.3(b), comply with the *automatic access standard*.

(f) Where this *Code* contemplates a matter being agreed between the *Network Operator* and the *Generator User* and such matter is not specified in the *connection agreement* then:

(i) the *Network Operator* may, as a condition to connecting the *plant* to the *electricity network* and permitting its commissioning, require that the *Network Operator* and the *Generator User* agree such matters and document them as an amendment to the connection agreement; or

(ii) if the *plant* is already *connected* and commissioned as at the time Version 4 of this *Code* comes into effect, the *Generating User* must, if required by the *Network Operator*, negotiate in good faith to agree and document such matters by an amendment to the *connection agreement* (and if such matters are not agreed within 4 months of the *Network Operator's* request then the matter may be referred for determination by the *Utilities Commission* under clause 1.6(b)).

(g) The *Generator User* must report the results of the tests conducted in accordance with a plan referred to in clause 12.3(b) to the *Network Operator* in such manner specified by the *Network Operator* acting reasonably. The *Generator User* must bear its own costs of undertaking such tests.

(h) Any grace periods referred to in this clause 12.3 shall only commence from the date that the *Network Operator* provides the *Generator User* with information and guidelines specified in clauses 3.3.4 and 3.3.5 to enable the *Generator User* to determine the ability of their plant to comply with the technical requirements in 3.3.5.

Part C Network Planning Criteria

Power and Water is the major custodian and operator of the power *network*s within the Northern Territory. *Power and Water* is responsible for the *network* security, *reliability* and *quality of supply* to all *Network Users*. *Power and Water'*s technical requirements are intended to ensure that a high *reliability* of service is maintained when additions and *change*s to the *network*s or *Users'* installations are made. Technical requirements are based on the rules, criteria and limits included in the *Technical Code* and these *Network Planning Criteria*.

The *Network Planning Criteria* allow *network customer*s to use *Power and Water'*s regulated *network*s to enable contracted trade between *Generator Users* and *customer Users*.

The purpose of *Network Planning Criteria* is to strike a balance between each *User's* need for a safe, secure, *reliable*, high quality electricity *supply* and the desire for this service to be provided at minimal cost. At the same *time*, environmental and social considerations shall be taken into account.

13 Introduction

(a) Additions to and reinforcement of the *network*s in the form of additional:

(1) *Transmission line*s and *distribution* feeders;

(2) *Transformers*;

(3) *Generators*;

(4) *Load*s; and

(5) Capacitors or *reactors*;

will produce an impact on the existing *network*s and *customer*s.

(b) This Part C presents the *Planning Criteria* applied to ensure that *Power and Water'*s *network*s:

(1) Provide a high quality electricity *supply*;

(2) Provide a *reliable* electricity *supply*;

(3) Provide a secure electricity *supply*;

(4) Meet safety standards;

(5) Meet environmental standards;

(6) Optimise equipment utilisation; and

(7) Optimise *network losses*.

(c) The philosophy of *network* planning and the rationale behind the *Planning Criteria* are discussed in clause 13.1 of this document.

(d) The guidelines for *network* planning, which are provided in this document, outline the range of technical and environmental *Planning Criteria*.

13.1 Network design philosophy

(a) The *Planning Criteria* are used to assess the *supply* system capacity and determine the need for and timing of:

(1) *Generation* support;

(2) *Demand* management;

(3) *Network* reinforcement; or

(4) *Network* re-configuration;

to meet *customer*s' *demand* for electricity.

(b) *Network* reinforcement plans may then be developed which will satisfy the *Planning Criteria* and environmental *constraint*s.

13.2 Amendments to the Planning Criteria

(a) Any *User* may propose an amendment to the *Planning Criteria*.

(b) A proposal to amend the *Planning Criteria* shall be made in writing by the *User* to the *Network Operator* and shall be accompanied by:

(1) the reasons for the proposed amendment to the *Planning Criteria*; and

(2) an explanation of the effect on *Users* of the proposed amendment to the *Planning Criteria*.

(c) Subject to paragraph (f) below, the *Network Operator* shall review the proposed amendment to the *Planning Criteria* and within 30 days advise the *User* or electricity entity:

(1) whether the proposed amendment to the Planning Criteria is accepted or rejected; and

(2) the reasons for the acceptance or rejection of the proposed amendment to the Planning Criteria.

(d) The 30 day period in clause 13.2(c) is extended as reasonably required to allow any public consultation or consultation with the Utilities Commission required under the *Electricity Reform Act*.

(e) The *Network Operator* shall review the operation of the *Planning Criteria* at intervals of no more than 5 years and may seek submissions from *Users* and the Utilities Commission during the course of the review.

(f) The *Network Operator* may amend this *Planning Criteria* in accordance with the legislative provisions.

13.3 132 kV and 66 kV networks

The traditional planning philosophy for a meshed *network* has been that the loss of any one component of the *network* at a *time* of *peak load* will not result in the loss of *supply* to any *customer*s. This is the 'n-1' criterion, which can result in imprudent capital expenditure if the *frequency* and consequences of breaching the criterion are not considered. Prudent capital expenditure involves the application of risk management techniques. This requires a consideration of the probability of an event occurring and the consequences of its occurrence, for example the impact on *customer*s. If the probability of the event is low and the consequences acceptable, it may be considered justified to delay system reinforcement beyond the date indicated by the n-1 criterion and *peak load*ing.

(a) *Power and Water* designs its 132 kV and 66 kV systems as meshed *network*s.

(b) There may be radial 132 kV and 66 kV lines extending from the meshed *network* to many rural and developing areas.

(c) *Generators* are connected to the *networks* at voltages of 132 kV and 66 kV. The technical characteristics of *Generator* connections may be negotiated with the *Generator* provided that the *network* performance standards of clause 2 of the *Network Technical Code* are maintained.

13.4 Distribution networks

Power and Water designs its *distribution network*s as radial systems.

13.4.1 CBD area

(a) In the Darwin central business district, five 11 kV switching stations *supply* a *network* of underground HV feeder rings, with open points approximately mid-way between switching stations [1].

(b) The switching stations are remotely controlled, but the intermediate switches used to transfer *load* and restore *supply* in the event of a *supply* contingency are operated manually.

13.4.2 Urban areas

(a) In urban areas the lower density of *Users* generally results in an open, meshed *network* of HV feeders run radially with open points.

(b) This operating mode minimises fault levels and simplifies technical and operational requirements.

---

1 Power and Water's High *Voltage* (HV) networks operate at *voltage* levels of 22 kV in rural areas and 11 kV in urban areas.

(c) In these situations, the extent of the loss of *supply* can be minimised by the use of reclosers and sectionalisers to limit the impact of faults and the speed of restoration improved through the use of fault indicators to locate faults.

13.4.3 Rural areas

(a) In rural areas the *distribution network* is generally radial and *interconnection* to reduce *supply* restoration times is often not possible.

(b) In normal circumstances the loss of a component of the *network* will result in the loss of *supply* to a number of *Users* until the *network* is reconfigured or repaired.

13.4.4 Enhanced security of supply

(a) The *Network Operator* will provide for the reasonable request of a *User* requiring additional security of *supply* above the standard design philosophy.

(b) Additional costs incurred in providing the additional security of *supply* would ordinarily be charged to the *User*.

(c) In some circumstances, on-site standby *generation* may be the only economic or practical alternative to improve *supply* security.

13.4.5 Embedded generation

(a) The *distribution network* is not designed to support the islanded operation of *embedded Generator*s and *Power and Water*'s *distribution* equipment is not normally fitted with *synchronising* equipment.

(b) Embedded *generating units*, including small solar photo-voltaic and wind *Generator*s at *Network Users'* premises shall be of a design that automatically *disconnect*s from the *network* if the *distribution* feeder that they are *connect*ed to is separated from the remainder of the *power system*.

(c) The requirements concerning the *connection* of *Small Generator*s and *Small Inverter Energy System*s are set out in clauses 3.4 and 3.5 of this *Code*.

13.5 Process to assess the need for network reinforcement

(a) *Network* capacity and the need for *network* reinforcement are assessed by comparing the *Planning Criteria* with *network* performance for:

(1) Increasing *load* levels;

(2) Changing *load demand* patterns;

(3) Particular *load* characteristics; and

(4) *Reliability*.

(b) To satisfy the performance levels, be they *reliability*, security, or quality levels, least cost and effective plans are developed. The extent of the *network* reinforcement works is dependent on:

(1) The *load* forecast;

(2) The anticipated maximum *demand*s of all *Users*;

(3) Special conditions of the *User's load*;

(4) The anticipated minimum *demand* of other *Users*;

(5) *Users' load* profiles;

(6) The availability of non-*network* alternatives to *network* reinforcement; and

(7) The age and condition of existing assets.

(c) Economic analysis is used in assessing *network* reinforcement requirements and serves four functions as it:

(1) Indicates the return to *Power and Water* of proposed capital investment;

(2) Helps to choose between options;

(3) Helps rank the project with other projects *generated* throughout *Power and Water*; and

(4) Ensures the equitable allocation of costs between *Users*.

(d) In some cases, *network* reinforcement works may also be justified on an economic basis where there are immediate benefits in return for capital invested, e.g. *network* loss optimisation.

13.6 The process of developing network concept plans

(a) *Power and Water*, in developing *network* concept plans for the long-term development of the *network*, uses ultimate *load* horizon planning.

(b) In this methodology *Power and Water* considers the following information in assessing the ultimate *load* for an area:

(1) Department of Lands Planning and Environment land use structure plans;

(2) Australian Bureau of Statistics censuses;

(3) Consultants' reports on population growth in the major centres;

(4) Any relevant town planning schemes;

(5) Local Government advice on future planning proposals;

(6) Geographic features and their associated design limitations; and

(7) Any environmental *constraint*s, including vegetation and ecology limitations.

(c) This information is combined with any other available future *load* information to produce an ultimate *load* assessment for an area and on the basis of this a *network* concept plan is developed.

13.7 Planning Criteria

Planning Criteria are a set of standards applied to maintain appropriate levels of *network* security and *reliability*. They are used as a planning and design tool to protect the interests of all *Network Users* in terms of *reliability* and *quality of supply*. The criteria are also applied to protect all *network*s against instability.

13.8 Network development

The *Network Operator* is required to ensure that non-*network* alternatives to the reinforcement of the *network* are considered on an equivalent basis to *network* reinforcement and adopted where they can economically meet the *network* performance standards in clause 2 of the *Network Technical Code* and the *supply* contingency criteria in clause 14 of the *Network Planning Criteria*.

Non-*network* alternatives may include, without limitation, the following programs and technologies:

- Pricing signals to influence *customer demand*;
- Direct control of *customer demand*;
- Installation of *power factor* correction;
- Installation of embedded *generation*.

Non-*network* alternatives may involve agreements between the *Network Operator* and third parties for the provision of support to the *network* in specified contingency conditions.

13.8.1 Annual planning review

The *Network Operator* shall annually:

(a) Prepare a forecast of loads and *generation* for the system for a period of at least 5 years.

(b) Conduct a planning review of the adequacy of existing *connection point*s and the capacity of the *transmission* and *distribution network*s to meet forecast *load demand*s and *generation demands*.

(c) Consider the potential for augmentations, or non-*network* alternatives to augmentations, that are likely to provide economic benefit to all *Network Users*.

(d) Identify where *network investment*s are likely to be required and classify those investments as:

(1) a *small network investment*; or

(2) a *large network investment*.

(e) Prepare a *Network Management Plan* containing, amongst other things, *network* limitations and potential non-*network* and *network* solutions for *small network investments* and *large network investment*s in a form suitable for public dissemination.

(f) The *Network Management Plan* shall be made available on Power and Water's website and made available to the interested parties established in clause 13.8.2(a) or to any person, upon application.

13.8.2 Non-network alternatives to network augmentation

(a) The *Network Operator* shall establish and maintain a list of interested parties that may be prepared to provide non-*network* alternatives to augmentation of the *network*.

(b) The *Network Operator* shall carry out a screening test to determine whether *demand* management or other non-*network* alternatives are likely to be viable for each *network investment* identified in clause 13.8.1(d).

(c) Where *demand* management or other non-*network* alternatives are not likely to be viable for a *network investment* the *Network Operator* shall carry out analysis of the *network* reinforcement in accordance with clause 13.9.

(d) Where *demand* management or other non-*network* alternatives are likely to be viable for a *large network investment*, the *Network Operator* shall:

(1) publish a report detailing the circumstances of the large network investment and the outcome of the demand management screening test in clause 13.8.2(b);

(2) advise interested parties of the large network investment;

(3) seek expressions of interest in providing a non-*network* alternative.

(e) If no expression of interest in providing a non-network alternative to a large network investment has been received within 60 business days the *Network Operator* shall carry out analysis of the *network* reinforcement in accordance with clause 13.9.

(f) Where *demand* management or other non-*network* alternatives are likely to be viable for a *small network investment*, the *Network Operator* shall inform interested parties of the outcome of the screening test in clause 13.8.2(b) and request expressions of interest in providing a non-*network* alternative.

(g) If no expression of interest in providing a non-network alternative to a small network investment has been received within 30 business days the *Network Operator* shall carry out analysis of the *network* reinforcement in accordance with clause 13.9.

(h) The *Network Operator* shall carry out the analysis of non-*network* alternatives provided by interested parties under clauses 13.8.2(d) and 13.8.2(f) in accordance with clause 13.9.

13.9 Investment analysis and reporting

In determining the preferred option for a new *large network investment*, the *Network Operator* shall:

(a) Analyse the proposed *large network investment* using financial parameters consistent with the most recent *Network* regulatory determination.

(b) Analyse non-*network* alternatives and *network* reinforcement alternatives on the same basis.

(c) Determine on a present value basis the least-cost non-*network* or *network* reinforcement alternative that meets the requirements of the *network* performance standards in clause 2 of the *Code* and the *supply* contingency criteria in clause 14 of the *Network Planning Criteria*.

(d) Include in the investment analysis an estimate of system benefits where they are likely to be material to the outcome of the analysis, including, but not limited to:

(1) Electrical losses;

(2) Changes in the level of involuntary *load* curtailment;

(3) Fuel and *generation* costs;

(4) *Ancillary services* provided to the system (e.g. *voltage* support, *spinning reserve* or C-FCAS as applicable in each regulated power system, black start).

(e) The level of analysis undertaken in relation to system benefits in clause 13.9(c) shall be proportionate to the size and scale of the proposed new *network* investment.

(f) Determine and assess any non-quantifiable economic benefits of alternative investment options.

(g) Determine the preferred non-*network* or *network* investment alternative.

(h) Prepare a report on the *network* investment analysis in clause 13.9(a) to (g).

14 *Supply* contingency criteria

(a) *Supply* contingency criteria relate to the ability of the *supply* system (*network* and *generation*) to be reconfigured after a fault, so that the *supply* to *customer*s is restored. The criteria apply to *generation* used to support the *network* and to the *network interconnection*s to *Generator*s.

(b) The following definitions apply.

14.1 Load areas

(a) The *load* areas that have been identified for the purpose of the *supply* contingency criteria are set out in Figure 12.

Figure 12 - Definition of *load* types

***Load* type**	**Definition**
CBD	Any area within a city or town that is zoned as CBD in the Northern Territory Planning Scheme.
Urban	An area in which the majority of the land is zoned for residential and/or commercial and/or industrial use within a major centre in the Northern Territory and is not CBD.
Non-urban	Areas that are not Urban and not within a CBD but which are within a 50km radius of a CBD.
Remote	Areas outside a 50km radius from a CBD.

