The intent of this Guide is to establish the interconnection requirements of Distributed Resources with the Wire Owner’s distribution system. While every precaution has been taken in the preparation of this Guide, it may contain inaccuracies or inconsistencies. The authors of this Guide assume no liability for errors or omissions, or damages resulting from the use or reliance upon the information contained herein.

This Guide has been developed without regard to whether its adoption may involve patents on articles, materials, or processes. Such adoption does not assume any liability to any patent owner, nor does it assume any obligation whatsoever to parties adopting this Guide.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 PURPOSE</td>
<td>3</td>
</tr>
<tr>
<td>2.0 LIMITATIONS</td>
<td>4</td>
</tr>
<tr>
<td>3.0 DEFINITIONS</td>
<td>4</td>
</tr>
<tr>
<td>4.0 GENERAL INTERCONNECTION AND PROTECTION</td>
<td>6</td>
</tr>
<tr>
<td>REQUIREMENTS</td>
<td></td>
</tr>
<tr>
<td>5.0 CONSTRUCTION</td>
<td>21</td>
</tr>
<tr>
<td>6.0 METERING</td>
<td>21</td>
</tr>
<tr>
<td>7.0 INSPECTION</td>
<td>23</td>
</tr>
<tr>
<td>8.0 TESTING</td>
<td>24</td>
</tr>
<tr>
<td>9.0 DATA REQUIREMENTS</td>
<td>28</td>
</tr>
<tr>
<td>10.0 MARKING AND TAGGING</td>
<td>29</td>
</tr>
<tr>
<td>11.0 MAINTENANCE</td>
<td>29</td>
</tr>
<tr>
<td><strong>Table 1</strong> Control, Protection for Single Phase DG</td>
<td>30</td>
</tr>
<tr>
<td><strong>Table 2</strong> Control, Protection for Three Phase DG</td>
<td>31</td>
</tr>
<tr>
<td><strong>Table 3</strong> Control, Protection, for Closed Transition Switching</td>
<td>33</td>
</tr>
<tr>
<td><strong>App 1</strong> Applicable Codes And Standards</td>
<td>34</td>
</tr>
<tr>
<td><strong>App 2</strong> Interconnection Single Line Diagram (WYE-DELTA)</td>
<td>35</td>
</tr>
<tr>
<td><strong>App 3</strong> Interconnection Single Line Diagram (WYE-WYE)</td>
<td>36</td>
</tr>
<tr>
<td><strong>App 4</strong> High Voltage Disconnect Switch</td>
<td>37</td>
</tr>
<tr>
<td><strong>App 5</strong> Low Voltage Disconnect Switch</td>
<td>38</td>
</tr>
<tr>
<td><strong>App 6</strong> Protective Settings Commissioning Document</td>
<td>39</td>
</tr>
<tr>
<td><strong>App 7</strong> Schedule 1 and Schedule 2 for Metering Equipment</td>
<td>41</td>
</tr>
<tr>
<td><strong>App 8</strong> Notes</td>
<td>42</td>
</tr>
</tbody>
</table>
1.0 PURPOSE

This Guide establishes criteria and requirements for interconnection of Distributed Resources (DR) with Distribution Systems. Specifically, this Guide describes the design and testing requirements of generator interconnections to the Wires Owner Distribution System.

The requirements established in this document cover a broad spectrum of interests. The addition of distributed resources to the distribution system may change the system and its response. Attaining a technically sound and robust interconnection among distributed resources and the distribution system mandates diligence on the part of everyone involved in the interconnection, including designers, manufacturers, users, owners, and operators of both distributed resources and distribution systems. The requirements in this Guide need to be cooperatively understood and met among the aforementioned groups.

This document provides a uniform Guide for the interconnection of distributed resources with distribution systems. This Guide has been developed with reference to international standards such as the IEEE (The Institute of Electrical and Electronic Engineers) standard P1547, Standard for Interconnecting Distributed Resources with Electric Power Systems. The Wires Owner Guide has been termed an interim Guide, as the intention is to upgrade it over time to conform to evolving Alberta and international standards, such as IEEE. It provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection.

