



## Market Rule Amendment Proposal

### PART 1 – MARKET RULE INFORMATION

Identification No.:	<b>MR-00244-R00</b>		
Subject:	<b>Technical Requirements</b>		
Title:	<b>Changes to Generation Facility Technical Requirements</b>		
Nature of Proposal:	<input checked="" type="checkbox"/> Alteration	<input type="checkbox"/> Deletion	<input type="checkbox"/> Addition
Chapter:	4	Appendix:	4.2
Sections:			
Sub-sections proposed for amending:	1; 12; 13; 15; 16		

### PART 2 – PROPOSAL HISTORY

Version	Reason for Issuing	Version Date
1.0	Technical Panel Review	22 Jul 04
2.0	Incorporate Technical Panel Comments and Publish for Stakeholder Review and Comment	28 Jul 04
3.0	Submit for Technical Panel Review and Vote	18 Aug 04
4.0	Incorporate Stakeholder and Technical Panel Comments and Submit for Technical Panel Review and Vote	15 Sep 04
5.0	Recommended by Technical Panel and Submitted for IMO Board Approval	6 Oct 04
6.0	Approved by the IMO Board	8 Oct 04
Approved Amendment Publication Date:	12 Oct 04	
Approved Amendment Effective Date:	8 Dec 04	

### PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

Provide a brief description of the following:

- The reason for the proposed amendment and the impact on the *IMO-administered markets* if the amendment is not made
- Alternative solutions considered
- The proposed amendment, how the amendment addresses the above reason and impact of the proposed amendment on the *IMO-administered markets*.

#### Summary

Rule amendments are proposed to the following technical and performance standards for generation facility equipment:

- Reactive power capability;
- Excitation system performance;
- Automatic voltage regulator;
- Power system stabilizer; and
- Speed governor.

The proposed changes represent either a relaxation or clarification of the existing requirements or align the requirements with applicable reliability standards. In some cases, the requirements specify a “default” standard and the IMO is permitted to require a stricter standard or permit a more relaxed standard as a result of the Connection Assessment and Approval process for a given generation facility.

The need for these amendments arose as the result of specific issues raised by market participants, by proponents of potential new generation investment in Ontario and by the IMO through experience gained in performing connection assessments or in directing the operation of the IMO-controlled grid. These proposed changes are expected to remove barriers to investment in new generation in Ontario and to clarify the existing technical and performance standard requirements, while maintaining and enhancing the reliable operation of the IMO-controlled grid.

This rule amendment originated from a request to address only the generator excitation system performance standards (MR-00244-Q00), but the scope of the proposed changes has been increased as a result of the additional issues raised.

#### Background and Discussion

Market participants and proponents of specific new generation investment in Ontario have, through the connection assessment, exemption or rule amendment processes, identified a number of issues with the existing market rule requirements for generation facility equipment technical and performance standards. Generally these persons have indicated that the existing requirements are unjustifiably onerous and/or are not compatible with specific existing generator technology. The IMO has also identified that a number of the existing requirements are not clear and/or not achieving the intended result. The issues regarding each technical and performance standard and the proposed changes to each standard are detailed below.

Reactive Power Capability (refer to section 1 of Appendix 4.2 below)

In its evaluation of several proposed installations of induction generation facilities (e.g. wind turbine generators) injecting electricity at nominal voltages equal to or less than 50 kV, the IMO has identified

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a potential adverse impact of such facilities on the reliable operation of the IMO-controlled grid. These facilities, which would typically be embedded in a distribution system, can result in a significant draw of reactive power from the IMO-controlled grid into that distribution system under certain conditions such as a sudden outage of the generator. This increased flow of reactive power can result in local area reliability problems. It is proposed to require that, at a minimum, such an induction generation facility (i.e. one that is injecting electricity at a nominal voltage equal to or less than 50 kV) be capable of operating at unity power factor and thus be able to compensate for its leading (underexcited) reactive power demand. Additional reactive power capabilities for such a facility may be identified during the IMO's Connection Assessment and Approval process for such a facility.