(b) A distinction has been made between the *supply* contingency criteria applicable to CBD and Urban *load* areas, and those applicable to Non-urban and Remote *load* areas.

(c) A *supply* contingency may involve the unplanned failure of an element of *network* equipment or the failure of a *Generator* used to support the *network* at a particular location.

14.2 Supply contingencies

(a) A single *supply* contingency (first contingency) may involve the unplanned failure of an element of *network* equipment (a cable, line or *transformer*), or the failure of a *Generator* used to support the *network* or *supply loads* at a particular location.

A second contingency provision has been included, which is similar to that in the CBD areas of most other Australian capital cities. Other CBDs currently are planned to provide second contingency capability at the sub*transmission* and zone *substation* level, as follows:

- **Brisbane:** in one hour;
- **Melbourne:** in 30 minutes; and
- **Sydney:** in one hour.

The longer *time* permitted for restoration of the Darwin CBD system recognises that manual switching of *load* on the CBD HV *network* would be necessary to restore capability.

(b) A second *supply* contingency involves the concurrent failure of two elements, which could comprise *network* equipment or *Generators*.

(c) In addition, at the discretion of the *Network Operator*, certain high impact but low risk failures such as the failure of a single zone *substation* HV *busbar*, or the failure of a both circuits of a double circuit line, shall be considered as second *contingency event*s.

14.3 Equipment capacities

Circuit capacities to be used in determining *supply* adequacy are the appropriate cyclic ratings for *network* equipment.

14.4 Forecast demand

(a) The forecast area *demand* used for determining *supply* adequacy is the coincident maximum *demand* for the *load* area, feeder or *transformer* concerned, with a 50% Probability of Exceedence.

(b) In calculating the maximum *demand* in clause 14.4(a), allowance shall be made for the coincident effect of *demand* reductions in the *load* area arising from:

(1) Any *demand* management initiative controlled by *Power and Water*;

(2) Any *customer* contracted to *Power and Water* to reduce *demand* upon request;

(3) The net effect of any embedded *Generation* used to provide a *demand* reduction under an agreement with *Power and Water*; and

(4) Small scale embedded *Generation* such as solar PV installations.

14.5 Radial supply arrangements

(a) Where restoration of *supply* requires reinstatement or repair, a secure *supply* having an alternative path is not provided. Restoration targets are set out in Figure 13.

Figure 13 – Radial *supply* restoration targets

Radial *supply* contingency	**Restoration target**
For failure of a *substation transformer*	≤ 36 hours
For failure of a sub*transmission line*	≤ 6 hours (*load*s greater than 5MVA)
For failure of a sub*transmission line*	≤ 12 hours (*load*s less than 5MVA)

(b) The restoration times in Figure 13 are *Power and Water's* internal targets. They do not represent *customer* guarantees.

(c) Actual restoration times will be based on ensuring staff safety and being able to access and address the asset related issues.

14.6 Supply contingency criteria

> The *supply* contingency criteria in the *Network Planning Criteria* have been designed to facilitate the *Network Operator* providing the specified response in the most appropriate and economical manner for the particular circumstances. The response to ensuring that the *supply* contingency criteria are met may include one or more of the following responses:
>
> - Augmentation of the *network*;
> - Reduction of *demand* on the *network* using demand management;
> - Connection of *generation* within the load area concerned;
> - Commercial arrangements with *generators* to provide *demand* support in contingency conditions;
> - Enhanced operational response;
> - Enhanced control of *network* configuration;
> - Contingency planning, using strategically positioned spare equipment or mobile equipment such as *generators* and transformers.

(a) The *supply* contingency criteria in this clause 14.6 apply to loads and to groups of loads supplied by the *network* at various voltage levels and locations.

(b) In determining the relevant supply contingencies to loads and groups of loads, the potential unavailability of:

(1) elements of the *network* that normally supply those loads;

(2) the *generators* that normally supply those loads; and

(3) the associated *Generator connections*;

shall all be considered.

(c) The relative likelihood (frequency) of *supply* contingencies shall also be considered by the *Network Operator*. The *Supply Contingency Criteria* requires that:

(1) The *equipment* that comprises elements of the system for the supply to loads and groups of loads shall be operated and maintained in such a way that the frequency of equipment unavailability is consistent with good industry practice; and

(2) The expected frequency of *supply* contingencies shall be considered by the *Network Operator* when developing options to maintain compliance with the *Supply Contingency Criteria.*

(d) The *Network Operator* shall aim to meet reliability of *supply* objectives established by the *Regulator*.

(e) Where the availability of *generation* is a factor in meeting the contingency criteria in a particular load area the *Network Operator* is required to consult with the relevant *Generators* to make appropriate allowance for *generating unit* maintenance.

(f) The *Network Operator* may enter into commercial arrangements with a *Generator* to provide *demand* support in *supply* contingency conditions.

(g) The *Planning Criteria* in Figure 14 apply for the specified *supply* contingencies in CBD and Urban areas.

(h) The *Planning Criteria* in Figure 15 apply for Non-Urban and Remote areas.

(i) The *Planning Criteria* in Figure 14 and Figure 15 apply to each load segment within the loads or groups of loads to which the associated *Planning Criterion* applies.

Figure 14 - *Supply* contingency criteria - CBD and Urban areas

Class of *supply*	Forecast area *demand*	Minimum *demand* to be met after: First *supply* contingency	Minimum *demand* to be met after: Second *supply* contingency	Notes
A	Up to 1MVA	Within 8 hours: area *demand*	No special provision	Area *demand* is normally supplied from one source. Restoration of *supply* requires reinstatement or repair. Includes most HV *customer connections* and *distribution substations*. Where a single *transformer* supplies *demand*, the area *demand* may cover the *transformer* cyclic capacity.
B	Over 1 MVA and up to 5 MVA	(a) Within 3 hours: area *demand* less 1 MVA (b) Within 8 hours: area *demand*		Area *demand* is normally supplied from one source and may have partial to full *supply* available from an alternative source. Includes most HV feeders, allows for manual field switching.
C	Over 5 MVA and up to 50 MVA	(a) Within 60 minutes: area *demand*		Area *demand* is normally supplied from one or more source and will have partial to full *supply* from an alternative source. Will include many HV feeders and all zone *substations*. Area *demand* will be restored with automatic or manual switching of alternative sources of *supply*.
D	Over 50 MVA	(a) Immediate restoration of area *demand*	(b) Within *time* to restore planned *outage*: area *demand* (c) Within 5 hours: area *demand*	Area *demand* will normally be supplied by more than two alternative circuits with high level automatic and supervisory switching. The *time* permitted for restoration of *supply* to the Darwin CBD following a second contingency recognises that manual switching of *load* on the CBD HV *network* would be necessary. The second contingency provision is not intended to restrict the period during which maintenance can be scheduled. The provision for a second circuit *outage* assumes that normal maintenance would be undertaken when *demand* is less than peak.

Figure 15 - *Supply* contingency criteria - Non-Urban and Remote areas

Class of *supply*	Forecast area *demand*	Minimum *demand* to be met after: First *supply* contingency	Minimum *demand* to be met after: Second *supply* contingency	Notes
E	Up to 1MVA	Within 12 hours: area *demand*	No special provision	Area *demand* is normally supplied from one source. Restoration of *supply* requires reinstatement or repair. Includes most rural spur *connection*s, HV *customer connection*s and *distribution substations*. Where a single *transformer* supplies *demand*, the area *demand* may cover the *transformer* cyclic capacity.
F	Over 1 MVA and up to 5 MVA	(a) Within 6 hours: area *demand* less 1 MVA (b) Within 12 hours: area *demand*		Area *demand* is normally supplied from one source and will have partial to full *supply* available from an alternative source. Full restoration of *supply* may require reinstatement or repair. Includes most HV feeders, allows for manual field switching.
G	Over 5 MVA and up to 15 MVA	(a) Within 3 hours: area *demand* (b) Within 36 hours: area *demand*		Area *demand* is normally supplied from more than one source and will have full *supply* from an alternative source. Includes many zone *substations*. Area *demand* will be restored with manual switching of alternative sources of *supply*. Where area *demand* supplied from a single source (b) will apply.
H	Over 15 MVA and up to 50 MVA	(a) Within 30 minutes: area *demand* (b) Within 36 hours: area *demand*		Area *demand* is normally supplied from more than one source and will have full *supply* from an alternative source. Will cover larger zone *substations*. Area *demand* will be restored with automatic or remote manual switching of alternative sources of *supply*. Where area *demand* supplied from a single source (b) will apply.

15 Steady state criteria

(a) The steady state criteria define the adequacy of the *network* to *supply* the *energy* requirements of *Users* within the equipment ratings, *frequency* and *voltage* limits, taking account of planned and unplanned *outage*s.

(b) The steady state criteria apply to the normal continuous behaviour of a *network* and also cover post disturbance behaviour once the *network* has settled.

(c) In planning a *network* it is necessary to assess the *reactive power* requirements under both extremes of light and heavy *load*, to ensure that the reactive *demand* placed on the *Generator*s, be it to absorb or generate *reactive power*, does not exceed the capability of the *Generator*s and that system *voltage* levels remain within equipment ratings.

(d) *Network frequency* will fall if there is insufficient total *generation* to meet *demand*. Although the reduction in *frequency* will cause a reduction in power *demand*, it is unlikely that this will be sufficient and in the event of a shortfall of *generation*, *load*s shall be *disconnect*ed until the *frequency* rises to an acceptable level.

(e) In the following sub-clauses, the various components of the steady state *Planning Criteria* are defined.

15.1 Real and reactive generating limits

(a) Limits to the VAr *generation* and absorption capability of *Generator*s shall not be exceeded.

(b) *Generator*s shall be specified and maintained so as to be capable of operating within the normal range of system *voltage* at their point of *connection*.

15.2 Steady state power *frequency voltage*

The range of steady-state *voltage* at different *voltage* levels of the *power system* under normal operating conditions is set out in this clause.

The *Australian Standard* for *low voltage* was altered in 2000. *Australian Standard* AS 60038-2000 establishes a revised nominal *voltage* of 230/400 V (single/three phase), to match the European standard set out in IEC 60038:1983.

Australian Standard AS 6038-2000 notes that 240/415 V systems shall evolve towards the new standard and a revised *supply voltage* range. *Power and Water* is participating in an Energy Networks Association review of issues associated with the potential migration from a nominal mid- range *voltage* of 240 V to 230 V.

(a) For *voltage*s of 11 kV or more, the *network* shall be planned and designed to maintain a continuous *network voltage* at a *User's connection* not exceeding the design limit of 110% of nominal *voltage* and not falling below 90% of nominal *voltage* during normal and maintenance conditions.

(b) The *network* shall be designed to maintain the *low voltage* steady state levels within the range set out in Figure 16 for *credible contingency event*s. These are referenced to the nominal *voltage* of 230/400 V.

Figure 16 – *Supply voltage* range

System condition	Lower range	Upper range
Normal conditions	- 2%	+ 11%
Planned maintenance conditions	- 4%	+ 13%
Unplanned *outage* conditions	- 6%	+ 15%

(c) The power *frequency voltage* may vary outside the ranges set out in this clause 15.2 as a result of a *non-credible contingency event*.

15.3 Thermal rating criteria

(a) It should be noted that the thermal rating limits of equipment might not determine the capability of the *network* in a particular situation. Other factors such as the *voltage* drop or rise, *voltage* stability or system stability may impose a lower limit in certain circumstances.

(b) The thermal ratings of *network* components shall not be exceeded under normal or emergency operating conditions when calculated on the following basis:

(1) ***Transformers*:** Manufacturer's name plate rating, unless specific modelling has been carried out to determine a cyclic rating for the anticipated cyclic *load*ing and ambient temperature conditions.

(2) **Switchgear:** Manufacturer's name plate rating.

(3) **Overhead Lines:** Rating calculated in accordance with ESAA Code D(b)5, and based on:

(i) ambient temperature of 35°C in the northern part of the Territory, and 40°C (summer) or 25°C (winter) in the southern part;

(ii) wind speed being 0.5 m/s;

(iii) solar radiation being 1000W/m^2 (weathered surface); and

(iv) conductor design clearance temperature as defined in ESAA Code C(b)l.

(4) **Cables:** Normal cyclic rating, calculated using the Neher McGrath methodology; with

(i) maximum operating temperatures of 90°C for XLPE cables;

(ii) 70°C for 11 kV paper insulated cable;

(iii) 65°C for 11 kV paper insulated, belted cable and 22 kV paper insulated cables and;

(iv) during an emergency, for a period of up to 12 hours, the maximum allowable operating temperature for paper insulated cables may be increased to 80°C and for XLPE insulated cables to 120°C.

It should be noted that the thermal rating limits of equipment might not determine the capability of the *network* in a particular situation. Other factors such as the *voltage* drop or rise, *voltage* stability or system stability may impose a lower limit in certain circumstances.

15.4 Fault rating criteria

For safety reasons, the fault rating of any equipment shall not be less than the fault level in that part of the *network* at any time and for any normal *network* configuration.

As the system configuration is changed, fault levels may increase over time. New connections to the *network* shall therefore be designed with equipment fault level ratings reflecting modern standards that may exceed existing fault levels.

(a) The minimum fault levels for equipment to be connected to *Power and Water's networks* are set out in Figure 17.

Figure 17 – *Network* equipment fault level ratings

***Network voltage* level**	**Fault level rupturing capacity**
415 V	31.5 kA where supplied from one *transformer*; or 63 kA where supplied from two *transformers* in parallel
11 kV	25 kA in metropolitan areas; 20 kA in rural areas
22 kV	15 kA
66 kV	31 kA
132 kV	31 kA

(b) Equipment owned by *Power and Water* and Users *connected* to the *network* shall be designed to withstand these fault levels for 1 second.

16 Stability criteria

(a) A *power system* is stable if it returns to a steady-state or equilibrium operating condition following a disturbance. This criterion shall hold true for all *loading* conditions and *generation* schedules, under normal operating conditions, following the loss of any item of *plant*, and for the most severe credible faults.

(b) In the planning and operation of a *power system*, it is important to consider the potential emergence of a variety of stability problems.

(c) The *Network Planning Criteria* are designed to ensure that the *network* has a high probability of returning to stable conditions, following all credible *network* disturbances.

(d) The stability of a *power system* can be classified into a number of categories to facilitate the analysis of stability problems, the identification of contributing factors, and the development of measures to control or prevent instability. Instability can take many different forms and is influenced by a wide range of factors.

(e) Two broad categories of stability are considered:

   (1) Angle stability, which mainly involves the dynamics of *Generator*s and their associated *control system*s. Angle stability can be further categorised into transient stability and small-signal or steady-state stability. *Frequency* stability is closely related to angle stability.

   (2) *Voltage* stability, which mainly involves the dynamic characteristics of *load*s and *reactive power* compensation. *Voltage* collapse is perhaps the most widely recognised form of *voltage* instability.

16.1 Angle stability

16.1.1 Transient stability criteria

(a) Transient stability is based on the relative rotor angle swing between two or more groups of synchronous machines when subjected to a disturbance. Relative rotor angle swings in excess of 90° may lead to the situation where the rotor angle does not return and increases beyond 180°, resulting in pole slipping or synchronous instability. Transient stability of the *power system* shall be maintained. To ensure transient stability is maintained, due consideration during system studies shall be given to the following:

   (1) the maximum allowable relative rotor angle swing between any two or more groups of *Generator*s on the *network* shall not exceed 180° (after allowing for a safety margin consistent with *good electricity industry practice*);

   (2) the transient *voltage* dip limit as specified in clause 16.2.6; and

   (3) the possibility of delayed clearance of faults on the *network*.

