



GENERATOR PERFORMANCE STANDARDS

COMPLIANCE FRAMEWORK

**COMPLIANCE PROGRAMME**  
**GUIDELINES AND TEMPLATE**

PREPARED BY: **National Generator Forum**

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## 1. Approach

The proposed approach for generators to develop and implement performance compliance programs comprises three elements:

***Generators must ensure that their plant is capable of achieving their registered performance standards.***

This is achieved by having a comprehensive, clear and measurable compliance plan and following it. The elements of the programme must be standardised as much as possible using guidelines and template developed by the Reliability Panel, in consultation with NEMMCO and participants.

***Good electricity industry practice (GEIP) must be agreed in advance.***

While defining this phrase in text is difficult, establishing what is meant in practice should be less so. A working group with good technical knowledge should agree how a specific performance standard should be applied to a particular technology and size of plant. This group would then determine a reasonable suite of test and monitoring regimes that could be used by various plants to ensure the performance standard is achieved.

***The AER can use the guidelines to assess whether a generator is compliant by assessing the application of compliance programmes.***

A generator should base their compliance programme on the relevant elements of the agreed guidelines for their specific plant. The AER can therefore assess the generator compliance with the Rules in relation to technical requirements before events occur by seeking information on the performance standards compliance programme, comparing it to the guidelines, and examining its outputs. The AER is also required by the National Electricity Law to assess a generator's use of compliance programmes in assessing breaches of rules after system events.

Compliance with Rule 4.15 can therefore be assessed with or without a system event (although, as now, major investigations will still occur after system events) providing NEMMCO, participants and consumers with assurance of generator performance.

The compliance programme template will define how a particular performance standard can be applied to different generator technologies and details the appropriate testing, monitoring or assessment methodology that can be used to confirm plant can achieve their performance standards. The approach will allow;

- the generator to pick their tests and develop their compliance programme with the knowledge that, assuming they follow the template, they will have an acceptable programme;
- the AER to be assured that they will be able to assess generator compliance at all times; and
- other parties, and specifically NEMMCO, can be assured that the generators are in the best position to support the system during system events.

The assurance approach also allows for improvement in the template when tests are shown to be deficient.

## 2. Plan Content

Guidelines:

1. The compliance programme should provide details on a performance test and/or assessment related to each performance standard area.
2. Ideally the compliance programme should include details of;
  - a. The nature of the test/assessment including, conditions and setting up details if relevant, and frequency of tests.
  - b. How the test/assessment is conducted
  - c. A risk assessment for specific testing on generating plant where appropriate, detailing risks and control measures to ensure generating unit security during the test
  - d. The data to be collected
  - e. Verification process.
3. Where the guidelines refer to periodic testing, generator compliance programmes should specify the frequency of the performance test in accordance with GEIP giving due consideration, where appropriate, to the generator technology, age of the plant, major overhaul schedule, operating hours or system to be tested. Also, testing frequency must be based on the categorisation of performance standards as indicated in the table 1 of the "Compliance Principles"

### 3. Compliance Programme Guidelines

These guidelines provide the basis for the more comprehensive template for compliance programmes and can be used by generators as the primary instruction for developing, implementing and maintaining compliance programs.

Rule	Guideline
<b>S5.2.5.1 Reactive Power Capability</b>	<p>The reactive power capability (generation and absorption) should be established by test;:</p> <ul style="list-style-type: none"> <li>• immediately after commissioning new plant; <b>or</b></li> <li>• at the time the Performance Standards were registered for existing plant.</li> </ul> <p>Subsequent testing shall occur;</p> <ul style="list-style-type: none"> <li>• after major work on generator windings; <b>or</b></li> <li>• when major changes are made to the excitation system, <b>or</b></li> <li>• at regular in service intervals (refer to guideline No.3 in 'Plan Content')</li> </ul> <p><b>Notes:</b></p> <ul style="list-style-type: none"> <li>• Adjustment can be monitored at the terminals of the generator or at the connection point.</li> <li>• NEMMCO will arrange for other generating units to be operated in a way that compensates for the generating unit under test if required.</li> </ul>
<b>S5.2.5.2 Quality of Electricity Generated</b>	<p>Quality of electricity generated should be established by testing:</p> <ul style="list-style-type: none"> <li>• Immediately after commissioning new plant; <b>or</b></li> <li>• At the time the Performance Standards were registered for existing plant</li> </ul> <p>Subsequent testing should occur</p> <ul style="list-style-type: none"> <li>• Only if there has been a change to the relevant characteristics of the plant; <b>or</b></li> <li>• An extraneous event has occurred on the network which may have changed the characteristics of the plant <b>or</b></li> <li>• At regular intervals (refer to guideline No.3 in 'Plan Content')</li> </ul> <p>In accordance with AS1359.101 and IEC 60034-1, subsequent performance testing should be undertaken when significant modifications have been made to the unit's magnetic path, rotor winding configuration or excitation system.</p>
<b>S5.2.5.3 Response to frequency Disturbances</b>	<p>Performance is confirmed by the generating unit remaining synchronised during major frequency disturbances.</p> <p>Response to frequency disturbances should be assessed by:</p> <ul style="list-style-type: none"> <li>• Monitoring in-service performance</li> <li>• Investigating unit trips that occur during significant frequency deviation</li> <li>• Periodic Testing of relevant protection relays (refer to guideline No.3 in 'Plan Content')</li> </ul> <p>Plant simulation studies shall be considered acceptable.</p>

