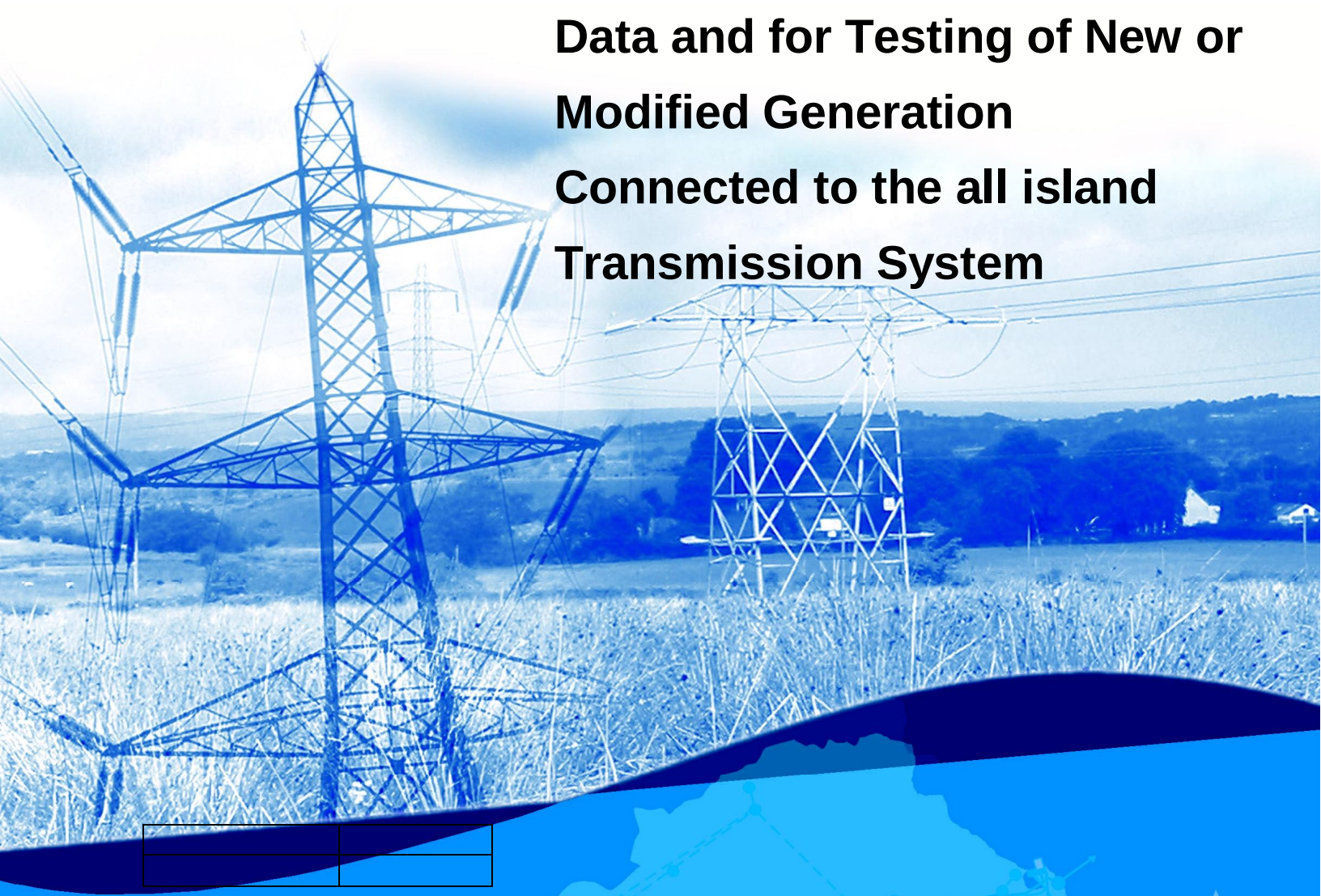
System Operator for Northern Ireland

Guidance for the Exchange of Data and for Testing of New or Modified Generation Connected to the all island Transmission System



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Revision D

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1. INTRODUCTION

This Guidance Note is produced to clarify the process to be followed by a person or organisation wishing to connect generation to the all island Transmission system (hereafter called the Generator).

The Guidance Note between the parties explains a process to manage crucial interactions and data exchange. The process also involves plant testing and reporting to demonstrate compliance with the NI Grid Code. Where a Connection Agreement specifically requires additional conditions or tests a schedule for those shall be agreed between the parties.

This Guidance Note is intended to inform the Generator of the necessary process and reference should be made to the Grid Code, the Connection Agreement and the Connection Agreement application process for a complete set of provisions relating to connection of generation. Where any of those documents differs from this Guidance Note, the terms of those documents shall prevail.

SONI will manage the connection process. The responsibility for deciding whether the Reports submitted by the Generator discharge the Generator's obligations will rest with the Grid Operations Planning Engineer, who shall decide also whether to have witnessed and recorded any testing or monitoring required**,** in all cases to be carried out by the Generator. (See Grid Code condition CC10.1.5)

If SONI considers it necessary, it may require the Report(s) to be prepared by an Independent Engineer. In this event, SONI will be responsible for informing the Generator as soon as it is practical to do so. The Engineer shall be agreed between the parties and the Engineer's fees and costs shall be met by the Generator (unless separately agreed).

2. PRIOR TO ENTERING INTO A CONNECTION AGREEMENT

SONI shall ensure that any new network additions or modifications do not result in unacceptable or unstable conditions on the all island Transmission system. This will be done by undertaking a number of system studies replicating the Generator's proposed development and the effect it may have on the all island Transmission system.

The cost of such studies shall be attributable to the prospective Generator**,** who shall be liable to meet the costs in full whether or not the Generator proceeds with any or all of the project(s) under investigation.

Initial studies may be indicative only, until the Generator is in a position to confirm machine and transformer data accuracy. The costs of further studies and witness testing shall be agreed between SONI and the Generator and shall be met in full by the generator. The costs may reflect SONI work or work by external consultants.

3. CONNECTION AGREEMENT

A Connection Agreement is an agreement specifying, inter alia, the capacity and characteristics of generation, which may be connected to the all island Transmission system and ensuring that the NI planning and security standards are met. This will, in the normal case, be the Licence Standard. The Agreement will show the configuration of the Generator's and NIE's equipment and will identify the point(s) of connection. It will state any special arrangements or responsibilities for continued operation or maintenance.

A Connection Agreement may contain provisions which prevent the Generator from monopolising capacity not taken up or abandoned.

For the avoidance of doubt, where connection boundaries and control boundaries are different, the Connection Agreement will identify both.