It is also proposed to change the reactive power capability requirements for an induction generation unit injecting electricity at a nominal voltage greater than 50 kV to be comparable to the requirements for a synchronous generation unit (i.e. within the range between 90% lagging (overexcited) and to 95% leading (underexcited)) unless a narrower (i.e. more relaxed) reactive power requirement is identified by the IMO as acceptable during the Connection Assessment and Approval process for such a facility. This would allow the IMO to permit a less onerous requirement provided there is not an unacceptable adverse impact on the reliable operation of the IMO-controlled grid. It is also proposed to remove the requirement for induction generation units to have the reactive power compensation installed "at its terminal" as some manufacturers install reactive compensation at locations other than the unit terminal.

It is also proposed to re-organize the existing reactive power requirements to clarify the application of provisions for generation units for which a licence was first issued before the coming into force of Chapter 4.

Excitation System Performance (refer to section 12 of Appendix 4.2 below)

The generator excitation system performance requirement presently set out in section 12 of Appendix 4.2 of the market rules effectively limits all new units over 10 MVA to the use of static excitation. This requirement may also apply to smaller units in a single facility with aggregate net output over 50 MVA. Facilities existing prior to the coming into force of this rule are not required to meet this standard unless and until their exciter is replaced.

Static excitation provides faster response and is significantly more costly than the alternative brushless excitation. While the faster response is required for system reliability reasons in certain circumstances, it has been suggested by market participants and agreed to by the IMO as having no- or low-impact on reliability in robust areas of the grid, except potentially for large generation units.

There are "off the shelf" generation units that utilize brushless excitation. The ability to install such generation units in Ontario would enable developers to procure equipment on the secondary market (machines ordered and manufactured for projects that were subsequently cancelled) and would remove both time and cost obstacles in developing such projects.

It is proposed to establish excitation system performance standards that would:

- (i) Specify default requirements on the basis of the rated size of the generation unit. A generation unit rated at less than 10 MVA would have a default requirement that is lower than the default requirement of a generation unit rated at 10 MVA or higher.
- (ii) Permit a generation unit rated at 10 MVA or higher to meet the lower default requirement when the IMO determines that application of the lower requirement would not have a material adverse effect on reliability;

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- (iii) Require a generation unit rated at less than 10 MVA to meet the higher default requirement when the IMO determines that application of the higher requirement is necessary to maintain reliable operation of the IMO-controlled grid.

This proposed lower default requirement is compatible with brushless excitation systems and is expected to allow the use of more off-the-shelf and lower cost generator technology and thus facilitate the incorporation of additional generation into the market.

It is proposed that the IMO would assess the impact on reliability as part of the Connection Assessment and Approval process for generation units. This is the appropriate time for such an assessment, as the overall impact on operation of the IMO-controlled grid is assessed at that time.

In the development of these revised requirements, the IMO identified two necessary clarifications to the existing requirements. The following clarification changes are proposed:

- The existing requirement implied that the positive and negative exciter ceiling voltages were required to be the same magnitude, which is not practicable. Separate positive and negative ceiling voltages are proposed.
- The maximum size of the voltage reference to be used for voltage response time calculations has been added to make the requirement clearer.

Automatic Voltage Regulator (refer to section 13 below)

As a result of experience directing the operation of the IMO-controlled grid, the following changes are proposed to the automatic voltage regulator (AVR) requirement.

- Clarify the default status of voltage control.
- Require all generation units equipped with AVR to regulate voltage unless the IMO permits otherwise.
- Revise the provision regarding IMO approval of extraordinary AVR compensation schemes to clarify that IMO approval is required rather than implying that the IMO is required to approve such schemes.

Power System Stabilizer (refer to section 15 below)

With the proposed change to the excitation system performance requirements, it is also proposed to require power system stabilizers only on those generation units that are required to meet the higher excitation system performance standard (i.e. those generation units required to have static excitation systems). It is also proposed to specify the operational tuning of the power system stabilizer so that the intended reliability benefits of a stabilizer can be realized.

Speed Governor (refer to section 16 below)

The existing market rules require separate speed governor control with droop and deadband requirements for each synchronous generation unit. A market participant for an existing combined cycle generation facility, through an exemption application, has demonstrated that this requirement is not practical for such a facility. A combined cycle generation facility typically has one or more gas turbines generating electricity as well as providing waste heat to a steam generator that also produces electricity. The steam unit is typically a “slave” of the upstream gas units, and it is not practical for this steam unit to have speed governor control.