Rule	Guideline
<b>S5.2.5.4 Response to voltage Disturbances</b>	<p>Performance is confirmed by the generating unit remaining synchronised during major voltage disturbances.</p> <p>Compliance demonstrated by :</p> <ul style="list-style-type: none"> <li>• Monitoring in-service performance</li> <li>• Investigating unit trips that occur during significant voltage deviations</li> <li>• Periodic Testing of relevant protection relays (refer to guideline No.3 in 'Plan Content')</li> </ul> <p>Plant simulation studies should be acceptable to confirm standards</p>
<b>S5.2.5.5 Generating Unit response to disturbances following contingency events</b>	<p>Performance is confirmed by the generating unit remaining synchronised during a credible contingency event and various transmission line faults that are cleared by primary protection and breaker fail protection.</p> <p>Compliance demonstrated by :</p> <ul style="list-style-type: none"> <li>• Monitoring in-service performance</li> <li>• Investigating unit trips that occur during significant system events</li> <li>• Periodic Testing of relevant protection relays (refer to guideline No.3 in 'Plan Content')</li> </ul> <p>Plant simulation studies should be acceptable to confirm standards</p>
<b>S5.2.5.6 Quality of Electricity Generated and Continuous un- interrupted Operation</b>	<p>Performance is confirmed by the <i>generating unit</i> and <i>reactive plant</i> remaining in <i>continuous uninterrupted operation</i> within the limits for voltage fluctuation, harmonic voltage distortion and voltage unbalance as specified by the <i>network service provider</i> at its <i>connection point</i>.</p> <p>Compliance demonstrated by :</p> <ul style="list-style-type: none"> <li>• Testing of relevant protection relays at regular intervals (refer to guideline No.3 in 'Plan Content')</li> <li>• Investigation of unit trips that result from the events detailed above.</li> </ul>
<b>S5.2.5.7 Partial Load Rejection</b>	<p>Compliance demonstrated by :</p> <ul style="list-style-type: none"> <li>• Monitoring in-service performance</li> <li>• Investigating all unit trips that result from a loading level reduction directly imposed by the power system</li> <li>• Testing Control systems, AVR and/or turbine based control systems at commissioning and after any modifications that affect the control loop.</li> <li>• Periodic testing (refer to guideline No.3 in 'Plan Content')</li> </ul>
<b>S5.2.5.8 Protection from Power System Disturbances</b>	<p>Performance is confirmed by the generating unit remaining synchronised during power system disturbance conditions where required under a provision of the Rules.</p> <p>Compliance demonstrated by :</p> <ul style="list-style-type: none"> <li>• Testing Protection system relays by secondary injection at intervals based on accepted GEIP for the protection system design. The intervals should attempt to follow industry practice regarding major outages for typical plant. (refer to guideline No.3 in 'Plan Content').</li> <li>• Investigating all unit trips in conjunction with a relevant system event, in which the unit should have remained synchronised.</li> </ul>
<b>S5.2.5.9 Protection which Impacts on Power System Security</b>	<p>Performance shall be confirmed by assessing operation of protection system against the requirements of the standard when a generator trips as a result of fault occurring between the generator unit stator and the connection point.</p> <p>Compliance demonstrated by :</p> <ul style="list-style-type: none"> <li>• Testing Protection system relays by secondary injection at intervals based on accepted GEIP for the protection system design. The intervals should attempt to follow industry practice regarding major outages for typical plant. (refer to guideline No.3 in 'Plan Content').</li> <li>• Investigating all unit trips in conjunction with a relevant system event, in which the unit should have remained synchronised</li> </ul>