An offer letter setting out the amount(s), which the Generator must pay for the connection, normally accompanies the Connection Agreement. No connection work will commence until these payments have been agreed and, as appropriate, paid.

4. THE CONNECTION REPORT

The Generator shall submit an interim report to SONI three months prior to connection, certifying that all relevant **Grid Code** Connection Conditions applicable to the Generator have been complied with. The report must demonstrate how these conditions have been met.

The purpose of the Report is to demonstrate to SONI the compliance of the Generator's plant and apparatus, as built, as regards:

- The relevant Connection Conditions in the **Grid Code**.
- Any Specific Technical Conditions in the Connection Agreement.

For each relevant condition, the Generator is required to evidence compliance.

It is recognised that some of the information necessary to demonstrate compliance may only be obtainable from tests and monitoring on the Generator's plant and apparatus carried out after it has been connected to the Transmission System**.** For this reason a Final Report will be required to be submitted within two months of the synchronisation date, which will include updated contents of the Interim report and test results.

SONI will require DRC data; this may be initially design data until commissioning is complete. The data will include AVR and Governor Control models. A report will be created using this data showing the expected AVR & Governor responses based on the models provided. The report will be used to measure actual performance of the Generator. The costs incurred by this report will be met by the Generator.

4.1 INTERIM REPORT

The Interim Report will be in 3 parts; each associated with a particular stage of the commissioning process:

Part 1: Safety Rule Clearance on Generator Apparatus

Part 1 of the Report is applicable to any direct connection to the SONI Transmission or Distribution System. It is concerned with establishing that the necessary documentation and procedures are in place to ensure safety from the other party's system for all persons carrying out work on SONI or the Generator's apparatus, such procedures to be implemented in accordance with the Grid Code**.**

Safety precautions are necessary with effect from the Safety Rule Clearance Date which is a specific date in the commissioning process agreed between SONI and the Generator. The precautions are necessary when the Generator's plant and apparatus could potentially be made live from the all island Transmission System or vice versa.

Part 2: Energisation of Generator Apparatus

Part 2 of the Report is applicable to any direct connection to all island Transmission System. It is concerned with establishing the suitability of the Generator's plant and apparatus for connection to the all island System, principally in terms of its design, manufacture, control and protection arrangements for interconnected power system operation.

Part 3: Synchronising of Generating Units

Part 3 of the report is concerned with the suitability of the design and manufacture of generating units and their control and protection systems for interconnected power system operation.

The contents of Parts 1, 2 and 3 of the Report will consist of a statement confirming compliance with each associated provision of the **Grid Code** and supporting information as detailed in Appendix B.

4.2 FINAL REPORT

The Final issue of the Report will be a fully comprehensive update of the composite Interim Report, including information obtained from on-site testing and monitoring on the Generator's equipment plant and apparatus**,** along with details of any changes made during commissioning. Section 6 of this document indicates the testing and monitoring requirements of the Generator's plant and apparatus**.**

After SONI has issued confirmation of approval to connect (CC10.2) the generator will submit the final report within two months of the generator synchronising date. The approval to connect is subject to satisfactory commissioning/acceptance test results and Grid Code Compliance detailed in the final report. If, for any reason, it is not possible to submit the Report by this date, SONI will require the Generator to submit progressive updates of compliance information until the report is complete.

4.3 CONTENTS OF THE REPORT

Registered Project Planning Data (PC6.4.4) is to be submitted at the same time as the Final Report.

The following points should also be borne in mind in constructing the final Report:

- Where applicable, supporting evidence (for example type test certificates, works test certificates, manufacturer correspondence) demonstrating compliance should be included.

- Where documents and diagrams are provided as supporting information, they should be legible and should include all relevant data assumptions (for example generator base, p.u., percentage values etc).

- Where information to demonstrate compliance has been passed to SONI by a mechanism other than the Report, a reference identifying this mechanism should be given.

- Where an Appendix of the **Grid Code** Connection Conditions is mentioned, the compliance response should take account of the requirements in the mentioned Appendix.

- Where a Connection Condition (itemised in Appendix B) has a number of sub-paragraphs, a response is required against each.

- Where test and monitoring results are provided they should be legible, appropriately sized, scaled and labelled.

5. COMMISSIONING PROCEDURES

Pre-Synchronisation

In advance of any generator commissioning tests**,** SONI will act as the interface with the Generator. The Generator should be aware that this interface would normally be available in weekday working hours only.

At least 6 weeks in advance of the adopted synchronising date the Generator must provide SONI with a schedule of commissioning tests and associated procedures for each unit**;** and indicate those tests which, to their knowledge, may impact on the all island System or part thereof or on other Generators.

In the case of embedded generating plant, SONI may delegate co-ordination to a distribution representative.

SONI's objective in seeking this information is to establish, from the Generator's schedule of commissioning tests, those tests which may inadvertently have an adverse impact on the all island System, or any equipment belonging to other Generators. In some occasions it may be necessary to carry out specific network studies using the models and DRC data provided by the Generator. The purpose of these operational studies is to determine if any of the proposed tests will have a detrimental affect on the all island system. The costs incurred by this report will be met by the Generator.

In particular, SONI will require detailed information on:

i. **Generator's excitation control system tests**
- AVR commissioning and step response tests
- Under excitation limit tests
- PSS commissioning tests
- MVAr capability tests

The operational settings of the AVR and PSS systems are to be agreed between SONI and the Generator in advance of tests taking place.

ii. **Generator's governor control system tests**
- Response tests
- Unit and station load rejection tests

With this information, SONI will be in a better position to determine if Generator testing can be accommodated on the all island Transmission system. SONI will also be able to advise the Generator of any requirements for commissioning tests procedures well in advance of the tests themselves.

Post-Synchronisation

Once the Generator is operational, SONI will continue to co-ordinate and plan any commissioning tests that will have an impact on the all island Transmission System.

Prior to synchronisation the Generator should advise SONI of the times of the tests and the tests to be carried out. At least 6 weeks advance notice of compliance tests should

be given to the Grid Operations Planning Engineer. If changes to the agreed testing procedures are necessary it is important that all such changes are agreed with SONI at least 2 weeks in advance of the test taking place. If insufficient notice is not provided by the Generator then, the proposed tests may not be accepted.

The Grid Operations Planning Engineer will remain the interface for technical discussions on testing, as discussed in Section 6 of this document.

6. COMPLIANCE TESTS & MONITORING

For all compliance tests, the Grid Operations Planning Engineer will act as the SONI interface with the Generator.