This document defines the technical requirements for connecting generation that is not exclusively owned by the Wires Owner but is connected to the Wires Owner’s facilities that have an operating voltage of 25,000 volts or lower.

This document does not constitute a design handbook. Distributed Resource Owners who are considering the development of a generation facility intended for connection to the Wires Owner’s distribution system should engage the services of individuals qualified to provide design and consulting services for electrical interconnection facilities. Section 3.0 of this document provides essential background such as definitions, and references required to be used in conjunction with this Guide are indicated in Appendix 1. Subsequent sections provide the interconnection specification requirements, and testing for their conformance.
2.0 LIMITATIONS

The criteria and requirements in this document are applicable to all distributed resource (DR) technologies and to the primary and secondary voltages of the electric power distribution systems. Installation of DRs on the radial primary and secondary distribution systems are the main emphasis of this version, although network distribution systems are considered. For this version, the requirements shall be met at the Point of Common Coupling (PCC), although the location of the protective devices may not necessarily be at that point.

This interconnection Guide is a minimum requirement for the interconnection of Distributed Resources. Additional requirements may have to be met by both the Distributed Resource owner and the Wires Owner to ensure that the final interconnection design meets all local and national standards and codes, and that the design is safe for the application intended. This Guide does not address any liability provisions agreed to elsewhere by both parties in a commercial agreement or tariff terms and conditions.

3.0 Definitions

“Distributed Generation (DG)” – Electric generation facilities connected to a Distribution System through the Point of Common Coupling (PCC). Distributed Generation is a subset of Distributed Resources (DR).

“Distributed Resources (DR)” – Sources of real electric power that are not directly connected to the bulk power transmission system. It includes both generators and energy storage technology.

“Distribution System” – Any facilities that operate at a nominal voltage of 25,000 volts or lower and that allow electric power to be delivered to a load, regardless of ownership.

“Island” – A condition in which a portion of the Wires Owner’s system is energized by one or more Power Producer generators through their PCC(s) while electrically separated from the rest of the Wires Owner’s system.

“Main Disconnect” shall mean a single disconnect switch or circuit breaker by means of which all customer loads, generator(s) and all protective devices and control apparatus can be simultaneously disconnected under full load entirely from the source supplied by the Wires Owner. The switch or breaker shall be provided with the means for locking of all contacts in the open position, and the blades or moving contacts shall be connected to the Power Producer side.
“Parallel (Operation)” with the Wire Owner will be used to refer to any electrical connection between the Wire Owner and the Power Producer’s generation equipment.

“Point of Common Coupling (PCC)” will be used to refer to the point where the electrical facilities or conductors of the Wire Owner are connected to the Power Producer’s facilities or conductors, and where any transfer of electric power between the Power Producer and the Wire Owner takes place.

“Power Producer” will be used to refer to anyone interconnected to the Wires Owner System for the purpose of generating electric power.

“Stabilized” will be used to refer to the Wires Owner’s distribution system, returning to the normal range of voltage and frequency for 5 minutes or a time as coordinated with the Wires Owner, following a disturbance.

“Target” (Operation Indicator) – A supplementary device operated either mechanically or electrically, to indicate visibly that the relay or device has operated or completed its function.

“Telemetering” – Transmission of measurable quantities using telecommunications techniques.

“Visible-break Disconnect” shall mean a single disconnect switch or circuit breaker by means of which the customer loads, generator and all protective devices and control apparatus can be simultaneously disconnected under full load entirely from the source supplied by the Wires Owner. The switch or breaker shall be provided with the means for locking of all contacts in the open position and allow for visible inspection of all contacts in the open position. The blades or moving contacts of this switch shall be connected to the Power Producer side. The switch or breaker shall be located at the Point of Common Coupling to facilitate access by the Wires Owner.