(b) The most severe disturbance is to be selected from the following fault types to determine the stability of the *power system* (with due regard to be taken of reclosing onto a fault):

   (1) a three-phase-to-earth fault;

   (2) a single phase to earth fault cleared by *backup protection*;

(3) high speed single phase auto-reclosing and

(4) sudden *disconnection* of any *plant*, including a *generating unit*.

(c) If the rotor angles between one (or a group) of synchronous machines and the rest of the *generating units* on the *network* reaches and/or exceeds 180°, a *"*pole slip*"* occurs. This results in loss of synchronism or synchronous instability.

16.1.2 Rotor angle swing

(a) In general, an initial *Generator* rotor angle swing which does not exceed 120° and with XT ≤ 1.0 p.u. is considered stable.

(b) A rotor angle swing exceeding 120° has only a small margin before pole slipping, and an initial rotor swing angle which is higher than 120° may result in a pole slip or repeated pole slipping which is considered unstable.

(c) The relative rotor angle concept of synchronous instability is based on the rotor angle between two synchronous machines. In the case of two or more *generation* groups containing various *Generator*s a correlated effect on the *network*, like transient *voltage* dip limits, shall be used to prevent synchronous instability.

(d) Rotor angle swings in excess of 120° or transient *voltage* dips in excess of 25% can result in the following detrimental effects on the *network*:

(1) *Network voltage* collapse; and

(2) Motor *load* loss on under*voltage*.

(e) Such impacts on a *network* are not acceptable and enforceable limits need to be used to prevent them.

16.1.3 Fault clearance time

(a) One of the major factors affecting transient stability is the *fault clearance time*. The *critical fault clearance time* is the longest *time* that a fault can be allowed to remain on the *network* whilst maintaining *network* stability. *Protection* shall be installed to ensure that the *critical fault clearance times* are achieved.

(b) A three-phase fault or a single-phase to ground fault (whichever is the more severe criterion), cleared by the primary *protection*, is selected by *Power and Water* as the basis for establishing transient stability. These faults shall be cleared within the *critical fault clearance time*.

(c) Transient stability shall be maintained for faults cleared by the tripping of any *network* element or a *Generator* under the worst possible *network load* or *generation* pattern.

(d) Any *plant* leading to *network* instability shall be separated from the healthy *network*.

16.1.4 Rotor angle swing and transient voltage dip

(a) Rotor angle swing is not a practical parameter to be in field measured, but a measurable impact on *Users* is the transient *voltage* dip (TVD) resulting from real power swings.

(b) Any *Generator connect*ed to the *distribution network* shall not cause the *Transmission voltage* to exceed the transient *voltage* dip criteria defined in the *Network Technical Code*.

16.1.5 Pole slip protection

(a) The function of pole slip *protection* is to remove an unstable *Generator* from the *network* and prevent the disturbance from causing problems with other *Users*. Pole slip *protection* only removes the pole-slipping *Generator* from the *network* after the machine has slipped at least one pole.

(b) Pole slip *protection* is to be installed on all *generating units* where simulations show that pole slipping is likely following any credible *plant outage* or fault.

16.1.6 Small-signal stability

(a) A *power system* is small-signal stable for a particular steady-state operating condition if, following any small disturbance, it reaches an equilibrium condition which is identical or close to the pre-disturbance condition. Small disturbances include the continuously changing system *load*, OLTC operations, and minor switching operations.

(b) Small-signal instability may be oscillatory, where undamped rotor angle oscillations grow to dangerous magnitudes, or monotonic, where rotor angle differences increase in one *direction*. In either case *generating units* can fall out of synchronism with each other and pole slipping can occur.

(c) Small-signal stability is assessed on the basis of the damping design criterion which states that *"*System damping is considered adequate if, at any credible operating point, after the most critical *single contingency*, simulations indicate that the halving *time* of the least damped electromechanical mode of oscillation is not more than 5 sec. (The 5 sec. halving *time* corresponds to a damping constant of 0.14 Nepers/sec.).*"*

(d) Statistical effects shall be taken into account when analysing test results.

16.2 Transient stability

Transient stability is the inherent ability of a *power system* to remain stable and maintain *network* synchronism when subjected to severe disturbances such as three-phase faults on power lines, loss of *generation*, loss of a large *load* or other failures. Such large disturbances need to be cleared in order to prevent *network* instability and physical damage to *plant*.

Transient stability is assessed on the basis of the first angular swing following a solid three phase fault or single phase-to-ground fault on one circuit at the most critical location that is cleared by the faster of the two *protection scheme*s with all intertrips assumed in service.

16.2.1 Oscillation damping

(a) All electromechanical oscillations resulting from any small or large disturbance in the *power system* shall be well damped and the *power system* shall return to a stable operating state.

(b) The damping ratio of the oscillations should be at least 0.5. For inter-area oscillation modes, lower damping ratios may be acceptable but the halving *time* of such oscillations should not exceed five seconds.

16.2.2 Power system stabilisers

(b) *Power system* simulation studies may indicate the possibility of insufficient damping on the system, and that the best solution to this problem would be the installation of *power system stabiliser*s. These are to be installed on those *generating units* where they will be most effective in improving overall system damping.

(c) The stabilising circuits shall be responsive and adjustable over a wide range of *frequency* range, which shall include frequencies from 0.1 Hz to 2.5 Hz. The PSS settings shall be optimised to provide maximum damping.

16.3 *Voltage* stability criteria

16.3.1 Voltage stability limits

(a) All necessary steps should be taken to ensure that *voltage* collapse does not occur for the most onerous *outage* of a *transmission element* under credible *generation* schedules under full *load* conditions. It should also be assumed that 3% of the installed capacitors are unavailable. *Voltage* collapse is associated with a deficit of *reactive power*. Adequate reactive *reserve*s based on *power system* studies should be provided (see notes below).

Notes:

(1) The system *load* to be used in studies is the 1 in 10 year probability forecast.

(2) All *generation* with the exception of one unit is to be taken as available with none of the MVAr limits to be exceeded.

(b) *Voltage* stability is a function of the dynamic characteristics of system *load*s. A *power system* at a given operating state and subject to a given disturbance is *voltage* stable if post-disturbance *voltage*s at every point on the system reach equilibrium within satisfactory limits. Disturbances may be small or large, and *time* frames may vary from tenths of a second to several hours.

(c) *Voltage* instability most commonly results in *voltage* collapse, but may give rise to excessively high *voltage* levels under some conditions.

(d) Adequate and appropriate *reactive power* compensation shall be provided to ensure that the *power system* is protected against all forms of *voltage* instability. This can include the use of shunt and series capacitors and / or *reactor*s, SVCs, *synchronous condensers*, etc.

16.3.2 Voltage collapse

(a) A *power system* undergoes *voltage* collapse if post-disturbance *voltage*s are below acceptable limits. *Voltage* collapse may be total (blackout) or partial.

(b) The possibility of an actual *voltage* collapse depends upon the nature of the *load*. If the *load* is stiff (constant power, such as a synchronous motor) the collapse is aggravated. If the *load* is soft, e.g. heating, the power absorbed by the *load* falls off rapidly with *voltage* and the situation is alleviated.

16.3.3 Resonance conditions

(a) *Voltage* oscillations can arise within a *power system* as a result of resonance conditions. Resonance effects are generally caused by a series resonance between a capacitance and an inductance, for example a *capacitor bank* and the inductive reactance of a *transmission line* or *transformer*.

(b) *Network* resonant frequencies can exist above and below synchronous *frequency* and a latent resonance can be excited by a variety of *network* disturbances (large or small).

(c) If resonance is excited following a *network* disturbance, then oscillations appearing as *network voltage* amplitude modulations can arise.

(d) If the damping mode of the *network* at the resonant *frequency* is positive then the *network* will absorb the oscillation. However, if the damping is negative, the oscillations will build up and lead to supersynchronous (>50 Hz) or subsynchronous (<50 Hz) instability.

(e) If corrective action (typically in the form of *load shedding*) is not taken, then this form of oscillation can lead to extensive damage to *network* and *customer* equipment.

(f) Locations with a low fault level and a weak electrical *connection* (usually with impedance higher than 1.0 p.u. to the source) are prone to sub-synchronous oscillations or resonance.

16.3.4 Transient over-voltages

Transient over-*voltage*s can arise from normal switching operations and external influences such as lightning strikes. Surge diverters are used where necessary to ensure that the transient over-*voltage* seen by an item of *network plant* is limited to its rated lightning impulse withstand *voltage* level.

16.3.5 Temporary over-voltages

Temporary AC over-*voltage*s should not exceed the *time* duration limits given in *Australian Standard* AS2926 – 1987 unless specific designs are implemented to ensure the adequacy and integrity of equipment on the *power system*, and that the effects on *load*s have been adequately mitigated.

16.3.6 Transient voltage dip criteria (TVD)

After clearing a system fault the *voltage* should not drop below 75% and shall not be below 80% for more than 0.4 seconds during the power swing that follows the fault. The maximum transient *voltage* dip is 25% and the maximum duration of *voltage* dip exceeding 20% is 20 cycles (400ms).

16.4 *Frequency* stability criteria

(a) The *frequency* stability criterion relates to the recovery times for excursions of the system *frequency* from the steady state limits.

(b) The *rate of change of frequency* for each of the regulated power systems is defined as:

Darwin – Katherine	± 4 Hz/ Sec
Alice Springs	± 4 Hz/ Sec
Tennant Creek	± 4 Hz/ Sec

(c) To cover for a loss of a *generating system facilities* there are two measures applied to bring back the falling *frequency*:

(1) *Spinning reserve*; and

(2) *Under frequency load shedding* (UFLS).

(d) *Under frequency load shedding* relays are installed at zone *substations* to shed *load* at pre-determined levels of *frequency* at or below 49.25 Hz following loss of a major *generating unit* or its *interconnection*.

(e) Following loss of a *generating system*, system *frequency*, depending on *spinning reserve* or C-FCAS as applicable in each regulated power system, may still decline to such levels that the UFLS automatic scheme will be used to reduce *network load* in order to help the *frequency* recovery.

(f) It is a requirement for *power system security* that 75% of the *power system load* at any *time* be available for *disconnection* under:

  (1) The automatic control of *under frequency* relays; and

  (2) Manual or automatic control from *control centre*s; and/or

  (3) The automatic control of under*voltage* relays.

(g) In some circumstances, it may be necessary to have up to 90% of the *power system load*, or up to 90% of the *load* within a specific part of the *network*, available for automatic *disconnection*. *Power and Water* will advise *Users* if this additional requirement is necessary.

(h) Special *load shedding* arrangements may be required to be installed to cater for abnormal operating conditions.

(i) The settings for *under-frequency load shedding* in the various *regions* throughout the Northern Territory are given in Figure 3 of *this Code*.

17 Quality of supply criteria

(a) *Quality of supply* criteria regulate the *voltage* and current waveforms in the *network* and criteria are established for the following aspects:

  (1) *Voltage* fluctuation;

  (2) System *Frequency*;

  (3) Harmonic distortion;

  (4) *Voltage* unbalance; and

  (5) *Network reliability*.

(b) The *network*s are analysed to ensure satisfactory performance, in accordance with the *quality of supply* criteria, whenever a new *User* is *connect*ed or a complaint from an existing *User* is received.

(c) The aspects of *quality of supply* that are analysed are:

  (1) *Steady state voltage;*

  (2) *Voltage* fluctuation; and

  (3) *Network frequency, on isolated regional networks.*

(d) Harmonic *voltage* and current and *voltage* unbalance will be analysed depending on the nature of the *load* of the new *User* being *connect*ed.

17.1 Voltage fluctuation criteria

A *voltage* disturbance is where the *voltage* shape is maintained but the *voltage* magnitude varies and may fall outside the steady state *supply voltage* range set out in clause 15.2 of the *Network Planning Criteria*.

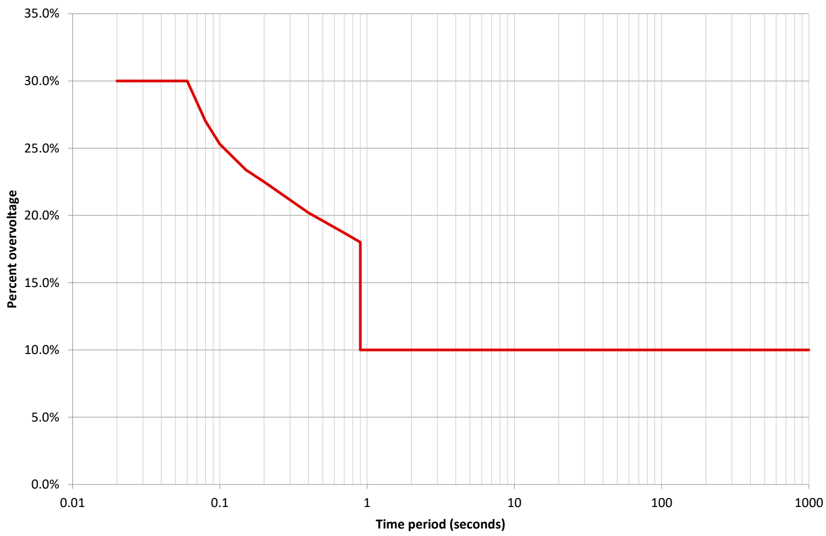
(a) Short duration *voltage* disturbances with durations of up to one minute are termed *voltage* sags and swells.

(b) Short duration *voltage* disturbances generally arise from faults on the *network* and may not be able to be economically eliminated.

17.1.1 Temporary over-voltages

(a) As a consequence of a *credible contingency event*, the *voltage* of *supply* at a *connection point* should not rise above its *normal voltage* by more than a given percentage of *normal voltage* for longer than the corresponding period shown in Figure 18 for that percentage.

Figure 18 – Over *voltage* limit for *contingency events*



(b) *Users'* equipment shall also be designed to withstand these *voltage* levels.

(c) As a consequence of a *contingency event*, the *voltage* of *supply* at a *connection point* could fall to zero for any period.

17.1.2 Step changes in voltage levels

(a) Step changes in the *power system voltage* levels may take place due to switching operations on the *network*. The step *change*s in *voltage* shall not exceed the limits set out in Figure 19.

Figure 19 – Step *change voltage* limits

Cause	Pre-tap-changing		Post-tap-changing (final steady state)	
	≥ 66 kV	< 66 kV	≥ 66 kV	< 66 kV
Routine Switching (1)	±4.0 % (max)	±4.0% (max)	*Network voltage*s shall be between 110% and 90% of *nominal voltage*	Should attain previous set point
Infrequent Switching (2)	+6%, –10% (max)	+6%, –10% (max)	±10% (max)	Should attain previous set point

Notes: 1 For example, capacitor switching, *transformer* tap action, motor starting, start-up and shutdown of *generating unit*s.

2 For example, tripping of *generating unit*s, *load*s, lines and other components.

(b) *Voltage* fluctuation severity is characterised by the following two quantities, which are defined in *Australian Standard* AS/NZS 61000.3.7 (2001):

(1) P_{st} - short-term flicker severity term (obtained for each 10 minute period); and

(2) P_{lt} - long-term flicker severity (obtained from 12 consecutive P_{st} periods for each 2 hour period).

(c) Under normal operating conditions, flicker severity caused by *voltage* fluctuation in the *transmission* and *network* shall be within the planning levels shown in Figure 20 for 99% of the *time*.