As mentioned previously, the purpose of this is for the Generator to demonstrate compliance with **Grid Code** Connection Conditions, and verify Connected Planning Data and Operating Code Data submissions.

The tests will need to be planned into the Generator's Commissioning Programme on dates agreeable to both the Generator and SONI. All compliance tests will be required to be carried out to agreed procedures prepared by the Generator. SONI will verify that the proposed tests will comply with Grid Code requirements.

If the tests may have a detrimental effect on the total system (CC10.1.4 (b)) they may fall within the scope of OC10. In which event the proposed commissioning program may be treated as a proposal notice submitted under OC10.4.1.

The Generator should note that their own generator commissioning testing can, where possible, be used for the purposes of demonstrating compliance with the tests indicated in this document.

The Grip Operations Planning Engineer will decide whether test witnessing will be carried out and arrange witnesses. The Grip Operations Planning Engineer will inform the Generator of the schedule of tests to be witnessed and may vary this by reasonable notice. Test witnessing costs will be met by the Generator.

It is the responsibility of the generator to produce credible results for each test. The format of the results for example in graphical or tabular form should be agreed with SONI 6 weeks in advance of the tests taking place. It is important that results are legible, clearly labelled and graphs appropriately scaled in engineering units.

At each witnessed test, SONI may wish to connect a data recorder for its own recording purposes. Details of this recorder will be made available to the Generator in advance. It is the responsibility of the Generator to provide fast speed recording equipment for the purpose of analysing test results.

Where SONI decides to witness any test, this shall not relieve the Generator of any responsibility for compliance with the Grid Code or other standard to be used as a fair measure, nor shall the act of witnessing be deemed to transfer any responsibility to SONI either for compliance or for the consequences of failure to comply.

6.1 EXCITATION SYSTEM OPEN CIRCUIT STEP RESPONSE TEST

SONI Compliance Testing/Monitoring	
Title of Test: Excitation System Open Circuit Step Response Test	Test Number: 1
Generator Procedure Reference:	

Description & Purpose of Test:

This test will be carried out by the Generator to assess the small signal performance of the excitation system with the unit operating at no load, at rated terminal voltage and speed.

The test will be carried out by a small step injection into the AVR reference. The magnitude of the step injection should be indicated (e.g. 2%).

The test will be carried out prior to synchronisation. The settings and results of this test will be required by SONI 2 days prior to synchronisation.

Results Required:

- V*t* - Generator Terminal Voltage.
- V*f* - Generator Field Voltage.
- I*f* - Generator Field Current.
- Step Injection Signal.

Results should be legible, clearly labelled, and should have appropriate scaling in engineering units.

The generator should provide a list of excitation system parameter values utilised at the time of the test.

Test Assessment:

This test is required to show compliance with CC.S1.5.1.
The test results will be assessed against the small signal open circuit excitation system requirements if specified in the Connection Agreement. SONI will also use at their discretion recognised international Standards for guidance, such as IEEE.IEC to interpret the results.

Criteria of Assessment:

Rise Time, Overshoot, Settling Time, Damping Factor, Nominal Response.

The Generator should note that test requirements are indicative. A meeting may be required to discuss and agree the timing of the tests, associated test programmes and any witnessing requirements.

6.2 OPEN & SHORT CIRCUIT SATURATION

SONI Compliance Testing/Monitoring	
Title of Test: Open & Short Circuit Saturation Curves	Test Number: 2
Generator Procedure Reference:	

Description & Purpose of Test:

This test is carried out by the Generator to verify the generator field current saturation characteristics.

The test should be carried out prior to synchronisation, and results sent to SONI two days afterwards.

Results Required:

- Graphical and tabular representations of per unit Terminal Voltage versus per unit Field Current on Open Circuit
- Graphical and tabular representations of per unit Terminal Voltage versus per unit Field current on Short Circuit

Results should be legible, clearly labelled, and should have appropriate scaling in engineering units.

Test Assessment:

The test results will be used to verify the design value of short circuit ratio (SCR), where

$$SCR = \frac{\text{Open Circuit Field Current to obtain 1 pu Terminal Voltage}}{\text{Short Circuit field current to obtain 1 pu Terminal Current}}$$

CC.S1.3.2 (iii) of the Grid code states that generating units should have an SCR of not less than 0.5

The Generator should note that test requirements are indicative. A meeting may be required to discuss and agree the timing of the tests, associated test programmes and any witnessing requirements.

6.3 UNDER EXCITATION LIMITERS

SONI Compliance Testing/Monitoring	
Title of Test: Excitation System Under Excitation Limiters	Test Number: 3
Generator Procedure Reference:	

Description & Purpose of Test:

This test will be carried out by the Generator to verify the performance of the under excitation limiter.

The test should be carried out initially with the limiter set near unity power factor to confirm its correct functioning. The limiter should then be set at the correct value and tests carried out at, or near, minimum generation and full load.

The status of the PSS during this test should be confirmed with SONI prior to the test taking place.

The Generator must provide a procedure to SONI describing how the tests will be carried out. This procedure should include the following details:

- Generator operating points (MW, MVAr).
- Proposed on-load step Injection size (normally 1-2%).
- Anticipated MW/MVAr changes on the HV side of the step-up transformer.
- Excitation System block diagram, showing limiter control.*
- PSS status.
- Generator performance chart indicating automatic and manual limits.*

***** As provided in **Grid Code** submissions (DRC Schedule 1).

The tests will be carried out to an agreed procedure and at an agreed time prior to the unit reliability/acceptance period.

The Generator should advise SONI if the under excitation limiter is active when the AVR is in both auto and manual modes.

Results Required:

- MW – Active Power at Generator Terminals
- MVAr – Reactive Power at Generator Terminals
- Vt – Generator Terminal Voltage
- Vf – Generator Field Voltage
- If – Generator Field Current
- Step injection

Results should be legible, clearly labelled, and should have appropriate scaling in engineering units.

The generator should provide a list of excitation system parameter values utilised at the time of the test.

Test Assessment:

The test results will be assessed against:

- CC.S1.5.3 of the **Grid Code**, which requires automatic excitation control without instability over the entire operating range of the generating unit, unless otherwise stated in the connection Agreement.

Criteria of Assessment:

- Correct operation of the under excitation limiter
- Damped control of generator terminal voltage, MW and MVAr.

The Generator should note that test requirements are indicative. A meeting may be required to discuss and agree the timing of the tests, associated test programmes and any witnessing requirements.