“Wires” will be used to refer to the Wire Owner’s distribution system below 25 kilovolts to which the generation equipment is interconnected.

“Wires Owner” will be used to refer to the Host Utility owning the Utility System. In the ENMAX distribution area, “Wires Owner” refers to ENMAX Power Corporation.
4.0 GENERAL INTERCONNECTION AND PROTECTION REQUIREMENTS

The Customer’s generation and interconnection installation must meet all applicable national, provincial and local construction and safety codes.

Any Customer may operate 60 Hertz, three phase or single phase generating equipment, in parallel with the Wires Owner System and in accordance with the Wires Owner Interconnection and Operating Agreement, provided the equipment and Power Producer meets or exceeds the requirements of this Guide.

The following three sections, 4.1, 4.2, and 4.3, define the system technical requirements. The Power Producer’s equipment must be able to operate within the ranges specified in Section 4.1. The technical requirements to be met by the Power Producer are described in Section 4.2. Section 4.3 provides the technical requirements to be met by the facilities interconnecting the producing facility and the distribution system.

These requirements promote safe operation and minimize the impact on the electrical equipment in the Wires Owner system and its other customers. This Guide is not intended to provide protection for the Power Producer’s generation equipment. It is the responsibility of the Power Producer to provide such protection. The Power Producer is responsible for protecting the Power Producer’s generating equipment in such a manner that Wires Owner system outages, short circuits or other disturbances, including excessive zero sequence currents and ferroresonant over-voltages, do not damage the Power Producer’s generating equipment. The Power Producer’s protective equipment shall also prevent excessive or unnecessary tripping that would affect the Wires Owner’s system reliability and power quality to other customers as required in this guideline.

The Power Producer is required to install, operate and maintain in good order and repair at all times in conformity with good electrical practice the facilities required by this guideline for the safe parallel operation with the Wires Owner system.

Refer to Tables 1, 2 and 3 and Appendix 2 and 3 for Summary Tables & Single Line Diagrams showing typical interconnection protection requirements.

4.1 DISTRIBUTION SYSTEM

4.1.1 System Frequency
The Alberta Interconnected System operates at 60 Hertz (Hz) Alternating Current (AC). Frequency deviations are typically 59.7 Hz to 60.2 Hz. for small contingencies that cause modest disturbances, but where the Alberta Interconnected System remains intact and connected to the Western System.
For large contingencies, variations of 58 Hz to 61 Hz or greater can occur. These variations can be experienced, for example if a portion of the Alberta Interconnected system had to be islanded.

4.1.2 Voltage Regulation
CSA Standard CAN3 C235 83 - Preferred Voltage Levels for AC Systems 0 to 50,000V provides general guidance as to appropriate performance.

4.1.3 Power Quality
All interconnected equipment must comply with the Wires Owner’s standards for power quality. The following industry standards may provide guidance as to appropriate performance. Voltage Flicker – IEC 1000-4-15 Electromagnetic Compatibility Part 4: Testing and measurement techniques; Part 15: Flickermeter – Functional and design specifications. Harmonics - Wires Owner’s guide for the connection of non-linear load (which is partly based on IEEE Std. 519 - 1992).

4.1.4 Voltage Unbalance
Distribution Facilities are typically three-phase systems incorporating single-phase distribution taps. The voltage unbalance on the Wires Owner distribution system under normal operating conditions may reach 3%, due to the unbalanced loading and single-phase regulation. Voltage unbalance will be calculated using:
Unbalance (%) = 100 x (deviation from average) / (average) as derived from NEMA MG1-1993 14.35.

4.1.5 Fault Levels
Fault levels, and maximum allowable fault levels, vary significantly through a distribution system and must be considered in the design of the interconnection. Fault levels and X/R ratios must be evaluated for the equipment selected.