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To address the combined cycle generation facility issue, it is proposed to change the speed governor requirement to be applicable to an entire combined cycle generation facility rather than to the individual steam and gas units.

As a result of the August 2003 blackout and subsequent investigation and review, it is also proposed to align the market rules with NERC Policy 1 – Generation Control and Performance in requiring speed governors to provide immediate, appropriate and sustained response to abnormal frequency excursions. This requirement also needs to recognize the limitations of the generation unit i.e. governor response should not result in generation unit trips. For this reason, this requirement is proposed to be qualified by stating the response should be immediate, appropriate and sustained to the extent practical.

## PART 4 – PROPOSED AMENDMENT

## Appendix 4.2 – Generation Facility Requirements (Embedded and Non-Embedded)

Each *generation facility* shall comply with the following requirements, provided that a *generation facility* that was in service or that existed and was *licensed* on the date of coming into force of this Chapter 4 shall preserve original excitation system design capabilities and shall not be required to comply with the requirements set forth in rows 12 to 15 of this Appendix until its exciter is replaced. Such *generation facility* shall, until that time, be required to operate in accordance with the design capabilities applicable in respect of each of the items referred to in rows 12 to 15 of this Appendix.

Ref	Item	Requirement
1	Reactive Power Capabilities	<p>1. A synchronous <i>generation unit</i> shall have the capability to supply at its terminal reactive power within the range <u>between</u> 90% lagging (overexcited) <u>and to</u> 95% leading (underexcited) power factor based on rated <u>real-active</u> power at rated voltage. Rated <u>real-active</u> power shall be the lesser of registered maximum continuous real power <u>or and</u> 90% of the unit nameplate MVA.</p> <p>2. A non-embedded <i>generation unit</i> within a <i>generation facility</i> shall have the capability to supply its entire range of reactive power for at least one constant voltage at a <i>connection facility</i> terminal greater than 50 kV. A non-embedded <i>generation unit</i> within a <i>generation facility</i> for which a licence has first been issued on or before the date of coming into force of this Chapter 4, and lacking the capability to meet this requirement, shall maintain its existing capability and shall establish the capability to supply its entire range of reactive power for at least one constant voltage at a <i>connection facility</i> terminal greater than 50 kV upon upgrading of all of the limiting components of its <i>connection facilities</i>.</p> <p>3. Where modifications to a <i>generation facility</i> made before the date of coming into force of this Chapter 4 make it no longer possible to meet these reactive requirements at a new higher active power, <i>generation units</i> within such <i>generation facility</i> shall, if so requested by the <i>IMO</i>, satisfy reactive power requirements based on rated active power before this modification.</p> <p><u>Induction generation facilities shall be supported by reactive power corrective equipment designed to raise the equivalent power factor of the unit to 90% lagging at rated output.</u></p> <p>4. <u>An induction generation unit that is injecting electricity at a nominal voltage of greater than 50 kV shall have the capability to supply reactive power at its terminal within the range 90% lagging (overexcited) to 95% leading (underexcited) power factor based on rated active power at rated voltage. Rated active power shall be the lesser of registered maximum continuous real power or 90% of the unit nameplate MVA.</u></p> <p>5. <u>An induction generation unit that is injecting electricity at a nominal voltage equal to or of less than 50 kV shall, as a minimum, have the capability of operating at unity power factor. Additional reactive power capabilities for such an induction generation unit, up to the capabilities specified for a synchronous generation unit of the same apparent power, may be required if identified during the Connection Assessment and Approval process for that induction generation unit</u></p>
2	Voltage Variations	<u>Each gGeneration facilities shall be capable of operating continuously at full output within ± 5% of the generation facility's rated terminal voltage. All plant auxiliaries shall be capable of running indefinitely continuously within this range. Each gGeneration facilities shall not be expected to operate continuously outside thithis voltage range to satisfy reactive power requirements.</u>
3	Frequency Variations	<u>Each gGeneration facilities shall be able to operate continuously at full power in the range between 59.4 to 60.6 Hz. Each generation facility Generation facilities shall be capable of operating at full power for a limited period of time at frequencies as low as 58.8 Hz. Each generation facility Generation facilities shall not trip for underfrequency excursions that are above a straight line defined on a linear-log plot of time and frequency by the points (300s, 59.0Hz) and (3.3s, 57.0 Hz) unless the IMO accepts other trip settings. Immediate tripping is allowed below 57.0 Hz.</u>