6.4 EXCITATION SYSTEM ON LOAD TESTS

SONI Compliance Testing/Monitoring	
Title of Test: Excitation System On Load Tests	Test Number: 4
Generator Procedure Reference:	

Description & Purpose of Test:

The On load tests are required to evaluate both the steady-state and dynamic stability of the excitation system. This will normally be through small signal step injection into the AVR voltage reference. The power system stabiliser (PSS) will be required to demonstrate:-

That the control system is capable of meeting the requirements for power oscillations damping. The PSS will need to be verified as capable of operation. PSS settings will be required to be verified and agreed by small signal step injection for time domain analysis. However, bandwidth-limited (200 mHz – 3Hz) random noise injection will be required for spectrum analysis. Both step injection and random noise injection will be carried out with and without PSS to demonstrate the damping effect. The PSS gain should be continuously controllable (i.e. not discrete components) during testing. The PSS should be able to be switched in and out of service at SONI's discretion, dependant on system conditions.

Prior to synchronising, in the Interim Report (Part 3), the Generator should provide SONI with a procedure for on load excitation tests, along with necessary supporting information. This should contain:

- Design study and simulation results, including generator operating points (MW, MVAr).
- Proposed on-load step injection size (normally 1-2%).
- Anticipated MW and MVAr changes on the HV side of the step-up transformer.
- Excitation System block diagram and settings, showing PSS control and settings where applicable.

Based on the information provided in the interim report (Part 3), SONI may meet with the Generator to discuss and agree PSS settings – where applicable.

SONI will not permit PSS commissioning unless the methodologies and study results used in any PSS settings proposal and optimisation have been provided to SONI in an acceptable timescale. Ideally, this should be provided along with the procedure in the Interim Report (Part 3).

Where a PSS has been specified, the Generator should provide a suitable band limited (200 mHz – 3 Hz) noise source to facilitate noise injection testing.

The tests will be carried out to an agreed procedure and at an agreed time prior to the unit reliability/acceptance period.

Results Required:

- MW – Active Power At Generator Terminals.
- MVAr – Reactive Power at Generator Terminals.
- V*t* – Generator Terminal Voltage.
- V*f* – Generator Field Voltage.
- If – Generator Field Current.
- Step injection.

Results should be legible, clearly labelled, and should have appropriate scaling in engineering units.

The generator should provide a list of excitation system parameter values utilised at the time of the test.

Test Assessment:

The test results will be assessed against:

- Performance specifications agreed as part of the Connection Agreement conditions or further Schedule which describes and clarifies the application of CC.S1.5.1 and CC.S1.5.3.

Criteria of Assessment:

- Both small signal and large signal performance criteria will be used in the evaluation of the excitation system, using recognised performance indices.
- Time Domain: step response voltage regulation (rise time, overshoot, settling time, damping factor), and power damping (number of cycles).
- Frequency Domain: damping of frequencies in the band 200 MHz – 3 Hz, gain margin, phase margin.

The Generator should note that test requirements are indicative. A meeting will be arranged to discuss and agree the timing of the tests, associated test programmes and any witnessing requirements.

6.5 GOVERNOR RESPONSE

SONI Compliance Testing/Monitoring	
Title of Test: Governor Response	Test Number: 5
Generator Procedure Reference:	

Description & Purpose of Test:

The tests, for compliance purposes, should; demonstrate the capability of each generating unit to continuously modulate active power to contribute to frequency control; validate the governor model submitted to SONI, assess dead-band, overall and incremental droop, steady-state/dynamic stability of the governor and demonstrate the robustness of the control system.

Appendix C gives typical governor response test signal parameters for 2 GTs and a ST and thermal plant. There is also information on dual fuelled power stations.

Where a load controller is fitted (CC.S1.5.5) the unit governor and load controller should be in Frequency Sensitive Mode. Simulated frequency deviation signals must be injected simultaneously at both speed governor and load controller references. For Combine Cycle Gas Turbine modules, simultaneous injection into all gas turbines, steam turbine governors and module controllers is required.

Prior to witnessing a governor test, SONI will request the Generator to conduct preliminary tests and send the results to SONI for assessment. These tests should be completed at least two weeks prior to the main governor response test. Details of preliminary and main test procedure are included in Appendix D.

Tests will occur in accordance with the submitted commissioning program detailed in Appendix A in accordance with CC10.1.4. The generator shall provide test information on, start times, duration of tests and active power output profiles through the test periods, this will enable SONI to evaluate the test programme.

Results Required:

The Generator will be required to provide their own digital monitoring and recording equipment to record the signals indicated in Appendix C for each of the tests listed in Appendix D.

Test Assessment:

The test results will be assessed against:

- CC.S1.5.1 and CC.S1.5.2

Criteria of Assessment:

- Governor dead-band +/-0.015Hz.
- Fast acting proportional control, with unit/module droop of 3-5%.
- Primary Response capability of the unit/module (% on unit/module Registered Capacity).
- Secondary Response capability of the unit/module (% on unit/module Registered Capacity).
- High Frequency Response capability of the unit/module (% on unit/module Registered Capacity).
- Stable operation from Designed Minimum Operating Level to maximum Declared Availability.
- Continuous frequency modulation capability across full generator operating range.
- Capable of experiencing large frequency disturbances and high rates of change without tripping.

The Generator should note that test requirements are indicative. A meeting will be arranged to discuss and agree the timing of the tests, associated test programmes and any witnessing requirements.

6.6 UNIT LOAD REJECTION

SONI Compliance Testing/Monitoring	
Title of Test: Unit Load Rejection	Test Number: 6
Generator Procedure Reference:	

Description & Purpose of Test:

The load rejection capability of a Generating Unit/GT Module is critical for System performance under islanding and System split conditions. The unit under these conditions, as indicated in CC.S1.5.2, must be able to control System Frequency below 52 Hz unless this causes the Generating Unit to operate below its Designed Minimum Operating Level (DMOL). It is acceptable that there may be a small transient overshoot above 52 HZ following the initial frequency rise without activation of the over speed protection.

Generators should confirm if possible, the speed control performance of the plant under an instantaneous load disconnection from 100% to DMOL through testing. If this test is proved to be impractical, results from computer simulation are acceptable provided the model is validated using full and partial load rejection tests carried out on each unit in the course of normal commissioning. These tests should verify the capability to sustain load rejection and return to synchronous speed under governor control.

The Generator should confirm in the Report, whether or not unit 'trip to house load' capability has been purchased. If so, results should be provided to demonstrate this.

A procedure indicating how the load rejection test will take place should be submitted to SONI.

The tests will normally be carried out to an agreed procedure and at an agreed time prior to the unit reliability/acceptance period.