4.1.6 System Grounding
Distribution facilities are typically operated as effectively (solidly) grounded and Wye-connected at the source substation bus. Other configurations are occasionally found. Distribution Facility grounding must conform to the Alberta Electrical and Communication Utility Code (formerly the Alberta Electrical and Communication Utility System Regulation 44/1976 or future amendments).

4.1.7 Fault and Line Clearing
To maintain the reliability of the distribution system, the Wires Owner uses automatic re-closing. The Power Producer needs to take into consideration line re-closing when designing generator protection schemes. This is to ensure that the generator is disconnected from the Wires Owner’s System prior to automatic re-close of breakers. The customer may reconnect when the Wires Owner’s System voltage and frequency return to normal range and is stabilized. To enhance reliability and safety and with the
Wires Owner’s approval, the Power Producer may employ a modified relay scheme with tripping or blocking using communications equipment between the Power Producer and Wires Owner facilities.

4.2 GENERATING FACILITY

4.2.1 Mitigation of Adverse Effects
Adding a generating facility can adversely affect the electric service to existing or future electric customers. The Power Producer shall work with the Wires Owner to mitigate any adverse affects.

If the generating facility is effecting customers adversely, the Wires Owner may disconnect it until such time as the concern has been mitigated. The Power Producer will be responsible for any costs incurred as a result of these actions.

4.2.2 Synchronism
Any generating facility that can create an AC voltage while separate from the electric system must have synchronization facilities to allow its connection to the electric system.

Inverter-type, voltage-following equipment that cannot generate an AC voltage while separate from the electric system do not require synchronization facilities. Nor do induction generators that act as motors during start-up, drawing power from the electric system before they themselves generate power.

The generating facility has the responsibility to synchronize and maintain synchronization to the Wires Owner system. The Wires Owner system cannot synchronize to the generating facility. A proposed synchronizing scheme must be submitted and outlined in the operating agreement and attachments.

Distribution and transmission facilities typically allow for automatic re-closing of electrical circuits after a variable time delay. The Power Producer is responsible for protecting their own facility from the impacts of such re-closing.

Generators can automatically restart following automatic re-closing of distribution facility electrical equipment if agreed to by the Wires Owner. Generators that automatically restart must have time delay on restart adjustable up to 60 minutes or as agreed to by the Wires Owner. The Wires Owner will coordinate the settings of generator restart time-delays so that generators on any feeder restart in staggered order.
4.2.3 Voltage Regulation and Power Factor

The Power Producer shall be responsible for ensuring that the voltage levels at the point of interconnection are maintained within the guidelines prescribed by the Wires Owner and/or at least equal to the voltage levels, at all feeder load conditions, prior to the interconnection.

Synchronous generators connected to the distribution system must be equipped with excitation controllers capable of controlling voltage. The generator-bus voltage setpoint shall be stable at and adjustable to any value between 95% and 105% so that the Wires Owner can maintain CSA voltage limits on their system.

Induction generators do not have voltage or reactive power control and consume reactive power (VAR). In this case, the generator must provide reactive compensation to correct the power factor to $\pm 0.90$ at the point of common coupling, unless other terms are negotiated with the Wires Owner.

Inverter-type generating equipment can control the power factor over a wide range, typically $\pm 0.75$. An inverter type generator connected to the distribution facility must be capable of adjusting the power factor in the range of $\pm 0.9$. The Power Producer may operate outside that range by agreement with the Wires Owner.

The Wires Owner will define voltage and reactive power control requirements on a project-by-project basis. Together, the Power Producer and the Wires Owner will identify the exact transformer ratio to allow best voltage regulation on the system, and whether an on-load tap-changer is needed.

In order to coordinate with its existing voltage control devices, the Wires Owner may require the generator to operate in a power factor control mode, i.e. within a constant power factor setpoint range. The voltage / power factor regulator shall be capable of controlling the power factor of the generator between $+0.90$ and $-0.90$. The Wires Owner shall determine the actual set point between these limits.