Figure 20 – Flicker severity – planning levels

Flicker Severity Quantity	LV 230/400 V	MV (11-66 kV)	HV (132 kV)
P_{st}	1.0	0.9	0.8
P_{lt}	0.7	0.7	0.6

Notes:

1. These values were chosen on the assumption that the transfer coefficients between MV or HV systems and *LV* systems are unity. The planning levels could be increased in accordance with AS61000.3.7 (2001).
2. The planning levels in this Table are not intended to apply to flicker arising from contingency and other uncontrollable events in the *power system*, etc.

(d) *Voltage* fluctuations for individual *Users* shall be measured at the point of Common Coupling, which is the point of *connection* to other *Users* in the same portion of the *network*.

17.2 Harmonic *voltage* and current distortion

(a) *Power and Water*'s power *network*s and all *plant* and equipment *connect*ed thereto shall be planned and designed to ensure that harmonic *voltage*s and currents do not exceed the limits defined in *Australian Standard* AS/NZS 61000.3.6 (2001).

(b) For planning purposes the harmonic *voltage* levels shown in Figure 21 apply to the respective system *voltage* level.

Figure 21 - Harmonic *voltage* distortion limits – planning levels

Odd harmonics non multiple of 3			Odd harmonics multiple of 3			Even harmonics		
Order h	**Harmonic *voltage* %**		**Order h**	**Harmonic *voltage* %**		**Order h**	**Harmonic *voltage* %**	
	LV	≥11 kV		*LV*	≥11 kV		*LV*	≥11 kV
5	5.0	2.0	3	4.0	2.0	2	1.6	1.5
7	4.0	2.0	9	1.2	1.0	4	1.0	1.0
11	3.1	1.5	15	0.3	0.3	6	0.5	0.5
13	2.5	1.5	21	0.2	0.2	8	0.4	0.4
17	1.6	1.0	>21	0.2	0.2	10	0.4	0.4
19	1.2	1.0				12	0.2	0.2
23	1.2	0.7				>12	0.2	0.2
25	1.2	0.7						
>25	$0.2 + 0.5 \cdot \frac{25}{h}$	$0.2 + 0.5 \cdot \frac{25}{h}$						

Notes to Figure 21:

1. This Table is derived from *Australian Standard* AS/NZS 61000.3.6 (2001).
2. The total harmonic distortion (U_t) is calculated from the expression

$$U_t = \frac{U_{nom}}{U_1}\sqrt{\sum_{h=2}^{40}(U_h)^2}$$

Where:

U_{nom} *nominal voltage* of a system

U_1 fundamental *voltage*

U_h harmonic *voltage* of order h expressed as a percentage of the *nominal voltage*.

3. The harmonic distortion limits apply to each phase.
4. Intermittent harmonic *voltage* distortion is subject to the same limits as continuous harmonic *voltage* distortion.

5. Existing (background) levels of harmonic *voltage* distortion are not included when assessing the harmonic contribution.

17.2.1 Inter-harmonic distortion

Inter-harmonic or non-integer harmonic distortion may arise from large convertors or power electronics equipment with Pulse Width Modulation (PWM) converters interfacing with the *power system*.

A *User's* inter-harmonic *voltage* distortion contribution shall not exceed the planning level of 0.2% specified in section 9 of *Australian Standard* AS/NZS 61000.3.6:2001.

17.2.2 Direct current

(a) *Plant* and equipment shall comply with the requirements on direct current components as stipulated in clause 3.12 of *Australian Standard* AS 3100. In particular, the direct current in the neutral caused by the *User's plant* and equipment shall not exceed 120mAh per *day*.

(b) The responsibility of the *Network Operator* for direct current in the neutral outside the limits specified in this clause shall be limited to direct current in the neutral caused by *network* assets.

(c) *Plant* and equipment at *Users'* premises shall perform to the standards specified in subclause (a).

17.3 Voltage unbalance

(a) For normal system operation and for planned system *outage*s, the *voltage* unbalance at each of *connection point*s to the *network* shall not exceed the limits set out in clause 2.4.3 of the *Code*.

(b) The responsibility of *Power and Water* for *voltage* unbalance outside the limits specified in clause 17.3(a) shall be limited to *voltage* unbalance caused by *network* assets.

(c) *Users'* equipment shall perform to the standards specified in clause 17.3(a).

17.4 Electromagnetic interference

Power and Water shall design its *network*s to ensure that the electromagnetic interference caused by its *plant* and equipment does not exceed the limits set out in Tables 1 and 2 of *Australian Standard* AS 2344.

18 Construction standards criteria

(a) *Power and Water* shall construct the overhead portions of its *network*s in accordance with the Electricity Supply Association of Australia publication

C(b)1 -"Guidelines for Design and Maintenance of Overhead Distribution and Transmission lines*"*.

(b) *Power and Water* shall construct the underground portions of its *network*s in accordance with the Electricity Supply Association of Australia publication C(b)2 - *"*Guide to the Installation of Cables Underground*"*.

18.1 Conductor selection criteria

(a) *Power and Water* generally uses overhead conductors for *transmission* and sub-*transmission* circuits in order to minimise construction costs. *Power and Water* may use underground cables for such circuits where required by environmental *constraint*s and where the additional cost can be justified.

(b) *Power and Water* uses underground cables for *distribution network* reinforcement and *extension* within the Darwin Metropolitan area, *Regional* Centres, new sub-divisions where in *Power and Water'*s opinion they are appropriate, or if required by legislation. Outside these areas *Power and Water* will generally install overhead conductors.

(c) In designing *extension*s to the *network*, ultimate *load* horizon planning shall be used to establish the *network* concept plan and the initial installation shall conform to that concept plan and use carriers that are appropriately sized. This methodology eliminates the need to disrupt the community in future years as *load* growth occurs and results in the minimum lifetime cost to the community.

(d) To achieve maximum cost efficiency in the installation of conductors, standard overhead conductor and underground cable sizes have been selected. This results in minimum stock holdings and purchase prices, giving the *User* the least cost *network*.

(e) The standard conductor size that is equal to, or greater than that required for the reasonably foreseeable *load*, shall be used for each overhead *network extension* or reinforcement.

(f) The standard cable size that is equal to, or greater than that required for the horizon *load*, shall be used for each underground *network extension* or reinforcement.

19 Environmental criteria

Power and Water's environmental policy states that:

"*Power and Water* recognises and accepts its environmental responsibilities arising from the provision of power, water and sewerage services.

"*Power and Water* will seek to minimise environmental impacts and comply with environmental regulations.

"Continual improvement in environmental performance will be sought by *Power and Water* through:

- Implementing a comprehensive Environmental Management System;
- Minimising the environmental impacts of its operations;
- Promoting individual ownership of environmental care among its people; and
- Consulting with the community on environmental issues.

"Sustainable Development will be pursued by *Power and Water* through:

- Adoption of integrated resource planning;
- Use of renewable resources;
- Maximisation of long term benefits from non-renewable resources; and
- Promotion and adoption of waste minimisation and recycling practices."

Power and Water commits to the following objectives to fulfil its environmental policy:

- To consult openly and fully with the community and government where Authority activity may affect the environment;
- To ensure that planning and design for new projects and *change*s to existing processes provide for consideration of best environmental practice technology and *time*ly impact assessment; and
- To carry out its business in a resource efficient manner.

*Power and Water'*s power *network*s will be developed so that these *commitment*s are met.

19.1 Social issues

Power and Water shall inform and consult with relevant public bodies and community interest groups and the general public on the planning of new developments and *facilities*.

19.2 Electromagnetic fields

Recognising the current state of scientific uncertainty regarding adverse health effects from exposure to power *frequency* electric and magnetic fields, *Power and Water* shall act prudently and design, construct and operate all equipment and *facilities* to maintain electromagnetic field exposure to the public and *Power and Water* employees at levels within the Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields set out in the ARPANSA Radiation Health Series No. 30 standard.

19.3 Land-Use considerations

Power and Water shall avoid, or minimise damage to natural, cultural and historical sites where reasonable and economically practical, consistent with the safe and *reliable* operation of the electricity *supply network*.

19.4 Noise

Power and Water shall comply with the noise limit provisions of relevant guidelines made under the *Waste Management and Pollution Control Act*.

19.5 Visual amenity

Given that the community and *customer*s are sensitive to the visual impact of electrical installations, *Power and Water* shall conduct its electricity *supply* operations in a manner that minimises visual impact.

Part D Attachments

Attachment 1 Glossary of Terms

In this *Code*, unless the contrary intention appears:

(a) A word or phrase set out in column 1 of the table below has the meaning set out opposite that word or phrase in column 2 of the table below;

(b) A word or phrase defined in the *Power and Water Corporation Act* has the meaning given in that Act unless redefined in the table below; and

(c) An italicised word or phrase defined in the *NT NER* has the meaning given in the *NT NER* unless redefined in the table below.

Terminology	Definition
Access Application	An "access application" made under clause 10 of the Networks Access Code or a connection application or application to connect made under Chapter 5 or Chapter 5A of the NT NER.
access services	The following services: *use of system services*; *common services*; *connection services* and *ancillary services*.
active energy	A measure of electrical *energy* flow, being the *time* integral of the product of *voltage* and the in-phase component of current flow across a *connection point*, expressed in Watt-hours (Wh) and multiples thereof.
active power	The rate at which *active energy* is transferred.
active power capability	The maximum rate at which *active energy* may be transferred from a *generating unit* to a *connection point* as specified in an *Access Agreement*.
active unit protection	Generally, a *protection scheme* that compares the conditions at defined *primary plant* boundaries and can positively identify whether a fault is internal or external to the protected *plant*. Unit *protection schemes* can provide high speed (less than 150 milliseconds) *protection* for the protected *primary plant*. Generally, unit *protection schemes* will not be capable of providing back up *protection*.
adverse system strength impact	An adverse impact, assessed in accordance with the *system strength impact assessment guidelines*, on the ability under different operating conditions of: (a) the *power system* to maintain system stability; or (b) a *generating system* forming part of the *power system* to maintain stable operation including following any *credible contingency event*, so as to maintain the *power system* in a *secure operating state*.
agreed capability	In relation to a *connection point*, the capability to receive or send out *active power* and *reactive power* for that *connection point* determined in accordance with the relevant *Access Agreement*.

Terminology	Definition
ancillary services	The following services: *voltage control*, *reactive power* control, *frequency* control, *control system services*, *spinning reserve* and *post-trip management*.
ancillary services agreement	An agreement covering the provision of *ancillary services*.
associated load	A *load* which is normally supplied by a particular *Generator* and is associated with that *Generator* by ownership or some contractual arrangement. The *load* may be remote from the *Generator* or on-site.
augment, augmentation	In relation to the *electricity network*, means to enlarge or expand the capability of the *electricity network* to accept, transport and deliver electricity.
***Australian Standard* (AS)**	The most recent edition of a standard publication by Standards Australia (Standards Association of Australia).
automatic access standard	In relation to a technical requirement of access, a standard of performance, identified in clause 3.3.5 of this *Code* as an automatic access standard for that technical requirement, such that a *plant* that meets that standard would not be denied access because of that technical requirement.
automatic reclose equipment	In relation to a power line, the equipment which automatically recloses the relevant line's circuit breaker(s) following their opening as a result of the detection of a fault in the power line.
backup protection	A *protection* intended to supplement the main *protection* in case the latter should be ineffective, or to deal with faults in those parts of the *power system* that are not readily included in the operating zone of the main *protection*.
black start capability	In relation to a *generating unit*, the ability to start and *synchronise* without using *supply* from the *power system*.
black start-up facilities	The *facilities* required to provide a *generating unit* with black start-up capability.
black system	The absence of *voltage* on all or a significant part of the *network* following a major *supply* disruption, affecting one or more *power stations* and a significant number of *customer*s.
breaker fail protection	In relation to a *protection scheme*, that part of the *protection scheme* that protects a *User's facilities* against the non-operation of a circuit breaker when it is required to open.
busbar	A common *connection point* in a *power station substation* or a *transmission network substation*.
business day	Any *day* other than a Satur*day*, Sun*day*, or *day* that is a public holi*day* in the City of Darwin.
capacitor bank, capacitor	A type of static electrical equipment used to generate *reactive power* and therefore support *voltage* levels on *network* elements.
cascading outage	The occurrence of an uncontrollable succession of *outage*s, each of which is initiated by conditions (e.g. instability or over*load*ing) arising or made worse as a result of the event preceding it.

Terminology	Definition
C-FCAS	Contingency frequency control ancillary services (a subset of FCAS).
change	Includes amendment, alteration, addition or deletion.
circuit breaker failure	A circuit breaker will be deemed to have failed if, having received a trip signal from a *protection scheme*, it fails to interrupt fault current within its design operating *time*.
Code, Technical Code	This *Code* called the *Technical Code*.
Code commencement date	The date given in clause 1.4 of this *Code*.
commitment	The commencement of the process of starting up and *synchronising* a *generating unit* to the *power system*.
common services	A *network* service that ensures the integrity of the *electricity network* and benefits all *Users* and that cannot be practically ~~be~~ allocated to *Users* on a locational basis.
complementary	In relation to *protection*, two *protection scheme*s are said to be *complementary* when, in combination, they provide dependable clearance of faults on *plant* within a specified *time*, but with any single failure to operate of the *secondary plant*, fault clearance may be delayed until the nature of the fault *change*s.
confidential information	In relation to a *Generator* or *Network Operator*, information which is or has been provided to that *Generator* or *Network Operator* under or in connection with the *Code* and which is stated under the *Code* or by the *Network Operator* or by the *Utilities Commission* to be confidential information or is otherwise confidential or commercially sensitive. It also includes any information which is derived from such information.
connect, connection	Means to establish an effective link via installation of the necessary *connection* equipment.
connection agreement	Means an agreement between a network provider and a *Network User* which permits a person to *connect* plant or premises to the *network*. It includes an agreement for the provision of *network access services* entered into *network* provider whether under the former Network Access Code, or under applicable provisions of the *NT NER.*
connection asset	Means all of the electrical equipment that is used only in order to transfer electricity to or from the *electricity network* at the relevant *connection point* and includes any *transformer*s or switchgear at the relevant point or which is installed to support or to provide backup to such electrical equipment as are necessary for that transfer.
connection point	A point at which electricity is transferred to or from an *electricity network*.
connection services	In relation to a *connection point*, means the establishment and maintenance of that *connection point*.