Results Required:

- MW – active Power at Generator Terminals.
- V*t* – Generator Terminal voltage.
- *fs* – Turbine Speed.
- Control Valve Position.
- Over-speed and acceleration protection (alarm and trip) settings.

Results should be legible, clearly labelled, and should have appropriate scaling in engineering units.

Test Assessment:

The test results will be assessed against:

- CC.S1.5.2

Criteria of Assessment:

- Confirmation that the unit returns to synchronous speed without operation of over speed (or other) protection.

The Generator should note that test requirements are indicative. A meeting will be arranged to discuss and agree the timing of the tests, associated test programmes and any witnessing requirements.

6.7 REACTIVE CAPABILITY

SONI Compliance Testing/Monitoring	
Title of Test: Reactive Capability	Test Number: 7
Generator Procedure Reference:	

Description & Purpose of Test:

SONI will require a demonstration of the leading and lagging reactive power capability on each generating unit to demonstrate compliance with CC.S1.3.2. The requirement is to have the capability to achieve 0.8 lagging and 0.95 leading power factors at the generator terminals, while supplying rated active power (MW) for all normal transmission system voltage conditions.

This will be achieved by operation of the generating unit at full load at the required power factor for an agreed duration. The test duration will be for a minimum period of 1 hour or a duration stipulated by SONI.

This test will be co-ordinated by SONI System Operations at an agreed time during the reliability/acceptance period of the commissioning process. The test will be to the instruction of the Transmission System Operator and should be monitored and recorded both at SONI Control Centre and by the Generator.

Results Required:

- MW - Active Power at Generator Terminals.
- MVAr - Reactive Power at Generator Terminals.
- V - System (HV) Voltage.
- Generator Transformer Tap Setting.
- Generating Unit Performance Chart.

Results should be legible, clearly labelled, and should have appropriate scaling in engineering units.

Test Assessment:

The test results will be assessed against the criteria below unless varied by the Connection Agreement. CC.S1.3.2

Criteria of Assessment:

- Confirmation of the full reactive capability of the generating unit, from 0.80 lagging to 0.95 leading.
- Confirmation of maintaining reactive range, for prevailing transmission voltage, variations (110kV, 275kV).

The Generator should note that test requirements are indicative. A meeting will be arranged to discuss and agree the timing of the tests, associated test programmes and any witnessing requirements.

6.8 COMPLIANCE WITH CC7.3.4

SONI Compliance Testing/Monitoring	
Title of Test: Compliance with CC5.3	Test Number: 8
Generator Procedure Reference:	

Description & Purpose of Test:

Generators are required to demonstrate that when despatched in limited frequency sensitive mode, in the frequency range 50.5 Hz to 49.5 Hz, a generating unit MW output will remain constant. For frequencies 49.5 Hz to 47 Hz, the generating unit MW output should fall off not more than pro-rata with frequency (i.e. no greater than 2%/Hz).

SONI will require the Generator to demonstrate generator unit performance in accordance with CC.S1.3.4 through testing and/or monitoring. Such testing and monitoring will be used to validate the proposed methodology submitted by the Generator in the Interim Report (Part 3).

Pre-commissioning:- The Generator will need to supply SONI with information relating to the plant output/speed/ambient temperature performance characteristics and the relevant design methodology employed within the control system, to ensure the necessary correction to the plant output to meet the requirements.

Functionality Testing:- Following installation of the control system, the Generator will propose and agree a test procedure with SONI, which will demonstrate how the plant output power responded to changes in system frequency and ambient conditions (eg by frequency and temperature injection methods.

Incident Monitoring: - There is a need for assessment of plant performance under real frequency disturbance conditions. Generators are required to record and provide SONI with data on plant control parameters which ensure the necessary correction during a frequency incident. This will confirm or otherwise, correct operation of the control scheme. Detailed monitoring requirements will be agreed on a local basis with respective stations.

Where possible, SONI will notify Generators of significant frequency incidents for the purpose of CC.S1.3.4 compliance monitoring. Continuous monitoring will be required until compliance is fully demonstrated.

Validation:- On satisfactory conclusion of the above stages, SONI would consider the Generators plant to be compliant. As part of the life time compliance, SONI will continue to monitor the plants performance and will discuss any concerns with the Generator as part of the normal and ongoing liaison process.

Monitoring:

Where possible SONI will notify Generators of significant frequency incidents for the purpose of CC.S1.3.4 compliance monitoring.

Monitoring may be carried out during the reliability/acceptance period of the generating unit.

Where SONI considers that further long-term monitoring is required, this may be carried out using SONI monitoring equipment.

Results Required:

- MW - Active Power at Generator Terminals.
- *fs* - System Frequency.
- Control System Parameters as agreed with SONI.
- Tamb-Ambient Temperature.

SONI may inform the Generator if additional control system parameters should be monitored.

The Generator should inform SONI if any load limiter control is additionally employed.

Signals should be sampled no slower than 1Hz.

Results should be provided to SONI in electronic form, in a format suitable for use in spreadsheets.

Test Assessment:

The test results will be assessed against:

- CC.S1.3.4 of the Grid Code.

Criteria of Assessment:

- Continuous compliance when despatched in limited frequency sensitive mode.

The Generator should note that test requirements are indicative. A meeting will be arranged to discuss and agree the timing of the tests, associated test programmes and any witnessing requirements.

APPENDIX A - SAMPLE COMPLIANCE REPORT CONTENTS

Interim Report Part 1 (3 months prior to connection)

Introduction

Statements of Compliance with Grid Code connection Conditions as indicated in Appendix B.

Supporting Information:

- Ownership Diagram (& Gas Zone Diagram if applicable)
- Site Responsibility Schedules and list of authorised managers
- Control Telephony
- Record of Inter System Safety Precautions (RISSP) Prefix

Interim Report Part 2 (3 months prior to connection)

Contents of Interim Part 1 and

Supporting Information:

- Grid Code Data Registration Code Schedules (as appropriate)
- Site Common Drawings
- Protection Settings Schedule for Interconnecting Circuit(s)
- Telephone and Facsimile Numbers
- AVR & Governor Models

Interim Report Part 3 (3 months prior to connection)

Contents of Interim Parts 1 and 2, and

Supporting information:

- Generator protection Settings Report (se Appendix A1)
- Power System analysis Studies (where applicable)
- Fault Current (Balanced and Unbalanced Faults)
- Motor Starting
- Generator Reactive Capability within stated voltage range
- Supporting Monitoring Information
- Generator Commissioning Programme including details of site testing and who will be carrying out commissioning. (To be provided at least 6 weeks prior to synchronisation).