Rule	Guideline
<b>S5.2.5.10 Protection to Trip Plant for unstable operation</b>	<p>Performance shall be confirmed by the correct operation of protection systems as required by the performance standards during a system event.</p> <p>Compliance demonstrated by :</p> <ul style="list-style-type: none"> <li>• Testing Protection system relays by secondary injection at intervals based on accepted GEIP for the protection system design. The intervals should attempt to follow industry practice regarding major outages for typical plant. (refer to guideline No.3 in 'Plan Content').</li> <li>• Investigating all unit trips in conjunction with a relevant system event, in which the unit should have remained synchronised</li> </ul>
<b>S5.2.5.11 Frequency Control</b>	<p>Performance shall be assessed by monitoring in-service performance during a system event that causes a relevant change in system frequency or oscillatory behaviour in respect of active power transfer.</p> <p>Performance capability limitations including, but not limited to, the following;</p> <ul style="list-style-type: none"> <li>- where the unit is close to minimum/maximum output;</li> <li>- the unit is ramping in the opposite direction to the required response,</li> <li>- relevant auxiliary plant outages,</li> <li>- relevant plant condition limitations; or</li> <li>- where a limiting boiler/turbine control mode is selected for station requirements;</li> </ul> <p>shall be taken into account as part of any performance assessment.</p> <p>Where governor design permits, a step response test of the governor control system shall be undertaken periodically (refer to guideline No.3 in 'Plan Content') and at a time when system conditions are acceptable. Test results should be compared with the results of the previous test to assess any unexpected change in performance.</p> <p>For generators with governor systems that cannot be practically step response tested or where indirect performance testing only can be undertaken, an alternate test consistent with GEIP shall be performed.</p> <hr/> <p>Generators will not be required to run a unit isolated and vary the frequency of the island as part of a test.</p>
<b>S5.2.5.12 Impact on Network Capability</b>	<p>Rule S5.2.5.12 refers to plant capabilities that are part of a generating unit design. Performance will generally not alter unless relevant changes are made to the unit design.</p> <p>AVR and PSS performance testing shall be carried out following modifications to the electrical characteristics of the generator, in line with provisions of NER 5.3.9</p>

Rule	Guideline
<b>S5.2.5.13 Voltage and Reactive Power Control</b>	<p>Performance should be assessed, where justified by risk assessment, by monitoring in-service performance related to voltage regulation and stability.</p> <p>Where in-service monitoring clearly indicates that an excitation system may not be performing strictly to the standard, then a step response test of the excitation control system should be carried at a major overhaul, where technology permits, and at a time when system conditions are acceptable. The tests need to include steps into limiter operation (by moving the operating point and reducing the normal limiter set point) to assess the stability of limiter operation.</p> <p>For generators with excitation systems that cannot be practically step response tested or where indirect performance testing only can be undertaken, an alternate test consistent with GEIP shall be performed.</p> <p>For excitation control equipment that is not susceptible to performance drift (e.g. digital components), assessment of performance need only be performed at time of commissioning or after modifications to the excitation control systems.</p> <p>Periodic testing of performance shall be performed in accordance with GEIP (refer to guideline No.3 in 'Plan Content').</p> <p>Excitation system performance is determined by input parameters and settings which are calculated from system studies performed by technical experts and approved by both the NSP and NEMMCO. Generators shall only be accountable for ensuring the unit excitation system is set up according to the approved system parameters and settings.</p>
<b>S5.2.5.14 Active Power Control</b>	<p>Performance should be assessed by monitoring in-service performance</p> <p>Testing should be carried out at the time of commissioning of new equipment, or after modification to existing control systems.</p> <p>Periodic testing of performance shall be performed in accordance with GEIP (refer to guideline No.3 in 'Plan Content').</p>
<b>S5.2.6.1 Remote Monitoring</b>	<p>Periodic testing to test the integrity of remote monitoring systems must be performed</p>
<b>S5.2.6.2 Communications Equipment</b>	<p>Periodic testing to test the integrity of communication equipment must be performed</p>
<b>S5.2.7 Power Station Auxiliary Supplies</b>	<p>S5.2.7 applies to Station Auxiliary Transformers only (that is auxiliary transformers directly connected to network. Unit auxiliary transformers are behind the Generator transformer and are subject to the quality standards at the connection point).</p> <p>Auxiliary power consumption (power factor) should be assessed by monitoring in-service performance if measurements are usually recorded. In the absence of in-situ monitoring equipment tests should be undertaken to meet the customer obligations under the S5.3.5 or the relevant connection agreement if applicable.</p>
<b>S5.2.8 Fault Current</b>	<p>The generator's contribution to a fault is fixed by its transient reactance as designed and cannot be changed unless modifications to the plant are carried out.</p> <p>Any modifications to existing plant must follow the procedure outlined in NER clause 5.3.9.</p> <p>Therefore there should be no testing obligation unless required by the connection agreement.</p>
<b>General Caveats</b>	<p>Testing must be exempted from compliance liabilities - If a fault occurs during testing, or a unit trips, or the test results indicate the standard is not met, the generator will be exempted from liability. NEMMCO must be notified as soon as the generator cannot meet agreed standards.</p> <p>Generators with a nameplate rating of less than 30MW or with low duty cycles will only be required to have on-line monitor system in place for compliance monitoring if such systems are already in place.</p> <p>At a time of major system stress, if a generator trips due to an unrelated plant issue, the generator should be explicitly exempted from being held liable.</p>