Terminology	Definition
constraint, constrained	A limitation on the capability of a *network*, *load* or a *generating unit* preventing it from either transferring, consuming or generating the level of electrical power which would otherwise be available if the limitation was removed.
contingency frequency control ancillary services	Services to correct the generation / demand balance following a major contingency event such as the loss of a *generating unit*, major industrial load, or a large transmission element.
contingency event	An event affecting the *power system* which the *Network Operator* expects would be likely to involve the failure or removal from operational service of a *generating unit* or *network* element.
continuous uninterrupted operation	In respect of a *generating system* or *generating unit* operating immediately prior to a *power system* disturbance: (a) not disconnecting from the *power system* except under its performance standards established under clauses 3.3.5.8 and 3.3.5.9; (b) during the disturbance contributing active and reactive current as required by its performance standards established under clause 3.3.5.5; (c) after clearance of any electrical fault that caused the disturbance, only substantially varying its active power and reactive power as required or permitted by its performance standards established under clauses 3.3.5.5, 3.3.5.11, 3.3.5.13 and 3.3.5.14; and (d) not exacerbating or prolonging the disturbance or causing a subsequent disturbance for other *connected plant*, except as required or permitted by its performance standards, with all essential auxiliary and *reactive plant* remaining in service.
control centre	The *facility* used by the *Power System Controller* for directing the minute to minute operation of the *power system*.
controller	A person employed by a *Power System Controller* engaged in the activities of controlling the transfer of electrical *energy* at a *connection point*.
control system	Means of monitoring and controlling the operation of the *power system* or equipment including *generating units connect*ed to a *network*.
control system services	The 24-hour control of the *power system* through monitoring, switching and *dispatch* which is provided through *control centre*s and SCADA and communication equipment.
credible contingency event	A *contingency event* the occurrence of which the *System Controller considers* to be reasonably possible in the surrounding circumstances.
critical fault clearance time	Refers to the maximum *total fault clearance time* that the *power system* can withstand without one or both of the following conditions arising: • Instability (refer to clause 2.6); and

Terminology	Definition
	• Unacceptable disturbance of *power system voltage* or *frequency*.
critical single credible contingency event	A single *credible contingency event* considered by the *Network Operator,* in particular circumstances, to have the potential for the most significant impact on the *power system* at that *time*. This would generally be the instantaneous loss of the largest *generating unit* or a fault on a *network* element on the *power system*. However, this may involve the consideration by the *Network Operator* of the impact of the loss of any *interconnection* under abnormal conditions.
credible contingency	An individual *credible contingency event* for which a *User* adversely affected by the event would reasonably expect, under normal conditions, the design or operation of the relevant part of the meshed *power system* would adequately cater, so as to avoid significant disruption to *power system security*.
current rating	The maximum current that may be permitted to flow (under defined conditions) through a power line or other item of equipment that forms part of a *power system*.
current transformer (CT)	A *transformer* for use with meters and/or *protection* devices in which the current in the secondary winding is, within prescribed error limits, proportional to and in phase with the current in the primary winding.
customer	A person who purchases electricity supplied through a *network*.
day	Unless otherwise specified, the 24 hour period beginning and ending at midnight Australian Central Standard *Time*.
decommission, decommissioning	In respect of an item of *plant* or a *generating unit*, ceasing to operate and being *disconnected* from a *network*.
derogation	Modification, variation or exemption to one or more provisions of the *Code* in relation to a *User* according to clause 12.
de-synchronising/ de-synchronisation	The act of *disconnection* of a *generating unit* from the *power system*, normally under controlled circumstances.
differing principle	Two *protection schemes* are said to be of *differing principle* when their functioning is based on different measurement or operating methods, or use similar principles but have been designed and manufactured by different organisations.
direction	A *direction* issued by the *Network Operator* or *Power System Controller* to any *User* requiring the *User* to do any act or thing which the *Network Operator* or *Power System Controller* considers necessary to maintain or re-establish *power system security* or to maintain or re- establish the *power system* in a *reliable* operating state in accordance with this *Code*.
disconnection, disconnect, disconnected, disconnecting	In respect of a *connection point* or item of *plant*, means to operate switching equipment so as to prevent the transfer of electricity through the *connection point* or item of *plant*.

Terminology	Definition
dispatch	The act of committing to service all or part of the *generation* available from a *scheduled generating unit*.
distribution system, distribution network	That part or those parts of the *electricity network* used for transporting electricity at *nominal voltage*s of less than 66 kV and at a nominal *frequency* of 50Hz.
dynamic performance	The response and behaviour of *network*s and *facilities* which are *connect*ed to the *network*s when the normal operating state of the *power system* is disturbed.
electrical energy loss	*Energy* loss incurred in the production, transportation and/or use of electricity.
electricity network	The *connection asset*s and *network* system assets which together are operated by the network provider for the purposes of transporting electricity from *Generator*s of electricity to a transfer point or to consumers of electricity.
Electricity Reform Act	The *Electricity Reform Act 2000* (NT)
Electricity Reform (Administration) Regulations	*Electricity Reform (Administration) Regulations 2000* (NT)
electricity transmission capacity	The capacity of the *transmission network* to transmit power between two or more points under the full range of operating conditions likely to be experienced in service.
embedded Generator	A *Generator* which supplies on-site *load*s or *distribution network load*s and is *connect*ed either indirectly (i.e. via the *distribution network*) or directly to the *transmission network*.
energise/energisation	The act of operation of switching equipment or the start-up of a *generating unit*, which results in there being a non-zero *voltage* beyond a *connection point* or part of the *network*.
energy	*Active energy* and/or *reactive energy*.
excitation control system	In relation to a *generating unit*, the automatic *control system* that provides the field excitation for the *Generator* of a *generating unit* (including excitation limiting devices and any *power system stabiliser*).
Existing Connection Plant	Has the meaning given in clause 12.2.
extension	The capital investment associated with the designing, constructing, installing and commissioning of the *electricity network* assets required to *connect* a *User* to the *electricity network*.

Terminology	Definition
facility, facilities	A generic term associated with the apparatus, equipment, buildings and necessary associated supporting resources provided at, typically: • a *power station* or *generating unit*, including start-up *facilities*; • a *substation* or *power station substation*; • a *control centre*.

Terminology	Definition
fault clearance time	The *time* interval between the occurrence of a fault and the fault clearance.
FCAS	*Frequency control ancillary services*
financial year	A period commencing on 1 September in one calendar year and terminating on 30 June in the following calendar year.
frequency	For alternating current electricity, the number of cycles occurring in each second. The term Hertz (Hz) corresponds to cycles per second.
frequency control ancillary services	The suite of services used by the *Power System Controller* to maintain the frequency on the electrical system, at any point in time, close to fifty cycles per second as required by the NT frequency standards.
frequency operating standards	The *frequency* standards set out in clauses 2.2, and 2.4 of this *Code*.
frequency response mode	The mode of operation of a *generating unit* which allows automatic *change*s to the *generated* power when the *frequency* of the *power system change*s.
generated	In relation to a *generating unit*, the amount of electrical *energy* produced by the *generating unit* as measured at its terminals.
generating system	A system comprising one or more *generating units* and includes auxiliary or *reactive plant* that is located on the *Generator's* side of the *connection point* and is necessary for the *generating system* to meet its performance obligations.
generating unit	The plant used in the production of electricity and all related equipment essential to its functioning as a single entity.
generation	The production of electrical *energy* by converting another form of *energy* in a *generating unit*.
generation centre	A geographically concentrated area containing a *generating unit* or *generating units* with significant combined generating capability.
Generator	A person who engages in the activity of owning, controlling or operating a *generating system* that is *connected* to a *Network* and, in respect of a *generating system* connected to the Darwin-Katherine power system, is either registered by the *Market Operator* as a *Generator* or, intends to register with the *Market Operator* as a *Generator*.
Generator User	A person who has been granted access to the electricity network by the network provider and who supplies electricity into the electricity network at an entry point.
good electricity industry practice	The exercise of that degree of skill, diligence, prudence and foresight that reasonably would be expected from a significant proportion of operators of *facilities* forming part of a *power system* for the *generation*, *transmission distribution* and *supply* of

Terminology	Definition
	electricity comparable to those applicable to the relevant *facility* consistent with applicable laws, the Access *Code*, the *Technical Code*, licences, industry *Code*s, *reliability*, safety and environmental *protection*.
governor system	The automatic *control system* which regulates the speed and power output of a *generating unit* through the control of the rate of entry into the *generating unit* of the primary *energy* input (for example, steam, gas or water).
inertia	Contribution to the capability of the power system to resist changes in frequency by means of an inertial response from a *generating unit*, network element or other equipment that is electro-magnetically coupled with the power system and synchronised to the frequency of the power system.
inertia FCAS	Inertia frequency control ancillary services (a subset of FCAS).
Inertia frequency control ancillary services	Services that contribute to the capability of the power system to resist changes in frequency by means of an inertial response from a *generating unit*, network element or other equipment that is electro-magnetically coupled with the power system and synchronised to the frequency of the power system.
instrument transformer	Either a *current transformer* (CT) or a *voltage transformer* (*VT*).
interconnection, interconnector, interconnect, interconnected	A *transmission line* or group of *transmission line*s that *connect*s the *transmission network*s in adjacent *regions*.
interruptible load	A *load* which is able to be *disconnect*ed, either manually or automatically initiated, which is provided for the restoration or control of the *power system frequency* by the *Power System Controller* to cater for *contingency event*s or shortages of *supply*
intra-regional	Within a *region*.
Large Generator	A *Generator* that is not a *Small Generator.*
large network investment	A proposed investment in augmentation of the *network* or a non-*network* alternative with a capitalised net present value in excess of $5 Million.
load, loading	The amount of electrical *energy* delivered at a defined instant at a *connection point* or aggregated over a group of *connection point*s.
load centre	A geographically concentrated area containing *load* or *load*s with a significant combined consumption capability.
load shedding	Reducing or *disconnect*ing *load* from the *power system*. (See also *under frequency load shedding*, *under voltage load shedding*).
local black system procedures	The procedures, described under clause 4.7 applicable to a *User* as procedures approved by the *Power System Controller* from *time* to *time*.

Terminology	Definition
***low voltage* (*LV*)**	That portion of the *network* and *connection*s to it operating at a *nominal voltage* of 230 volts single phase or 400 volts three phase.
Market Operator	A function of the *Power System Controller* pursuant to the *Electricity Reform Act* and *Electricity Reform (Administration) Regulations*.
maximum fault current	The current that will flow to a fault on an item of *plant* when *maximum system conditions* prevail.
maximum system conditions	For any particular location in the *power system*, *maximum system conditions* are those which will prevail with the maximum number of *Generator*s and *network* elements normally *connect*ed at *time*s of maximum *generation*.
meter, metering, metering equipment	Equipment used to measure and record the rate at which electricity is transferred and the quantity of electricity transferred to and from the *network*.
minimum fault current	The current that will flow to a fault on an item of *plant* when present *day minimum system conditions* prevail.
minimum system conditions	For any particular location in the *power system*, *minimum system conditions* are those which will prevail with the least number of *Generator*s and *network* elements normally *connect*ed at *time*s of minimum *generation*, in combination with one *primary plant outage*. The *primary plant outage* shall be taken to be that which, in combination with the minimum *generation*, leads to the lowest fault current at the particular location for the fault type under consideration.
monitoring equipment	The testing instruments and devices used to record the performance of *plant* for comparison with expected performance.
month	Unless otherwise specified, the period beginning at 12.00 am on the *"*relevant commencement date*"* and ending at 12.00 am on the date in the *"*next calendar *month"* corresponding to the commencement date of the period. If the *"*relevant commencement date*"* is the 29th, 30th or 31st and this date does not exist in the *"*next calendar *month"*, then the end date in the *"*next calendar *month"* shall be taken as the last *day* of that *month*.
nameplate rating	The maximum continuous output or consumption in MW or MVA of an item of equipment as specified by the manufacturer.
NATA	National Association of Testing Authorities.
network	See definition for *electricity network*.
negotiated access standard	In relation to a technical requirement of access for a particular plant, an agreed standard of performance determined in accordance with this Code and identified as a negotiated access standard for that technical requirement in a connection agreement.

Terminology	Definition
Network Access Code	The Northern Territory Electricity Networks (Third Party Access) Code that was established under Part 2 of the Northern Territory *Electricity Networks (Third Party Access) Act* (now repealed).
network capability	The capability of the *network* or part of the *network* to transfer electrical *energy* from one location to another.
network losses	The *energy* loss incurred in the transportation of electricity from an entry or transfer point to an exit point or another transfer point on an *electricity network*.
Network Management Plan	A report prepared and published annually by the *Network Operator*. Amongst other things, this report contains the following details: • network limitations; • potential non-network and network solutions for small network investments; and • potential non-network and network solutions for large network investments.
Network Operator	A person defined as a *"*network provider*"* under section 4(1) of the *Electricity Reform Act* as in force at 1 July 2019.
Network Planning Criteria	Criteria consistent with this *Code* prepared by the *Network Operator* which include the following: contingency criteria; steady-state criteria; stability criteria (transient, dynamic, *voltage*, and *frequency*); *quality of supply* criteria (*voltage* limits, *voltage* fluctuation, system *frequency*, harmonic *voltage*, harmonic current, *voltage* unbalance, electro-magnetic interference) and environmental criteria.
Network User	Any person or body that has entered into a *connection agreement* with the *Network Operator* to convey electricity from an *entry point* to an *exit point*.
nomenclature standards	The standards approved by the *Network Operator* relating to numbering, terminology and abbreviations used for information transfer by *Users* as provided for in clause4.9.
non-credible contingency event	A *contingency event* other than a *credible contingency event*. It means a *contingency event* in relation to which, in the circumstances, the probability of occurrence is considered by the *System Controller* to be very low.
normal operating frequency band	In relation to the *frequency* of the *power system*, means the range specified in clause 2.2.1.
normal operating frequency excursion band	In relation to the *frequency* of the *power system*, means the range specified as being acceptable for infrequent and momentary excursions of *frequency* outside the *normal operating frequency band* being the range specified in clause 2.2.1.
nominal voltage	The design *voltage* level, nominated for a particular location on the *power system*, such that power lines and circuits that are electrically *connected* other than through transformers have the same *nominal voltage* regardless of operating *voltage*.

Terminology	Definition
normal voltage	In respect of a *connection point*, its *nominal voltage* or such other *voltage* up to 10% higher or lower than *nominal voltage*, as approved by the *Network Operator*, for that *connection point.*
NT NER	The National Electricity Rules as applicable in the Northern Territory.
operational communication	A communication concerning the arrangements for, or actual operation of the *power system* in accordance with the *Code*.
operational frequency tolerance band	The range of frequency within which the power system is to be operated under abnormal operating conditions as specified in clause 2.2.2 (b).
outage	Any planned or unplanned full or partial unavailability of *plant* or equipment.
peak load	Maximum *load*.
plant	Includes all equipment involved in generating, utilising or transmitting electrical *energy*.
post-trip management	The maintenance of system security in the aftermath of trips.
Power and Water Corporation	The body corporate established under the *Government Owned Corporations Act* .
power factor	The ratio of the *active power* to the apparent power at a point.
power station	In relation to a *Generator*, a *facility* in which any of that *Generator's generating units* are located.
power system	The *generation facilities* and *electricity network facilities* which together are integral to the *supply* of electricity, operated as an integrated arrangement.
Power System Controller	The entity licenced by the Utilities Commission pursuant to section 30 of the Electricity Reform Act.
power system operating procedures	The procedures to be followed by *Users* in carrying out operations and /or maintenance activities on or in relation to primary and *secondary equipment connect*ed to or forming part of the *power system* or *connection point*s, as described in the System Control Technical Code.
power system security	The safe scheduling, operation and control of the *power system* on a continuous basis in accordance with the principles set out in the System Control Technical Code.
power system security responsibilities	The responsibilities described in clause 4.3 and in the System Control Technical Code.
power system stabiliser	An auxiliary control device *connect*ed to an *excitation control system* to provide additional feedback signals to reduce *power system* oscillations.
power transfer	The instantaneous rate at which *active energy* is transferred between *connection point*s.
power transfer capability	The maximum permitted *power transfer* through a *network* or part thereof.