Final Report **(within two months of the synchronising date or such other period as may be agreed with SONI)**

Updated Contents of Interim Reports 1, 2 and 3 and

Test Results:

- Excitation System Test results
- Governor System Test results
- Plant & Apparatus Type Test results
- Reactive Capability Test results
- Load Rejection Test results

The above structure is indicative, but is a useful convention for Generators to follow. SONI will inform the Generator where additional supporting information is required.

A1 - PROTECTION REQUIREMENTS

Under section CC6.4 of the Grid Code the Generator must meet a set of minimum protection requirements. The generator should provide details of protection arrangements and settings CC10.1.2. As part of the Connection Report the Generator should submit a Generator Protection Settings report together with an overall trip logic diagram.

The Generator should provide details of all the protection devices fitted to the Generators plant together with settings and time delays, including:-

Protection Fitted	Typical Information Required
Over Speed/Under Speed Protection	Number of stages, frequency settings and time delays before operation.
Over Fluxing Protection/Control	V/Hz limiter setting, status and time delay settings
Over Excitation Protection/Control	Control characteristics, settings and time delays
Under/Over voltage protection	Number of stages, trip settings
Under/Over frequency protection	Number of stages, trip settings
Pole Slipping protection (if fitted)	Full power system analysis study results including settings and impedance diagrams
Under Excitation limiter protection	Settings and time delays (For both Auto and Manual AVR operation)
Loss of Mains protection (if fitted)*	Settings, type and time delays

* An intertripping scheme is recommended.

APPENDIX B - COMPLIANCE STATEMENT

Check List – Please initial each item or note any issue.

No.	Reference	Compliance Requirement of User	Initial
1.	General Information	Confirm that each item has been complied with. Include the following data: a) Updated Planning Code Data b) Ownership Diagram CC.A2, CC9.1 c) Name of User Site d) Confirmation that Safety Co-ordinators are authorised and competent e) List of telephone numbers for joint system incidents f) List of managers authorised to sign Site Responsibility Schedules g) List of telephone numbers of fax machines	
2.	CC5.5 CC5.6	Confirm that the User's plant can withstand the specified harmonics and unbalance levels. State, where applicable, the levels of unbalance or harmonic voltage generated by the plant at the point of common coupling. If a static frequency converter is employed, provide generic details of the equipment (e.g. rating, voltage, pulse number).	
3.	CC5.4.1	Confirm that the plant can withstand – without tripping, the transient voltage conditions in which the 50Hz component of voltage, on one or more phases, falls to zero or rises to 140% phase-to-earth voltage. Confirm earthing arrangements at the User's site.	
4.	CC6.2.1	Confirm that the plant/apparatus within the SONI Busbar protection zone complies with the appropriate technical specification. Confirm that the plant/apparatus has been designed, manufactured and tested in premises certified to BS EN ISO 9000 Series or equivalent.	

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No.	Reference	Compliance Requirement of User	Initial
5.	CC6.2.2	State the single and three phase fault interruption ratings of the User's HV circuit breaker. This information should be provided in Grid Code Data submissions. Where available, confirm by including type test certificates or other appropriate documentation.	
6.	CC6.4.2	Confirm the fault clearance time and the probability of clearance within the specified time. Indicate the breakdown of this time i.e. Xms protection operation, Yms circuit breaker opening. Confirm the values of X & Y by including, where available, type test certificates or other supporting information.	
7.	CC6.4 CC.S1.6.3	Confirm the number of Main Protections provided to clear faults on the HV generator connections. Confirm that back-up protection is installed. Confirm the back-up fault clearance time. Confirm any figures provided in a format as described in item 6 above. Confirm the required discrimination of back-up protection.	
8.	CC6.4.3 CC.S1.6.4	Confirm the installation of appropriate protections (interconnecting connections protection,* circuit-breaker fail protection, loss of excitation protection and pole-slipping protection), and provide generator protection settings report. Indicate, if applicable, time scales of operation of the protection.	
9.	MC Subcode 1	Confirm the provision of signals for tariff metering.	
10.	OC6	Confirm that the appropriate working procedures have been set up and agreed with SONI.	

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No.	Reference	Compliance Requirement of User	Initial
11.	CC6.4.3	Confirm co-ordination of protection relay settings across the Connection Point.	
12.	PC. A3	Confirm the as built, MW & MVAr operating range of each generator. Indicate, if applicable, effect of ambient temperature on these figures. An Operating Chart should be included in the DRC Schedule 1 submission, and should be drawn according to Grid Code OC2, Appendix 1. State the Short Circuit Ratio (SCR) of each generator. Include open and short circuit saturation curves which confirm the SCR figure.	
13.	MFS CC5.3	Confirm that the plant can continuously supply its active power output in accordance with the specified output power/frequency characteristic contained in the Minimum Functional Specification (MFS). Include characteristics which demonstrate the capability of the plant over a range of ambient temperatures up to 25^{o}C. Confirm any reduction in output power is pro-rata with falling frequency as shown in MFS. Include test data to demonstrate the characteristic.	
14.	MFS CC5.4	Confirm that MW active power, under steady-state conditions, will not be affected by the stated voltage changes (CC5.4 indicates the Grid Voltage variations). Confirm the availability of reactive power output under steady-state conditions within the stated voltage ranges. Provide a diagram showing MVAr generated versus HV voltage to demonstrate this capability across the entire generator transformer tapping range. A reactive capability test should be performed during the commissioning process to demonstrate compliance CC.S1.3.2.	

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No.	Reference	Compliance Requirement of User	Initial
15.	CC.S1.4	Confirm the provision, or otherwise, of Black Start facilities. Provide, if applicable, a detailed technical statement of how the facility will be provided. Testing of black Start facilities will be co-ordinated by SONI. Conform whether or not independent power supplies are provided for jacking and barring gear.	
16.	MFS	Confirm compliance with the MFS.	
17.	CC.S1.5.2	Confirm that each generating unit is fitted with a fast acting proportional turbine speed governor and unit load controller or equivalent control device to provide frequency response under normal operational conditions. State the standard(s) to which the governor is manufactured. Provide details for each generating unit as required in Schedule 1 of the DRC (functional description, block diagram, settings etc) on each of the following:- i. Turbine speed governor. ii. Unit load controller or equivalent control device. Confirm that the speed governor, in co-ordination with other control devices, controls the Generating Unit active power output with stability over the entire operating range of the Generating Unit. Indicate the governor droop characteristic and deadband of each generating unit.	