## 4. Compliance Programme Template

Compliance programme template must cover all performance standards and spell out appropriate testing methodologies for each performance standard so that generators can select the most appropriate testing regime for each generator category/size etc. Also, testing frequency for each test must be clearly indicated.

Using the guidelines detailed in the Section 3 of this report, this template can be developed.

The following sample template indicates a testing regime appropriate for large thermal generators. In the template testing methods for other technologies must be included.

The extent of the details in the template would need to be determined following an industry consultation.

### Suggested Template Structure

Performance Standard	Test/Assessment	Supplementary Details															
Reactive Power Capability (S5.2.5.1)	<p><b><u>Routine Testing of Generator</u></b></p> <p>1. Overview</p> <ul style="list-style-type: none"> <li>• Test to be performed on each generating unit approximately every XX months.</li> <li>• Suitable times to be coordinated with NEMMCO to undertake a unit MVAR export and import capability test.</li> </ul> <p>2. Conducting the test</p> <ul style="list-style-type: none"> <li>• Generating unit setting are:.....</li> <li>• Reactive power to be measured at machine terminals or connection point</li> <li>• NEMMCO to coordinate system reactive power requirements from other sources</li> <li>• Instrumentation used includes ....</li> <li>• Basic test steps are;               <ol style="list-style-type: none"> <li>a. Step 1 .....</li> <li>b. Step 2 .....</li> </ol> </li> </ul> <p>3. Risk Assessment</p> <table border="1"> <thead> <tr> <th>Risk</th> <th>Additional Info</th> <th>Control Measure</th> </tr> </thead> <tbody> <tr> <td>Generator Stator Core Alarm Point exceeded</td> <td>Alarm Temp = XXX Deg Will be an issue at under-excited (MVAR absorb) limits</td> <td>Operator and Plant owner to monitor. If alarm temperature exceeded, change taps or reduce generation to bring MVar away from UEL.</td> </tr> <tr> <td>Operating beyond OEL/UEL</td> <td>Unit settings at MCR are xxxxxx</td> <td>Change Generator tx taps to bring MVAR back into operating envelope.</td> </tr> <tr> <td>Tap Changer mechanical/electrical Failure.</td> <td></td> <td>Operator to assess. Can tap be changed manually? NEMMCO to be notified of situation...</td> </tr> <tr> <td>Etc...</td> <td>Etc...</td> <td>Etc...</td> </tr> </tbody> </table> <p>4. Data to be collected (at generator terminal or connection point)</p> <ul style="list-style-type: none"> <li>• Maximum unit MVAR export</li> <li>• Maximum unit MVAR import</li> </ul> <p>5. Verification Process</p> <p>Unit MVAR capability to meet or exceed;</p> <ul style="list-style-type: none"> <li>• MVAR export standard = XXX.XX MVAR</li> <li>• MVAR import standard = YYY.YY MVAR</li> </ul> <p>Where measurements cannot be taken at the generator connection point, auxiliary load consumption measurements are necessary to determine the capability at the connection point.</p>	Risk	Additional Info	Control Measure	Generator Stator Core Alarm Point exceeded	Alarm Temp = XXX Deg Will be an issue at under-excited (MVAR absorb) limits	Operator and Plant owner to monitor. If alarm temperature exceeded, change taps or reduce generation to bring MVar away from UEL.	Operating beyond OEL/UEL	Unit settings at MCR are xxxxxx	Change Generator tx taps to bring MVAR back into operating envelope.	Tap Changer mechanical/electrical Failure.		Operator to assess. Can tap be changed manually? NEMMCO to be notified of situation...	Etc...	Etc...	Etc...	<p>Other Tests:</p> <p>A reactive power capability test shall be conducted in the same way as the routine test whenever;</p> <ul style="list-style-type: none"> <li>• after major work on generator windings; and</li> <li>• when major changes are made to the excitation system, <b>or</b></li> <li>• at regular in service intervals</li> </ul>
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