Terminology	Definition
primary equipment, primary plant	Refers to apparatus which conducts *power system load* or conveys *power system voltage*.
protection	Used to describe the concept of detecting, limiting and removing the effects of *primary plant* or *primary equipment* faults from the *power system*. Also used to refer to the apparatus required to achieve this function.
protection apparatus	Includes all relays, meters, power circuit breakers, *synchroniser*s and other control devices necessary for the proper and safe operation of the *power system*.
protection scheme	A collection of one or more sets of *protection* for the purpose of protecting *facilities* and the *electricity network* from damage due to an electrical or mechanical fault or due to certain conditions of the *power system*.
protection system	A system which includes all the *protection scheme*s applied to the system.
quality of supply	Refers to, with respect to electricity, technical attributes to a standard referred to in clause 2.4, unless otherwise stated in this *Code* or a connection *agreement*.
ramp rate	The rate of *change* of electrical power produced from a *generating unit*.
rate of change of frequency, (ROCOF)	The rate of change of power system frequency.
reactive energy	A measure, in var-hours (VArh) of the alternating ex*change* of stored *energy* in inductors and capacitors, which is the *time*-integral of the product of *voltage* and the out-of-phase component of current flow across a *connection point*.
reactive plant	*Plant* which is normally specifically provided to be capable of providing or absorbing *reactive power* and includes the *plant* identified in clause 3.6.7.
reactive power	The rate at which *reactive energy* is transferred. *Reactive power* is a necessary component of alternating current electrical power which is separate from *active power* and is predominantly consumed in the creation of magnetic fields in motors and *transformer*s and produced by *plant* such as: • alternating current *Generator*s; • capacitors, including the capacitive effect of power lines; and • *synchronous condensers*.
reactive power capability	The maximum rate at which *reactive energy* may be transferred from a *generating unit* to a *connection point* as specified in a *connection agreement*.
reactive power reserve	Unutilised sources of *reactive power* arranged to be available to cater for the possibility of the unavailability of another source of *reactive power* or increased requirements for *reactive power*.

Terminology	Definition
reactive power support/ reactive support	The provision of *reactive power*.
reactor	A device, similar to a *transformer*, specifically arranged to be *connect*ed into the *network* during periods of low *load demand* or low *reactive power demand* to counteract the natural capacitive effects of long *transmission line*s in generating excess *reactive power* and so correct any *voltage* effects during these periods.
reconnection	In respect of a *connection point*, means to operate switching equipment so as to restore the transfer of electricity through the *connection point*.
region, regional	An area determined by the *Network Operator*, being an area served by a particular part of the *transmission network* containing one or more major *load centre*s *or generation centres* or both.
regulating duty	In relation to a *generating unit*, the duty to have its *generated* output adjusted frequently so that any *power system frequency* variations can be corrected.
regulating frequency control ancillary services	Services to correct the *generation* / demand balance in response to minor deviations in *load* or *generation*.
releasable user guide	A document associated with the data and model provided under clause 3.3.4 (combined, forming the model), that contains sufficient information to enable *connection applicants* for a new or modified *generating unit* or *generating system* to use the model to carry out *power system studies* for planning and operational purposes. The information in a *releasable user guide* must include, but is not limited to: (1) the model parameters and their values; (2) information about how the model parameter values vary with the operating state or output level of the *plant* or with the operating state or output level of any associated *plant*; (3) instructions relevant to the use and operation of the model; (4) settings of *protection systems* that are relevant to load flow or dynamic simulation studies; (5) information provided in accordance with other provisions on the NTC only to the extent that the information is not a part of the model or the model parameters and that is reasonably necessary to allow modelling of the *generating unit, generating system* or related *plant* in *power system* load flow or dynamic simulation studies; (6) *connection point* details including its parameters and values, location, network augmentations or modifications and other relevant connection information; (7) in regards to any relevant *generating unit* or *generating system*, the date on which any of the following has occurred or is expected to occur:

Terminology	Definition
	(i) a *connection application* is made under clause 5.3.4(a) of the NT NER; (ii) (ii) a *connection agreement* is entered into under clause 5.3.7 of the NT NER; (iii) the *Generator* submits a proposal to alter a *connected generating system* or a *generating system*, for which *performance standards* have previously been accepted by the *Network Operator*, under clause 3.3.5; (iv) (iv) the *Generator* is notified that the *Network Operato*r is satisfied with the proposed alterations to the *generating plant* under clause 5.3.10 of the NT NER; (v) *connection*; (vi) commencement of commissioning; and (vii) conclusion of commissioning; and (8) the date this document was prepared or updated.
reliability	The probability of a system, device, *plant* or equipment performing its function adequately for the period of *time* intended, under the operating conditions encountered.
reliable	The expression of a recognised degree of confidence in the certainty of an event or action occurring when expected.
remote back up protection	Refers to the detection and initiation of tripping at a location other than that at which the main *protection scheme* of the faulted *plant* is located. Remote back up *protection* provides a means of detecting and initiating clearance of *small zone fault*s or fault contributions supplied via failed circuit breakers.
remote control equipment (RCE), remote monitoring equipment (RME)	Equipment installed to enable control or monitoring of a *facility* from a *control centre*, including a remote terminal unit (*RTU*).
representative	In relation to a person, any employee, agent or Consultant of: (a) that person; or (b) a related body corporate of that person; or (c) a third party contractor to that person.
reserve	The *active power* and *reactive power* available to the *power system* at a nominated *time* but not currently utilised.
R-FCAS	Regulating frequency control ancillary services (a subset of FCAS)
rotating rectifier	A type of brushless excitation system for a *synchronous generating unit.*
RTU	A Remote Terminal Unit installed within a *substation* or *generator's facility* to enable monitoring and control of a *facility* from a *control centre*.
satisfactory operating state	In relation to the *power system*, has the meaning given in the System Control Technical Code.

Terminology	Definition
SCADA system	Supervisory control and data acquisition equipment which enables the *Power System Controller* to continuously and remotely monitor, and to a limited extent control, the import or export of electricity from or to the *power system*.
scheduled generating unit	A *generating unit* which is *dispatched* by the *Power System Controller*.
secondary equipment, secondary plant	Those assets of a *facility* and the *electricity network* which do not carry the *energy* being traded, but which are required for control, *protection* or operation of assets that carry such *energy*.
secondary plant contingency	Any single failure of *secondary plant*.
secure operating state	In relation to the *power system* has the meaning given in the System Control Technical Code.
sensitivity	In relation to *protection schemes*, has the meaning in clause 6.1.6.1.
single contingency	In respect of a *network*, a sequence of related events which result in the removal from service of one line, *transformer* or other item of *plant*. The sequence of events may include the application and clearance of a fault of defined severity.
small network investment	A proposed investment in augmentation of the *network* or a non-*network* alternative with a capitalised net present value in excess of $1 Million that is not a *large network investment*.
Small Generator	A person who engages in the activity of owning, controlling or operating a *small generating system.*
small generating system	A *generating unit* or group of *generating units* with: (1) aggregate rated capacity of no more than 2 MW or 10% of the minimum *demand* of an isolated *network*, whichever is the lesser; (2) *connect*ed to the 22 kV, 11 kV or *low voltage network*s; and (3) not subject to *dispatch* by the System Operator.
Small Generation Unit	A *generating unit* that forms part of a *small generating system.*
Small Inverter Energy System	A *Small Inverter Energy System* is a *generating unit* which uses an inverter that changes its direct-current power to alternating current power acceptable for power system connection. The nominal network voltages and maximum energy system capacities for which these requirements apply are: (1) 230 V single phase 10 kVA (2) 400 V three phase 30 kVA
small zone fault	A fault which occurs on an area of *plant* that is within the zone of detection of a *protection scheme*, but for which not all contributions will be cleared by the circuit breaker(s) tripped by that *protection scheme*. For example, a fault in the area of *plant* between a *current transformer* and a

Terminology	Definition
	circuit breaker, fed from the *current transformer* side, may be a *small zone fault*.
spare network capacity	The capacity to transport electricity over a particular *electricity network* which the network provider assesses is in surplus to the capacity that existing end-use *customer*s forecast will be required to satisfy their reasonably foreseeable requirements for the transport of electricity.
spinning reserve	The ability to immediately and automatically increase *generation* or reduce *demand* in response to a fall in *frequency*.
standby power	The amount of electrical *energy* which could be supplied to a *load User* in accordance with the terms of a standby *generation* agreement.
static excitation system	An *excitation control system* in which the power to the rotor of a *synchronous generating unit* is transmitted through high power solid-state electronic devices.
static var compensator	A device specifically provided on a *network* to provide the ability to generate and absorb *reactive power* and to respond automatically and rapidly to *voltage* fluctuations or *voltage* instability arising from a disturbance or disruption on the *network*.
sub-network	A particular portion of the *network*.
substation	A *facility* at which lines are switched for operational purposes. May include one or more *transformer*s so that some *connect*ed lines operate at different *nominal voltage*s to others.
supply, supplying	The delivery of electricity.
synchronise	The act of *synchronising* a *generating unit* to the *power system*.
synchronised	In the case of a *generating unit*, to be *connected* to and *operate* at the same *frequency* as the *power system*.
synchronising, synchronisation	To electrically *connect* a *generating unit* to the *power system*.
synchronous condensers	*Plant*, similar in construction to a *generating unit* of the *synchronous Generator* category, which operates at the equivalent speed of the *frequency* of the *power system*, specifically provided to generate or absorb *reactive power* through the adjustment of excitation current.
synchronous Generator voltage control	The automatic *voltage control system* of a *generating unit* of the *synchronous Generator* category which *change*s the output *voltage* of the *generating unit* through the adjustment of the *Generator* excitation current and effectively *change*s the *reactive power* output from that *generating unit*.
synchronous Generator, synchronous generating unit	The alternating current *Generator*s which operate at the equivalent of the *frequency* of the *power system* in its *satisfactory operating state*.
system strength connection works	Investment in a *transmission* or *distribution system* in order to remedy or avoid an *adverse system strength impact* arising from establishing a *connection* for a *generating system* or from any alteration to a *generating system*.

Terminology	Definition
system strength impact assessment	*Power system* studies to assess the impact of the *connection* of a new *generating system* or of any proposed alteration to a *generating system* on the ability under different operating conditions of: (a) the *power system* to maintain system stability; and (b) *generating systems* forming part of the *power system* to maintain stable operation including following any credible contingency event, so as to maintain the *power system* in a *secure operating state*.
system strength impact assessment guidelines	The guidelines for conducting *system strength impact assessments* developed by the Network Operator under clause 3.3.5.16.
system strength remediation scheme	A scheme required to be implemented as a condition of a *connection agreement* to remedy or avoid an *adverse system strength impact*.
tap-changing transformer	A *transformer* with the capability to allow internal adjustment of output *voltage*s which can be automatically or manually initiated and which is used as a major component in the control of the *voltage* of the *network*s in conjunction with the operation of *reactive plant*.
teleprotection signalling	Equipment used to transfer a contact state from one location to another using communications equipment. The equipment used for this purpose will meet the *reliability* and quality requirements *protection* equipment.
time	Standard Time in the Northern Territory as defined by the *Standard Time Act 2005* (NT).
total fault clearance time	Refers to the *time* from fault inception to the *time* of complete fault interruption by a circuit breaker or circuit breakers.
transformer	A *plant* or device that reduces or increases the *voltage* of alternating current.
transformer tap position	Where a tap *change*r is fitted to a *transformer*, each tap position represents a *change* in *voltage* ratio of the *transformer* which can be manually or automatically adjusted to *change* the *transformer* output *voltage*. The tap position is used as a reference for the output *voltage* of the *transformer*.
transmission element	A single identifiable major component of a *transmission network* involving: • an individual *transmission* circuit or a phase of that circuit; and • a major item of *transmission plant* necessary for the functioning of a particular *transmission* circuit or *connection point* (such as a *transformer* or a circuit breaker).
transmission line	A power line that is part of a *transmission network*.
transmission network	The components of the *electricity network* used for transmitting electricity at *nominal voltage*s of 66 kV or higher and at a nominal *frequency* of 50Hz.
transmission network connection point	A *connection point* on a *transmission network*.

Terminology	Definition
transmission network test	Test conducted to verify the magnitude of the *power transfer capability* of the *transmission network* or investigating *power system* performance in accordance with clause 5.5.
transmission plant	Apparatus or equipment associated with the function or operation of a *transmission line* or an associated *substation*, which may include *transformer*s, circuit breakers, *reactive plant* and *monitoring equipment* and control equipment.
trip circuit supervision	A function incorporated within a *protection scheme* that results in alarming for loss of integrity of the *protection scheme'*s trip circuit. *Trip circuit supervision* supervises a *protection scheme'*s trip *supply* together with the integrity of associated wiring, cabling and circuit breaker trip coil.
trip supply supervision	A function incorporated within a *protection scheme* that results in alarming for loss of trip *supply*.
two fully independent protection schemes of differing principle	Where an item of *plant* is required to be protected by *two fully independent protection schemes of differing principle*, such *protection scheme*s shall, in combination, provide dependable clearance of faults on that *plant* within a specified *time*, with any single failure to operate of the *secondary plant*. To achieve this, complete *secondary plant* redundancy is required including, but not necessarily limited to, *current transformer* and *voltage transformer* secondaries, auxiliary supplies, signalling systems, cabling, wiring, and circuit breaker trip coils. Auxiliary supplies include DC supplies for *protection* purposes. Therefore, to satisfy the redundancy requirements, each fully independent *protection scheme* would need to have its own independent battery and battery charger system *supplying* all that *protection scheme'*s trip functions. The *protection scheme*s shall be so chosen as to have *differing principle*s of operation.
under frequency load shedding	A *load shedding* scheme designed to automatically disconnect *load* on the *network* to restore *frequency* to the *normal operating range*.
under voltage load shedding	Equipment designed to automatically *disconnect load* from the *power system* if the *voltage* falls below a set level.
under frequency relay	The component of an *under frequency load shedding* scheme that initiates disconnection of the *load*.
unsynchronised	In the case of a *generating unit*, to operate *disconnected* from the power system, or to *operate* at a different *frequency* to the *power system* during an electrical disturbance.
User	A person, whether a *Network User* or a *Generator User*, who has been granted access to the *electricity network* by the *Network Operator* in order to transport electrical *energy* to or from a particular point.

Terminology	Definition
use of system services	A *network* service provided to a *User* for use of the *electricity network* for the transportation of electrical *energy* that can be reasonably allocated to a *User* on a locational basis.
voltage	The electronic force or electric potential between two points that gives rise to the flow of electrical *energy*.
voltage control	Keeping *network voltage*s within operational limits in normal operation and in the aftermath of trips by automatic regulation of *generation* MVAr output or by *voltage control* equipment such as *capacitor bank*s and automatic tap-*changer*s.
voltage transformer (VT)	A *transformer* for use with meters and/or *protection* devices in which the *voltage* across the secondary terminals is, within prescribed error limits, proportional to and in phase with the *voltage* across the primary terminals.

Attachment 2 Rules of interpretation

Subject to the *Interpretation Act*, this *Code* shall be interpreted in accordance with the following rules of interpretation, unless the contrary intention appears:

(a) a reference in this *Code* to a contract or another instrument includes a reference to any amendment, variation or replacement of it;

(b) a reference to a person includes a reference to the person's executors, administrators, successors, substitutes (including, without limitation, persons taking by novation) and assigns;

(c) if an event shall occur on a *day* which is not a *business day* then the event shall occur on the next *business day*;

(d) any calculation shall be performed to the accuracy, in terms of a number of decimal places, determined by the *Network Operator* in respect of all *Users*;

(e) if examples of a particular kind of conduct, thing or condition are introduced by the word "including", then the examples are not to be taken as limiting the interpretation of that kind of conduct, thing or condition;

(f) a *connection* is a *User's connection* or a *connection* of a *User* if it is the subject of an *Access Agreement* between the *User* and the *Network Operator*; and

(g) a reference to a half hour is a reference to a 30 minute period ending on the hour or on the half hour and, when identified by a *time*, means the 30 minute period ending at that *time*.

Attachment 3 Technical details for *connection* and access

A3.1 Introduction

Various clauses of the *Code* require that *Users* submit technical data to the *Network Operator*. This attachment contains schedules which list the typical range of data which may be required. Data additional to those listed in the schedules may be required. The actual data required will be advised by the *Network Operator* at the *time* of assessment of a *network Access Application*, and will form part of the technical specification in the *Access Agreement*.