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No.	Reference	Compliance Requirement of User	Initial
		Confirm the Generating Unit/GT Module speed control performance characteristics under an islanded or System split condition. The generation load is assumed to be reduced instantaneously from full load to DMOL. The plant is expected to be able to control the frequency at or below 52 HZ accepting that there may be a small transient overshoot following the initial frequency rise without activation of the over-speed protection. Confirm the provision, or otherwise, of a "trip to house load" capability on each generating unit. Confirm the provision of a "Target Frequency" facility. Confirm the target frequencies available. If the unit is capable of being powered by more than one type of fuel, confirm that the above plant performance requirements are met by all types of fuel to be used. For each Generating Unit and/or GT module, confirm the plant is capable of meeting the minimum frequency response requirement profile shown in planning data supplied as a basis for the Connection Agreement.	
18.	CC.S1.5.3	Confirm that each generating unit has been fitted with a continuously acting automatic excitation control facility to control the terminal voltage without instability over the entire operating range. Confirm that the controller meets the provisions of the MFS and planning data supplied as a basis for the Connection Agreement. Where a power system stabiliser (PSS) is specified in the Supplemental Agreement, provide the methodology and design studies for deriving optimised PSS settings, or confirm that settings have been agreed with SONI.	

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No.	Reference	Compliance Requirement of User	Initial
19.	CC.S1.5	State the standard deviation of load error.	
20.	CC.S1.7	Confirm that the plant can withstand – without tripping – the NPS loading arising before a close-up phase-to-phase fault is cleared by back-up protection. State the maximum continuous and transient NPS current withstand capability of the generator.	
21.	PC A3.1.10	Confirm generator transformer earthing arrangements. This information should be provided in the DRC Schedule 5 submission.	
22.	MFS	Confirm the operating range (for frequency) of each generating unit. Confirm whether frequency sensitive relays have been installed indicating the settings, tolerance and any timer delay.	
23.	Connection Agreement	Confirm the provision, or otherwise, of fast-start capability. Confirm relay settings, if provided.	
24.	Connection Agreement CC8.1	Confirm the provision of control telephony.	
25.	Connection Agreement	Confirm the provision of operational metering. For generators, MC Subcode 3, confirm the provision on each unit.	
26.	Connection Agreement CC8.3	Confirm the provision of facsimile machines.	

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The following items confirm that effective general communication has taken place

No.	Reference	Compliance Requirement of User	Initial
27.	CC8	Confirm the provision of signals for system monitoring and space for system monitoring equipment.	
28.	CC9.1 CC10.1.3 OC6	Confirm the provisions relating to Safety Rules and Site Responsibility Schedules.	
29.	CC10.1.3	Include the site Responsibility Schedules.	
30.	CC9.1.4	Confirm preparation and provision of an Ownership Diagram and single line drawings of generators apparatus. Confirm, if applicable, preparation and provision of a Gas Zone Diagram. Include copies of the appropriate diagrams.	
31.	CC10.1.3	Confirm arrangements and provision of Site Common Drawings. Include a copy of the diagrams.	
32.		Acknowledge appropriate maintenance requirements for user plant and apparatus at SONI Substations.	
33.	CC10.1.3	Confirm authorised staff availability, stating names and contact numbers (where different from CC5.2).	

APPENDIX C - TYPICAL GOVERNOR RESPONSE TEST SIGNAL SCHEDULES

The following tables give a typical set of signals to be recorded on GT, thermal and hydro-electric plant. The list is generic and therefore the schedules may be adjusted to suit site requirements although these should be discussed with SONI prior to preparing the test procedures.

GT Plant (2 Gas turbines + 1 Steam Turbine)

Signal No.	Plant Parameter	Symbol	Unit	Unit Range*	Signal Range (V)*	Scaling Factor*	Offset*
1	System Frequency/GT Speed	FSYS	Hz				
2	Injected GT1 Speed Reference	FGT1	HZ				
3	GT1 Output Power	MWGT1	MW				
4	GT2 Output Power	MWGT2	MW				
5	ST Output Power	MWST	MW				
6	Module Sent Out Power	MWSO	MW				
7	GT1 Fuel Demand	FSR	%				
8	GT1 Fuel Valve Position	FSG	%				
9	GT1 Inlet Guide Vane Position	IGV	%				
10	GT1 Exhaust Gas Temperature	EGT	°C				
11	ST Pressure Before Turbine Valve	PTGV	BAR				
12	HP ST Valve Position	VHP	%				
13	IP ST Valve Position	VLP	%				
14	Stop/Start Logic signal	ON/OFF					

* Generator Supplied

Thermal Plant

Signal No.	Plant Parameter	Symbol	Unit	Unit Range*	Signal Range (V)*	Scaling Factor*	Offset*
1	System Frequency/Machine Speed	FSYS	HZ				
2	Injected Frequency Signal	FINJ	Hz				
3	Generator Output Power	MWGEN	MW				
4	Power Sent Out	MWSO	MW				
5	Governor Oil Pressure	SOP	BAR				
6	Turbine Governor Valve Position 1	TGV1	%				
7	Turbine Governor Valve Position 2	TGV2	%				
8	Pressure Set Point	PSP	BAR				
9	Superheater Outlet Pressure	PSH	BAR				
10	Pressure before Turbine governor Valve	PBGV	BAR				
11	Pressure after Turbine Governor Valve	PAGV	BAR				
12	Boiler Firing Demand	BFD	%				
13	Stop/Start logic signal	ON/OFF					

* Generator Supplied

Hydro Electric Plant **(table available on request)**

Wind Turbines **(table available on request)**

C1 - DUAL FUELLED POWER STATIONS

For GT plants which are capable of running on alternative fuels, then additional governor response tests will be required to demonstrate performance when running on these fuels. Depending on plant design, detailed tests will be agreed between SONI and the Generator at the early stage of the compliance process.

APPENDIX D - FREQUENCY RESPONSE TEST SEQUENCE

Past experience has demonstrated that significant delays can occur during testing because of problems associated with the governor/load controller set-up or frequency injection method. In order to avoid the risk of re-testing, it is important that the injection method and the plant control re proved well in advance of the main tests by the station or site contractor. A preliminary test is therefore required with details given in section D1 below.

For all tests, the target frequency selected on the generating plant is that instructed by the SONI Control Centre. This should normally be 50.00 Hz.

D1 - PRELIMINARY GOVERNOR FREQUENCY RESPONSE TESTING

This should be done by performing preliminary tests. With the plant running at approximately MLP4 the following frequency injections should be applied.