<b>Ref</b>	<b>Item</b>	<b>Requirement</b>
4	Phase Unbalance	Phase voltage unbalance of <i>generation facilities</i> shall be limited to 1% measured with the units operating unsynchronised. <i>Generation facilities</i> shall be able to continuously operate with a phase unbalance of 2%.
5	Connection Equipment	All equipment connecting the <i>generation unit's</i> terminal to the <i>IMO-controlled grid</i> shall be able to conduct for at least 4 hours the <i>generation unit's</i> rated apparent power, being the product of root-mean-square (rms) voltage and the rms current, minus auxiliary power requirements necessary to operate the unit at maximum output and minus a fair portion of the common service load required to run the entire <i>generation facility</i> .
6	[Intentionally left blank]	
7	Protective Systems and Relaying System Requirements	Protection systems shall be constructed and maintained in accordance with all applicable <i>reliability standards</i> .
8	[Intentionally left blank] Line	
9	<i>IMO</i> Monitoring and Telemetry Requirements	<i>Generation facilities</i> that are required by this Chapter 4 to be monitored shall provide suitable space and facilities for the installation of telecommunications equipment to interface with the <i>generator's</i> data acquisition equipment. Data monitoring equipment shall be compatible with the <i>IMO</i> telecommunications interface and meet the requirements of this Chapter 4 and of Appendix 2.2 of Chapter 2, if such equipment is not already installed on the date of coming into force of this Chapter 4. Any such new installation shall be done at the <i>generator's</i> cost.
10	Communication Facilities	Communication facilities are required for several or all of the following functions: protective relaying, SCADA, <i>IMO energy</i> management system, voice communication, <i>automatic generation control (AGC)</i> , and <i>special protection systems (generation rejection or runback)</i> . Details depend on the size and specific location of the generating plant under consideration
11	Testing/ Compliance Monitoring	<i>Generators</i> shall test and maintain their equipment in accordance with all applicable <i>reliability standards</i> .