A3.2 Data categories

Data is coded in categories, according to the stage at which it is available in the build-up of data during the process of forming a *connection* or obtaining access to a *network*, with data acquired at each stage being carried forward, or enhanced in subsequent stages, for example by testing.

A3.2.1 Preliminary system planning data

This is data required for submission with the *Access Application*, to allow the *Network Operator* to prepare an offer of terms for an *Access Agreement* and to assess the requirement for, and effect of, *network augmentation* or *extension* options. Such data is normally limited to the items denoted as Standard Planning Data (S) in the technical data schedules S3.1 to S3.7.

The *Network Operator* may, in cases where there is reasonable doubt as to the viability of a proposal, require the submission of other data before making an access offer to *connect* or to amend an *Access Agreement*.

A3.2.2 Registered system planning data

This is the class of data which will be included in the *Access Agreement* signed by both parties. It consists of the preliminary system planning data plus those items denoted in the attached schedules as Detailed Planning Data (D). The latter shall be submitted by the *User* in *time* for inclusion in the *Access Agreement*.

Registered data

Registered Data consists of data validated and *augment*ed prior to actual *connection* as a provision of access, from manufacturers' data, detailed design calculations, works or site tests, etc. (R1); and data derived from on-system testing after *connection* (R2).

All of the data will, from this stage, be categorised and referred to as Registered Data; but for convenience the schedules omit placing a higher ranked *Code* next to items which are expected to already be valid at an earlier stage.

A3.3 Data review

Data will be subject to review at reasonable intervals to ensure its continued accuracy and relevance. The *Network Operator* shall initiate this review. A *User* may *change* any data item at a *time* other than when that item would normally be reviewed or updated by submission to the *Network Operator* of the revised data, together with authentication documents, e.g. test reports.

A3.4 Data schedules

Schedules S3.1 to S3.7 cover the following data areas:

(a) Schedule S3.1 - *Generating Unit* Design Data. This comprises *generating unit* fixed design parameters.

(b) Schedule S3.2 - *Generating Unit* Setting Data. This comprises settings which can be varied by agreement or by *direction* of the *Network Operator*.

(c) Schedule S3.3 – *Generator* data for small *generating units*

(d) Schedule S3.4 – Technical data for *Small Invertor Energy Units*

(e) Schedule S3.5 - *Network* and *Plant* Technical Data. This comprises fixed electrical parameters.

(f) Schedule S3.6 - *Plant* and Apparatus Setting Data. This comprises settings which can be varied by agreement or by *direction* of the *Network Operator*.

(g) Schedule S3.7 - *Load* Characteristics. This comprises the estimated parameters of *load* groups in respect of, for example, harmonic content and response to *frequency* and *voltage* variations.

A3.5 Non *synchronous Generator*s

A *Generator* that *connect*s a *generating unit*, that is not a *synchronous generating unit*, shall be given exemption from complying with those parts of schedules S3.1 and S3.2 that are determined by the *Network Operator* to be not relevant to such *generating unit*, but shall comply with those parts of Schedules S3.3, S3.5, and S3.6 that are relevant to such *generating units*, as determined by the *Network Operator*.

*Code*s:

S = Standard Planning Data

D = Detailed Planning Data

R = Registered Data (R1 pre-*connection*, R2 post-*connection*)

Schedule S3.1 *Generating unit* design data

Symbol	Data Description	Units	Data Category
	***Power station* technical data:**		
	Connection point to *Network*	Text, diagram	S, D
	Nominal *voltage* at *connection* to *Network*	kV	S
	Total Station Net Maximum Capacity (NMC)	MW (sent out)	S, D, R2
	At *connection point*:		
	Maximum 3 phase short circuit infeed calculated by method of AS 3851 (1991):		
	• Symmetrical	kA	S, D
	• Asymmetrical	kA	D
	Minimum zero sequence impedance	% on 100 MVA base	D
	Minimum negative sequence impedance	% on 100 MVA base	D
	Short circuit ratio The lowest short circuit ratio at the *connection point* for which the *generating system*, including its *control systems*: (i) will be commissioned to maintain stable operation; and (ii) has the design capability to maintain stable operation. For the purposes of the above, "short circuit ratio" is the synchronous *three phase fault level* (expressed in MVA) at the *connection point* divided by the rated output of the *generating system* (expressed in MW or MVA).	Numeric ratio	S, D, R1
	Individual *generating unit* data:		
MBASE	Rated MVA	MVA	S, D, R1
PSO	Rated MW (Sent Out)	MW (sent out)	S, D, R1
PMAX	Rated MW (*Generated*)	MW (Gen)	S, D
VT	Nominal Terminal *Voltage*	kV	S, D, R1
PAUX	Auxiliary *load* at PMAX	MW	S, D, R2
Qmax	Rated Reactive Output at PMAX	MVAr (sent out)	S, D, R1
PMIN	Minimum *Load* (ML)	MW (sent out)	S, D, R2
H	Turbine plus *Generator* Inertia Constant	MWs/rated MVA	S, D, R1
Hg	*Generator* Inertia Constant (applicable to synchronous condenser mode of operation)	MWs/rated MVA	S, D, R1

GSCR	Short Circuit Ratio		D, R1
ISTATOR	Rated Stator Current	A	D, R1
IROTOR	Rated Rotor Current at rated MVA and *Power factor*, rated terminal volts and rated speed	A	D, R1
VROTOR	Rotor *Voltage* at which IROTOR is achieved	V	D, R1
VCEIL	Rotor *Voltage* capable of being supplied for five seconds at rated speed during field forcing	V	D, R1
	***Generating unit* resistance:**		
RA	Stator Resistance	% on MBASE	S, D, R1, R2
RF	Rotor resistance at 20˚ C	ohms	S, D, R1
	***Generating unit* sequence impedances (saturated):**		
Z0	Zero Sequence Impedance	(a+jb)% on MBASE	D,R1
Z2	Negative Sequence Impedance	(a+jb)% on MBASE	D,R1
	***Generating unit* reactances (saturated):**		
XD′(sat)	Direct Axis Transient Reactance	% on MBASE	D,R1
XD″(sat)	Direct Axis Sub-Transient Reactance	% on MBASE	D,R1
	***Generating unit* reactances (unsaturated):**		
XD	Direct Axis Synchronous Reactance	% on MBASE	S, D, R1, R2
XD′	Direct Axis Transient Reactance	% on MBASE	S, D, R1, R2
XD″	Direct Axis Sub-Transient Reactance	% on MBASE	S, D, R1, R2
XQ	Quadrature Axis Synch Reactance	% on MBASE	S, D, R1, R2
XQ′	Quadrature Axis Transient Reactance	% on MBASE	S, D, R1, R2
XQ″	Quadrature Axis Sub-Transient Reactance	% on MBASE	S, D, R1, R2
XL	Stator Leakage Reactance	% on MBASE	S, D, R1, R2
XO	Zero Sequence Reactance	% on MBASE	S, D, R1
X2	Negative Sequence Reactance	% on MBASE	S, D, R1
XP	Potier Reactance	% on MBASE	S, D, R1
	***Generating unit time* constants (unsaturated):**		
TDO′	Direct Axis Open Circuit Transient	Seconds	S, D, R1, R2
TDO″	Direct Axis Open Circuit Sub-Transient	Seconds	S, D, R1, R2
TKD	Direct Axis Damper Leakage	Seconds	S, D, R1, R2
TQO′	Quadrature Axis Open Circuit Transient	Seconds	S, D, R1, R2
TQO″	Quadrature Axis Open Circuit Sub-Transient	Seconds	S, D, R1, R2

	Charts:		
GCD	Capability Chart	Graphical data	S, D, R1, R2
GOCC	Open Circuit Characteristic	Graphical data	R1
GSCC	Short Circuit Characteristic	Graphical data	R1
GZPC	Zero *power factor* curve	Graphical data	R1
	V curves	Graphical data	R1
GOTC	MW, MVAr outputs versus temperature chart	Graphical data	D, R1, R2
	***Generating unit transformer*:**		
GTW	Number of windings	Text	S, D
GTR_n	Rated MVA of each winding	MVA	S, D, R1
$GTTR_n$	Principal tap rated *voltage*s	kV/kV	S, D, R1
$GTZl_n$	Positive Sequence Impedances (each wdg)	(a - jb)% on 100 MVA base	S, D, R1
$GTZ2_n$	Negative Sequence Impedances (each wdg)	(a - jb)% on 100 MVA base	S, D, R1
$GTZ0_n$	Zero Sequence Impedances (each wdg)	(a - jb)% on 100 MVA base	S, D, R1
	Tapped Winding	Text, diagram	S, D, R1
GTAPR	Tap *Change* Range	kV - kV	S, D
GTAPS	Tap *Change* Step Size	%	S, D
	Tap *Change*r Type, On/Off *load*	On/Off	S, D
	Tap *Change* Cycle *Time*	Seconds	D
GTVG	Vector Group	Diagram	S, D
	Earthing Arrangement	Text, diagram	S, D
	Saturation curve	Diagram	R1
	***Generating unit* reactive capability (at machine terminals):**		
	Lagging *Reactive power* at PMAX	MVAr export	S, D, R2
	Lagging *Reactive power* at ML	MVAr export	S, D, R2
	Lagging Reactive Short *Time* capability at rated MW, terminal *voltage* and speed	MVAr (for *time*)	D, R1, R2
	Leading *Reactive power* at rated MW	MVAr import	S, D, R2
	***Generating unit* excitation system:**		
	Make		S, D
	Model		S, D
	General description of *excitation control system* (including functional block diagram)	Text, diagram	S, D

Rated Field *Voltage* at rated MVA and *Power factor* and rated terminal volts and speed	V	S, D, R1
Maximum Field *Voltage*	V	S, D, R1
Minimum Field *Voltage*	V	S, D, R1
Maximum rate of *change* of Field *Voltage*	Rising V/s	S, D, R1
Maximum rate of *change* of Field *Voltage*	Falling V/s	S, D, R1
Generating unit and exciter Saturation Characteristics 50 - 120%	Diagram	S, D, R1
Dynamic Characteristics of Over Excitation Limiter	Text/ Block diagram	S, D, R2
Dynamic Characteristics of Under Excitation Limiter	Text/ Block diagram	S, D, R2

***Generating unit load controller* (governor):**

General description of governor *control system* (including functional block diagram). Format to be compatible with PSS/E software from Siemens PTI.	Text, diagram	S, D
Maximum Droop	%	S, D, R1
Normal Droop	%	D, R1
Minimum Droop	%	D, R1
Maximum *Frequency* Dead band	Hz	D, R1
Normal *Frequency* Dead band	Hz	D, R1
Minimum *Frequency* Dead band	Hz	D, R1
MW Dead band	MW	D, R1

***Generating unit* response capability:**

Sustained response to *frequency change*	MW/Hz	D, R2
Non-sustained response to *frequency change*	MW/Hz	D, R2
Load Rejection Capability	MW	S, D, R2

Mechanical shaft model:

(Multiple-stage steam turbine *Generator*s only)

Dynamic model of turbine/*Generator* shaft system in lumped element form showing component inertias, damping and shaft stiffness. Format to be compatible with PSS/E software from Siemens PTI.	Diagram	S, D
Natural damping of shaft torsional oscillation modes (for each mode)		
• Modal *frequency*	Hz	D

	• Logarithmic decrement	Nepers/Sec	D
	Steam turbine data:		
	(Multiple-stage steam turbines only)		
	Fraction of power produced by each stage:		
	Symbols KHP	Per unit of Pmax	D
	KIP		
	KLP1		
	KLP2		
	Stage and reheat *time* constants:		
	Symbols THP	Seconds	D
	TRH		
	TIP		
	TLP1		
	TLP2		
	Turbine *frequency* tolerance curve	Diagram	S, D, R1
	Gas turbine data:		
HRSG	Waste heat recovery boiler *time* constant (where applicable e.g. for co*generation* equipment)	Seconds	D
	MW output versus turbine speed (47-52 Hz)	Diagram	D, R1, R2
	Type of turbine (heavy industrial, aero derivative etc.)	Text	S
	Number of shafts		S,D
	Gearbox Ratio		D
	Fuel type (gas, liquid)	Text	S,D
	Base *load* MW vs temperature	Diagram	D
	Peak load MW vs temperature	Diagram	D
	Rated exhaust temperature	°C	S,D
	Controlled exhaust temperature	°C	S,D,R1
	Turbine *frequency* tolerance capability	Diagram	D
	Turbine compressor surge map	Diagram	D
	Hydraulic turbine data		
	Required data will be advised by the *Network Operator*		
	Wind farm/wind turbine data		
	A typical 24 hour power curve measured at 15-minute intervals or better if available;		S, D, R1

	maximum kVA output over a 60 second interval		S, D,R1
	Long-term flicker factor for *generating unit*		S, D, R1
	Long term flicker factor for wind farm		S,D,R1
	Maximum output over a 60 second interval kVA		S,D,R1
	Harmonics current spectra	A	S,D,R1
	Power curve MW vs. wind speed	Diagram	D
	Spatial Arrangement of wind farm	Diagram	D
	Startup profile MW, MVAr vs *time* for individual Wind Turbine Unit and Wind farm Total	Diagram	D
	Low Wind Shutdown profile MW, MVAr vs *time* for individual Wind Turbine Unit and Wind farm Total	Diagram	D
	MW, MVAr vs *time* profiles for individual Wind Turbine Unit under normal ramp up and ramp down conditions.	Diagram	D
	High Wind Shutdown profile MW, MVAr vs *time* for individual Wind Turbine Unit and Wind farm Total	Diagram	D

Induction *generating unit* data

	Make		
	Model		
	Type (squirrel cage, wound rotor, doubly fed)		
MBASE	Rated MVA	MVA	S,D,R1
	PSO Rated MW (Sent out)	MW	S,D,R1
	PMAX Rated MW (*generated*)	MW	D
	VT Nominal Terminal *Voltage* kV S,D,R1		
	Synchronous Speed	rpm	S,D,R1
	Rated Speed	rpm	S,D,R1
	Maximum Speed	rpm	S,D,R1
	Rated *Frequency*	Hz	S,D,R1
Qmax	Reactive consumption at PMAX	MVAr import	S,D,R1
	Curves showing torque, *power factor*, efficiency, stator current, MW output versus slip (+ and -).	Graphical data	D,R1,R2
	Number of *capacitor bank*s and MVAr size at rated *voltage* for each *capacitor bank* (if used).	Text	S
	Control philosophy used for VAr /*voltage control*.	Text	S

H	Combined inertia constant for all rotating masses *connect*ed to the *generating unit* shaft (for example, *generating unit*, turbine, gearbox, etc.) calculated at the synchronous speed	MW-sec/MVA	S,D,R1
	Resistance		
Rs	Stator resistance	% on MBASE	D,R1
Rs	Stator resistance versus slip curve, or two extreme values for zero (nominal) and unity (negative) slip	Graphical data or % on MBASE	D,R1
	Reactances (saturated)		
X′	Transient reactance	% on MBASE	D,R1
X″	Subtransient reactance	% on MBASE	D,R1
	Reactances (unsaturated)		
X	Sum of magnetising and primary winding leakage reactance.	% on MBASE	D,R1
X′	Transient reactance	% on MBASE	D,R1
X″	Subtransient reactance	% on MBASE	D,R1
Xl	Primary winding leakage reactance	% on MBASE	D,R1
	***Time* constants (unsaturated)**		
T′	Transient	sec	S,D,R1,R2
T″	Subtransient	sec	S,D,R1,R2
Ta	Armature	sec	S,D,R1,R2
To′	Open circuit transient	sec	S,D,R1,R2
To″	Open circuit subtransient	sec	S,D,R1,R2
	Converter data		
	Control: *transmission* system commutated or self commutated		
	Additional data may be required by the *Network Operator*		
	Doubly fed induction *generating unit* data		
	Required data will be advised by the *Network Operator*		