Test No.	Frequency Injection	Notes
1	Inject –0.5Hz frequency fall over 10 sec Hold until conditions stabilise Remove the injected signal and re-stabilise at MLP4	
2	Inject +0.5Hz frequency rise over 10 sec Hold until conditions stabilise Remove the injected signal and re-stabilise at MLP4	
3	Inject –0.5Hz frequency fall over 10 sec Hold for a further 20 sec At 30 sec from the start of the test, Inject a +0.3Hz frequency rise over 30 sec. Hold until conditions stabilise Remove the injected signal and re-stabilise at MLP4	
A	Inject 0.01Hz frequency fall as a step change Hold until conditions stabilise Remove the injection signal and re- stabilise at MLP4	To assess governor deadband
B	Inject 0.01Hz frequency rise as a step change Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP4	To assess governor deadband
C	Inject 0.02Hz frequency fall as a step change Hold until conditions stabilise Remove injection signal and re-stabilise at MLP4	To assess governor deadband
D	Inject 0.02Hz frequency rise as a step change Hold until conditions stabilise Remove injection signal and re-stabilise at MLP4	To assess governor deadband

The recorded results (eg Frequency injected, MW and control signals) should be sampled at a minimum rate of 1 Hz to allow SONI to assess the plant performance from the initial transients (seconds) to the final steady state conditions (5-15 minutes depending on the plant design).

The preliminary test results should be sent to SONI for assessment at least two weeks prior to the final witnessed tests.

D2 - SONI WITNESSED FREQUENCY RESPONSE TESTING SEQUENCE

The test sequence is outlined below with the initial test establishing the maximum steady state output condition of the plant (ie MLP 6).

1. Establish Maximum Plant Capacity as Loading Point MLP6

(a) Switch GT governors to manual and raise load demand to confirm the maximum output level at the base settings.

(b) Record plant and ambient conditions.

2. Response Tests at Loading Point MLP6 (Maximum output)

(a) Operate the plant at MLP6

(b) Inject ramp/profiled frequency changes simultaneously into the GT governor and load controller as listed in Appendix D3 and record plant responses.

3. Response Tests at Loading Point MLP5 (0.95 RC)

(a) Operate the plant at MLP5.

(b) Conduct tests as listed in Appendix D3 and record plant responses.

4. Response Tests at Loading Point MLP4 (0.8 RC)

(a) Operate the plant at loading point 4 (MLP4)

(b) Conduct tests as listed in Appendix D3 and record plant responses.

(c) Conduct tests A & B to establish the GT step response characteristics for governor modelling purposes.

(d) Conduct test C to establish the robustness of the control system under simulated extreme disturbances (eg, system islanding or system split).

5. Response Tests at Minimum Generation MLP2 (0.65 RC)

(a) Operate the plant at MLP2.

(b) Conduct tests as listed in Appendix D3 and record plant responses.

6. Response Tests at Designed Minimum Operating Level MLP1 (0.55 RC)

(a) Operate the plant at DMOL.

(b) Conduct tests as listed in Appendix D3 and record plant responses.

(c) Conduct test D to establish the robustness of the control system under simulated extreme disturbances (eg, system islanding or system split).

D3 - GENERIC SONI WITNESSED GOVERNOR FREQUENCY RESPONSE TEST SCHEDULE

Since the governor response tests described above are to be arranged and conducted by the Generator, it is their responsibility to propose a test programme to suit their site specific requirements. A typical example of the test programme is given in this Appendix. This programme is required to be submitted to SONI for approval at the early stage of the compliance process.

Initial Checks on Maximum Plant Capability at MLP6	
Action	Notes
Record plant MLP6 condition including levels for GT's and ST and module MW output, ambient temperature, governor control signals and steam conditions. Change GT governor control to manual and increase output power demand to maximum. Record Plant conditions when plant is thermally stabilised. Reset governor to normal operating mode and allow MLP6 condition to be established.	

Injection Tests at MLP6			
Test No.	Action	Frequency Injection	Notes
1	Inject 0.10Hz frequency rise over 10 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP6	+0.10 Hz	
2	Inject 0.20Hz frequency rise over 10 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP6	+0.20 Hz	
3	Inject 0.50Hz frequency rise over 10 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP6	+0.50 Hz	

Injection Tests at MLP5			
4	Inject 0.50Hz frequency fall over 10 sec Hold for 20 sec Inject 0.30Hz frequency rise over 30 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP5	-0.50 Hz +0.30 Hz	
5	Inject 0.50Hz frequency rise over 10 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP5	+0.50 Hz	

Injection Tests at MLP4			
6	Inject 0.50Hz frequency fall over 10 sec Hold for 20 sec Inject 0.30Hz frequency rise over 30 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP4	-0.50 Hz +0.30 Hz	
7	Inject 0.10Hz frequency fall over 10 sec Hold until conditions stabilise Remove the injection signal nd re-stabilise at MLP4	-0.10 Hz	
8	Inject 0.10Hz frequency rise over 10 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP4	+0.10 Hz	
9	Inject 0.20Hz frequency fall over 10 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP4	-0.20 Hz	
10	Inject 0.20Hz frequency rise over 10 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP4	+0.20 Hz	
11	Inject 0.50Hz frequency rise over 10 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP4	+0.50 Hz	
A	Inject 0.20Hz frequency falls as a step change Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP4	-0.2 Hz	To assess step response characteristic of plant
B	Inject 0.20Hz frequency rise as a step change Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP4	+0.2 Hz	To assess step response characteristic of plant
C	Inject 1.0Hz/sec frequency fall over 2 sec Hold for 30 sec Remove the injection signal and re-stabilise at MLP 4	-2.0 Hz	To assess plant performance under islanding and system split conditions

Injection Tests at MLP2			
12	Inject 0.50Hz frequency fall over 10 sec Hold for 20 sec Inject 0.30Hz frequency rise over 30 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP2	-0.50 Hz +0.30 Hz	
13	Inject 0.20Hz frequency rise over 10 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP2	+0.20 Hz	
14	Inject 0.80Hz frequency fall over 10 sec Hold for 20 sec Inject 0.30Hz frequency rise over 30 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP2	-0.80 Hz +0.30 Hz	

Injection Tests at MLP1			
15	Inject 0.20Hz frequency rise over 10 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP1	+0.20 Hz	
16	Inject 0.80Hz frequency fall over 10 sec Hold for 20 sec Inject 0.30Hz frequency rise over 30 sec Hold until conditions stabilise Remove the injection signal and re-stabilise at MLP1	-0.80 Hz +0.30 Hz	
D	Inject 0.5Hz frequency fall over 1sec Hold for 30 secs Remove the injection signal and re-stabilise at MLP1	-0.5 Hz	To assess plant performance under islanding and system split conditions