Ref	Item	Requirement
		<b>Generator Controls</b>
12	Excitation System Performance	<p>1. <u>Each synchronous generation unit rated at 10 MVA or higher shall be equipped with an excitation system with:</u></p> <ul style="list-style-type: none"> <li>• <u>A voltage response time not longer than 50 ms for a voltage reference step change not to exceed 5%;</u></li> <li>• <u>A positive ceiling voltage of at least 200% of the rated field voltage, and</u></li> <li>• <u>A negative ceiling voltage of at least 140% of the rated field voltage.</u></li> </ul> <p><u>This performance requirement would not apply to a generation unit rated at 10 MVA or higher where the IMO determines through the connection assessment for that generation unit, that a lower requirement would not adversely impact the reliable operation of the IMO-controlled grid. In these circumstances, the synchronous generation unit shall be equipped with an excitation system with:</u></p> <ul style="list-style-type: none"> <li>• <u>A response ratio of at least 0.50 and</u></li> <li>• <u>A positive ceiling voltage at least 150% of rated field voltage</u></li> </ul> <p>2. <u>Each synchronous generation unit rated at less than 10 MVA shall be equipped with an excitation system with:</u></p> <ul style="list-style-type: none"> <li>• <u>A response ratio of at least 0.50 and</u></li> <li>• <u>A positive ceiling voltage at least 150% of rated field voltage</u></li> </ul> <p><u>This performance requirement would not apply to a generation unit rated at less than 10 MVA where the IMO determines through the connection assessment for that generation unit, that a higher requirement is required to maintain reliable operation of the IMO-controlled grid. In these circumstances, the synchronous generation unit shall be equipped with an excitation system with:</u></p> <ul style="list-style-type: none"> <li>• <u>A voltage response time not longer than 50 ms for a voltage reference step change not to exceed 5%;</u></li> <li>• <u>A positive ceiling voltage of at least 200% of the rated field voltage, and</u></li> <li>• <u>A negative ceiling voltage of at least 140% of the rated field voltage.</u></li> </ul> <p><del>Each synchronous generation unit that is rated at 10 MVA or larger shall be equipped with an excitation system with voltage response time not longer than 50 ms, and ceiling voltage at least twice the rated field voltage.</del></p> <p><del>Generation units rated less than 10 MVA within a generation facility with an aggregated rated net output of greater than 50 MVA may be required to observe these criteria.</del></p>
13	Automatic Voltage Regulator	<p><del>Each synchronous generating unit shall be equipped with a continuously acting automatic voltage regulator (AVR) that can maintain terminal voltage under steady state conditions within <math>\pm 0.5\%</math> of any set point within <math>\pm 5\%</math> of rated voltage. Each synchronous generation unit shall regulate voltage except where permitted by the IMO. Each induction generation unit that is injecting electricity at a nominal voltage of greater than 50 kV shall regulate voltage except where permitted by the IMO.</del></p> <p><del>Automatic set point adjustments shall be suspended when terminal voltage deviates from a fixed set point by an amount not to exceed <math>\pm 2\%</math> of the fixed set point.</del></p> <p><del>Where multiple generation units are connected to a common bus, each generation unit's AVR reference shall be compensated to a point as close as practicable to but not farther than this common bus. The reach of AVR compensation shall not exceed 10% of the generation unit's synchronous direct axis impedance from the common bus. IMO approval is required for all other schemes that compensate the AVR to a point other than the generation unit's terminals.</del></p> <p><del>A continuously acting automatic voltage regulator (AVR) shall be provided for every synchronous generation unit. For generation units rated at 10 MVA or more, the AVR shall be able to maintain over its entire operating range, a steady-state terminal voltage within <math>\pm 0.5\%</math> of the set point. Automatic set point adjustments shall be suspended when terminal voltage deviates from a fixed set point by an amount not to exceed <math>\pm 2\%</math> of the fixed set point. Where multiple generation units are connected to a common bus, each generation unit's AVR reference shall be compensated to a point as close as practicable to but not farther than this common bus. The reach of AVR compensation shall not exceed 10% of the generation unit's synchronous direct axis impedance from the common bus. The IMO shall approve all other schemes that compensate the AVR to a point other than the generation unit's terminals.</del></p>
14	Power Factor Regulator	<p>Each synchronous generation unit connected to the system at a voltage under 50 kV shall be provided with a power factor regulator or VAR regulator. A power factor regulator shall be capable of maintaining a power factor within <math>\pm 1\%</math> between 90% lagging and 95% leading. A VAR regulator shall be capable of maintaining reactive power within <math>\pm 2.5\%</math> of rated MVA. The power factor or VAR regulator shall have an adjustable effective response time between 10 to 60 seconds.</p>

<b>Ref</b>	<b>Item</b>	<b>Requirement</b>
15	Power System Stabilizer	<p><del>Each synchronous <i>generating unit</i> that is equipped with an excitation system that meets the performance requirements specified in sub-section 1 of section 12 above, shall also be equipped with a power system stabilizer. The power system stabilizer shall, to the extent practicable, be tuned to increase damping torque without reducing synchronizing torque.</del></p> <p><del>Each synchronous <i>generation unit</i> that is rated at 10 MVA or larger shall be equipped with a power system stabilizer; when required by the IMO. <i>Generation units</i> rated less than 10 MVA within a <i>generation facility</i> with an aggregated rated net output of greater than 50 MVA may be required to be equipped with power system stabilizers.</del></p>
16	Speed Governor	<ul style="list-style-type: none"> <li>• Each synchronous <i>generation unit</i> with a nameplate rating of greater than 10 MVA shall be operated with a speed governor. The governor shall have a permanent speed droop that can be set in the range between 3% and 7% and the intentional deadband shall not be wider than <math>\pm 36</math> mHz .</li> <li>• <del>The above droop and deadband requirements shall apply to an entire combined-cycle <i>generation facility</i>.</del></li> <li>• The governor shall be able to arrest the unit's speed, following full load rejection to prevent a trip due to overspeed, and shall demonstrate stable performance with adequate damping under all operating conditions.</li> <li>• Governors shall control speed in a stable fashion during both island and interconnected operation.</li> <li>• <del>To the extent practical governors shall provide immediate, appropriate and sustained response to abnormal frequency excursions.</del></li> <li>• Control systems that inhibit governor response shall be automatically disabled by frequency deviations not larger than <math>\pm 100</math> mHz.</li> </ul>

#### PART 5 – IMO BOARD COMMENTS

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