Schedule S3.2 *Generating unit* setting data

Description Category	Units	Data Category
***Protection* data:**		
Settings of the following *protections*:		
Loss of field	Text	D
Under excitation	Text, diagram	D
Over excitation	Text, diagram	D
Differential	Text	D
Under frequency	Text	D
Over *frequency*	Text	D
Negative sequence component	Text	D
Stator over *voltage*	Text	D
Stator overcurrent	Text	D
Rotor overcurrent	Text	D
Reverse power	Text	D
Stator E/F	Text	D
Rotor E/F	Text	D
Out of step	Text	D
Control Data:		
Details of *excitation control system* described in block diagram form showing transfer functions of individual elements, parameters and measurement units (in Siemens PTI PSS/E format).	Text, diagram	S, D, R1, R2
Automatic *voltage* regulator	Text, diagram	S, D, R1, R2
Power system stabiliser	Text, diagram	S, D, R1, R2
Settings of the following controls:		
Details of the *governor system* described in block diagram form showing transfer functions of individual elements and measurement units (in Siemens PTI PSS/E format).	Text, diagram	S, D, R1, R2
Over excitation limiter	Text, diagram	S, D
Under excitation limiter	Text, diagram	S, D
Stator current limiter (if fitted)	Text, diagram	S, D
Manual restrictive limiter (if fitted)	Text	S, D
Load drop compensation/VAr sharing (if fitted)	Text, function	S, D
V/f limiter (if fitted)	Text, diagram	S, D

Schedule S3.3 *Generator* data for small *generating systems*

Power station	Data Category
Address	S, R1
Description of *power station*, for example, is it a green or brownfield site, is there a process steam or heat requirement, any other relevant information	S
Site-specific issues which may affect access to site or design, e.g. other construction onsite, mine site, environmental issues, soil conditions	S, D
Number of *generating unit* and ratings (kW)	S, D, R1
Type: e.g. synchronous, induction	S, D, R1
Manufacturer	D
Connected to the *network* via: e.g. inverter, *transformer*, u/g cable etc.	S
Prime mover types: e.g. reciprocating, turbine, hydraulic, photovoltaic, other	S
Manufacturer	D
Energy source: e.g. natural gas, landfill gas, distillate, wind, solar, other	S
Total *power station* total capacity (kW)	S, D, R1
Power station export capacity (kVA)	S, D, R1
Forecast annual *energy generation* (kWh)	S, D
Normal mode of operation as per clause 3.4.3 of the *Network Technical Code* i.e. (1) continuous parallel operation (2) occasional parallel operation (3) short term test parallel operation (4) bumpless (make before break) transfer (i) rapid transfer (ii) gradual transfer	S
Purpose: e.g. power sales, peak lopping, *demand* management, exercising, emergency back up	S

Schedule S3.4 Technical data for *Small Inverter Energy Systems*

Description	Units	Data Category
Address	Text	S
Number of *Small Inverter Energy Systems* and ratings	kW	S, D
Manufacturer	Text	D
Connection *voltage*		
Nominal *voltage*	V	S, D
Single/three phase	Number	S, D

Schedule S3.5 *Network* and *plant* technical data

Description	Units	Data Category
***Voltage* rating**		
Nominal *voltage*	kV	S, D
Highest *voltage*	kV	D
Insulation co-ordination		
Rated lightning impulse withstand *voltage*	kVp	D
Rated short duration power *frequency* withstand *voltage*	kV	D
Rated currents		
Circuit maximum current	kA	S, D
Rated Short *Time* Withstand Current	kA for seconds	D
Ambient conditions under which above current applies	Text	S,D
Earthing		
System Earthing Method	Text	S, D
Earth grid rated current	kA for seconds	D
Insulation pollution performance		
Minimum total creepage	mm	D
Pollution level	Level of IEC 815	D
Controls		
Remote control and data *transmission* arrangements	Text	D
Metering* provided by *customer		
Measurement *transformer* ratios:		D
Current *transformers*	A/A	D
Voltage transformers	V/kV	D
Measurement *Transformer* Test Certification details	Text	R1
***Network* configuration**		
Operation Diagrams showing the electrical circuits of the existing and proposed main *facilities* within the *User's* ownership including *busbar* arrangements, phasing arrangements, earthing arrangements, switching *facilities* and operating *voltages*	Single line Diagrams	S, D, R1

***Network* impedances**		
For each item of *plant* (including lines): details of the positive, negative and zero sequence series and shunt impedances, including mutual coupling between physically adjacent elements.	% on 100 MVA base	S, D, R1
Short circuit infeed to the *network*		
Maximum *Generator* 3-phase short circuit infeed including infeeds from *generating units connect*ed to the *User's* system, calculated by method of AS 3851 (1991).	kA symmetrical	S, D, R1
The total infeed at the instant of fault (including contribution of induction motors).	kA	D, R1
Minimum zero sequence impedance of *User's network* at *connection point*.	% on 100 MVA base	D, R1
Minimum negative sequence impedance of *User's network* at *connection point*.	% on 100 MVA base	D, R1
***Load* Transfer Capability:**		
Where a *load*, or group of *load*s, may be fed from alternative *connection point*s:		
Load normally taken from *connection point* X	MW	D, R1
Load normally taken from *connection point* Y	MW	D, R1
Arrangements for transfer under planned or fault *outage* conditions	Text	D
Circuits Connecting Embedded *generating units* to the *Network*:		
For all *generating units*, all *connect*ing lines/cables, *transformer*s etc.		
Series Resistance (-ve, -ve & zero seq.)	% on 100 MVA base	S, D, R
Series Reactance (-ve, -ve & zero seq.)	% on 100 MVA base	S, D, R
Shunt Susceptance (-ve, -ve & zero seq.)	% on 100 MVA base	S, D, R
Normal and short-*time* emergency ratings	MVA	S, D, R
Technical Details of *generating units as* per schedules S1, S2, S3.		
***Transformer*s at *connection point*s:**		
Saturation curve	Diagram	R

Schedule S3.6 *Network plant* and apparatus setting data

Description	Units	Data Category
Protection **data for** ***protection*** **relevant to** ***connection point*****:**		
Reach of all *protection schemes* on lines, or cables	ohms or % on 100 MVA base	S, D
Number of *protection schemes* on each item	Text	S, D
Total fault clearing *times* for near and remote faults	ms	S, D, R1
Line reclosure sequence details	Text	S, D, R1
Tap ***change*** **control data:**		
Time delay settings of all *transformer* tap *changers*.	Seconds	D, R1
Reactive compensation (including filter banks):		
Location and Rating of individual shunt *reactors*	MVAr	S, D, R1
Location and Rating of individual shunt *capacitor banks*	MVAr	S, D, R1
Capacitor bank capacitance	Microfarads	S, D
Inductance of switching *reactor* (if fitted)	millihenries	S, D
Resistance of capacitor plus *reactor*	Ohms	S, D
Details of special controls (e.g. Point-on-wave switching)	Text	S, D
For each shunt ***reactor*** **or** ***capacitor bank*** **(including filter banks):**		
Method of switching	Text	S
Details of automatic control logic such that operating characteristics can be determined	Text	D, R1
FACTS Installation:		
Data sufficient to enable static and *dynamic performance* of the installation to be modelled	Text, diagrams, control settings	S, D, R1
Under frequency load shedding **scheme:**		
Relay settings (*frequency* and *time*)	Hz, seconds	S, D
Islanding scheme:		
Triggering signal (e.g. *voltage*, *frequency*)	Text	S, D
Relay settings	Control settings	S, D

Schedule S3.7 *Load* characteristics at *connection point*

Data Description	Units	Data Category
For all types of *load*		
Type of *load* e.g. controlled rectifiers or large motor drives	Text	S
Rated capacity	MW, MVA	S
Voltage level	kV	S
Rated current	A	S
For fluctuating *load*s		
Cyclic variation of *active power* over period	Graph - MW/*time*	S
Cyclic variation of *reactive power* over period	Graph - MVAr/*time*	S
Maximum rate of *change* of *active power*	MW/s	S
Maximum rate of *change* of *reactive power*	MVAr/s	S
Shortest Repetitive *time* interval between fluctuations in *active power* and *reactive power* reviewed annually	s	S
Largest step *change* in *active power*	MW	S
Largest step *change* in *reactive power*	MVAr	S
For commutating power electronic *load*:		
No. of pulses	Text	S
Maximum *voltage* notch	%	S
Harmonic current distortion (up to the 50th harmonic)	A or %	S

Schedule S4 Grace periods for purposes of clause 12.3

Clause	Clause Title	Transition to Compliance Grace Period
3.3.5.1	Reactive power capability	13 months
3.3.5.2	Quality of electricity generated	30 days
3.3.5.3	Generation unit response to frequency disturbance	30 days
3.3.5.4	Generating System Response to Voltage Disturbances	13 months
3.3.5.5	Generating System Response to Disturbances Following Contingency Events	6 months
3.3.5.6	Quality of Electricity Generated and Continuous Uninterrupted Operation	30 days
3.3.5.7	Partial Load Rejection	30 days
3.3.5.8	Protection of generating units from Power System Disturbances	30 days
3.3.5.9	Protection Systems that Impact on Power System Security	30 days
3.3.5.10	Protection to Trip Plant for Unstable Operation	30 days
3.3.5.11	Frequency Control	30 days
3.3.5.12	Impact on Network Capability	30 days
3.3.5.13	Voltage and Reactive Power Control	30 days
3.3.5.14	Active Power Control	30 days
3.3.5.15	Inertia and Contingency FCAS	30 days
3.3.5.16	System Strength	30 days
3.3.5.17	Capacity Forecasting	13 months
3.3.6.1	Remote Monitoring and Control	30 days
3.3.6.2	Communications Equipment	30 days

Explanatory notes:

1. The transition to compliance timeframes includes the 30 days for the generator to provide a compliance plan and confirm the generator performance standard.
2. The transition to compliance grace periods include all aspects including design, modelling, procurement, programming, installation and testing as appropriate.
3. Clauses with 30 day timeframe to compliance reflect that the requirements are either:
    a. the same or equivalent outcome as those under the existing NTC V3.1; or
    b. not expected to result in a compliance gap.
4. For the clause with a 6 month timeframe, a compliance gap is considered at least possible, with any gap most likely related to a programming / setting change and testing to demonstrate compliance.
5. For the clauses with a 13 month timeframe, a potential compliance gap is considered possible, with that gap most likely related to requiring additional plant or equipment and testing to demonstrate compliance.
6. A generator may seek an extended derogation under NTC clause 12.1, but only where it can be justified, and the generator demonstrates its best endeavours to achieve timely compliance.

Attachment 4 [Deleted]

(a)

Attachment 5 Test schedule

The following test schedule is used for specific performance verification and model validation.

A5.1 General

(a) Recorders should be calibrated or checked prior to use.

(b) Recorders should not interact with any *plant* control functions.

(c) Galvanic isolation and filtering of input signals should be provided whenever necessary.

A5.2 Test preparation and presentation of test results

Information/data prior to tests

(a) a detailed schedule of tests agreed by the *Network Operator*. The schedule should list the tests, when each test is to occur and whose responsibility it will be to perform the test.

(b) Schematics of equipment and *sub-network*s plus descriptive material necessary to draw up/agree upon a schedule of tests

(c) Most up to date relevant technical data and parameter settings of equipment as specified in Attachment 3 of this *Code*.

Test notification

(a) Prior notice of test commencement should be given to the *Network Operator* for the purpose of arranging witnessing of tests.

(b) The *Network Operator's representative* should be consulted about proposed test schedules, be kept informed about the current state of the testing program, and give permission to proceed before each test is carried out.

Test results

(a) Test result data shall be presented to the *Network Operator* within 5 *business day*s of completion of each test or test series.

(b) Where test results are not favourable it will be necessary to rectify problems and repeat tests.

A5.3 Quantities to be measured

(a) Wherever appropriate and applicable for the tests, the following quantities should be measured on the machine under test:

***Generator* and excitation system**

- stator L-N terminal *voltage*s

- stator terminal currents
- *Active power* MW
- *Reactive power* MVAr
- *Generator* rotor field *voltage*
- *Generator* rotor field current
- Main exciter field *voltage*
- Main exciter field current
- AVR reference *voltage*
- *Voltage* applied to AVR summing junction (step etc.)
- *Power system stabiliser* output
- DC signal input to AVR which corresponds to terminal volts

Steam turbine

- Shaft speed
- *Load demand* signal
- Valve positions for control and interceptor valves
- Governor set point

Gas turbine

- Shaft speed (engine)
- Shaft speed of turbine driving the *Generator*
- Engine speed control output Free turbine speed control output
- *Generator*-compressor speed control output
- Ambient/turbine air inlet temperature
- Exhaust gas temperature control output
- Exhaust temperature
- Fuel flow
- Governor/*load* reference set point

Reciprocating engine

- Engine crank speed driving the *Generator*
- Type of governor *load* / speed control

- Ambient / charge air / exhaust temperature
- Fuel flow

(b) Additional test quantities may be requested and advised by the *Network Operator* if other special tests are necessary.

(c) Key quantities such as stator terminal *voltage*s, currents, *active power* and *reactive power* of the other *generating units connect*ed on the same bus and also *interconnection* lines with the *Network Operator's network* (from control room readings) before and after each test shall also be provided.

Schedule of Tests

Test No	TEST DESCRIPTION General Description	*Changes* Applied	Test Conditions
C1	Step *change* to AVR *voltage* reference with the *Generator* on **open circuit**	(a) -2.5% (b) –2.5% (c) -5.0% (d) –5.0%	nominal stator terminal volts
C2	Step *change* to AVR *voltage* reference with the *Generator connect*ed to the system at the following outputs 50% rated MW 100% rated MW	(a) -1.0% (b) –1.0% (c) -2.5% (d) –2.5% (e) -5.0% (f) –5.0% repeat (e) & (f) twice see notes below	nominal stator terminal volts unity or lagging *power factor* system base *load* *Generator* outputs: (i) 50% rated MW (ii) 100 % rated MW all tests in (i) should precede test in (ii) smaller step *change*s should precede larger step *changes*
C3	As for C2 but with the *power system stabiliser* in service and with the system conditions (i) and (ii) as indicated in column 3 (Test Conditions)	As in C2	As in C2, but system base *load* with no other *generation* on the same bus system maximum *load* and maximum *generation* on same bus
C4	Manual variation of *Generator* open circuit *voltage*	Stator terminal *voltage* (U_t) (a) increase from 0.5 pu to 1.1 pu (b) decrease from 1.1 pu to 0.5 pu	in 0.1 pu step for U_t between 0.5 – 0.9 pu on 0.5 pu step for U_t between 0.9 – 1.1 pu
C5	*Load* rejection (*active power*)	(a) 25% rated MW (b) 50% rated MW (c) 100% rated MW	nominal stator terminal volts unity *power factor* smaller amount should precede larger amount of lead rejection
C6	*Load* rejection (*reactive power*)	(5) –30% rated MVAr (6) -25% rated MVAr	nominal stator terminal volts 0 or minimum MW output
C7	*Load* rejection (*reactive power*)	(a) –30% rated MVAr	nominal stator terminal volts Excitation Manual Control