In power factor control mode, the voltage regulator shall have a voltage override that causes it to reduce excitation if the voltage at the Point of Common Coupling exceeds an upper limit to be specified by the Wires Owner. The normal upper limit is 105% of nominal; however, the voltage regulator shall have provision to adjust this upper limit between 100 and 110% of nominal. The voltage regulator shall also have provision for a time delay between sensing an excursion of the upper voltage and initiating control action. The power factor control equipment shall have provision to allow for the adjustment of this time delay between 0 and 180 seconds. The Wires Owner will specify the required time delay.
4.2.4 Frequency Control

An interconnected generating facility must remain synchronously connected for frequency excursions as identified in this guideline and the table below.

For generators connected to the Alberta Interconnected System, islanded operations are not allowed. (See 4.3.10) Generators not connected to the Alberta Interconnected System that serve remote isolated systems must be capable of controlling the frequency of the system to between 59.7 Hz to 60.2 Hz for normal operation. Under frequency and over frequency relaying that automatically disconnects generators from the Alberta Interconnected System shall not operate for frequencies in the range of 59.5 to 60.5 Hz.

The frequency of the electric system is controlled by all synchronous generator governor systems that connect to the electric system. Such governor systems respond automatically to changes in system frequency to prevent further deviation. Synchronous generators and other generators with stand-alone capability and capacity of 10 MW or more must have a speed droop governor. The droop setting of the governor shall be 5%, and the governor system must be operated at all times so that it is free to respond to system frequency changes. If a 5% setting is not possible, the Power Producer must obtain acceptance from the AESO (Alberta Electric System Operator) for some other droop setting.

In accordance with the AESO (Alberta Electric System Operator) and WECC (Western Electricity Coordinating Council) off-frequency requirements, Generators connected to the grid that protect for off-nominal frequency operation should have relaying protection that accommodates, as a minimum, under frequency and over frequency operation for the following specified time frames:
### Generator Interconnection Requirements

#### Guideline Limit (Hz) | Duration to Trip (Guideline Limit)
--- | ---
**Continuous Operating Range** | 59.4 < \( f < 60.6 \) | NA
**Under Frequency** | 58.4 < \( f \leq 59.4 \) | 3 min.
 | 57.8 < \( f \leq 58.4 \) | 30 seconds
 | 57.3 < \( f \leq 57.8 \) | 7.5 seconds
 | 56.8 < \( f \leq 57.3 \) | 45 cycles
 | 56.4 < \( f \leq 56.8 \) | 7.2 cycles
 | equal / less than 56.4 | Maximum 100 ms
**Over Frequency** | 60.6 <= \( f < 61.6 \) | 3 min.
 | 61.6 <= \( f \leq 61.7 \) | 30 seconds
 | greater than 61.7 | Maximum 100 ms

Note: Systems that have generators that do not meet the above requirements must automatically trip load to match the anticipated generation loss, at comparable frequency levels.

Systems that have generators that do not meet the above requirements must automatically trip load to match the anticipated generation loss, at comparable frequency levels.

#### 4.2.5 Voltage Unbalance
Any three-phase generating facility must have a phase-to-phase voltage unbalance not exceeding 1%, as measured both with no load and with balanced three-phase loading.

Voltage unbalance will be calculated using:
Unbalance (%) = 100 x [(deviation from average)/(average)]
as derived from NEMA MG1-1993 14.35.

Single-phase generators must not adversely unbalance the three-phase system. When they are connected in multiple units, an equal amount of generation capacity must be applied to each phase of a three-phase circuit, and the group of generators must maintain balance when one unit trips or begins generating before or after the others. A single one-phase generator may be connected alone only if it does not cause voltage unbalance on the distribution system in excess of 2%.

4.2.6 Resonance and self excitation of induction generators
A) Resonance should be considered in the design of the Power Producer’s facility, as certain resonance can cause damage to existing electrical equipment, including the electrical equipment of the Power Producer. Engineering analysis by the Power Producer should be a part of the design process to evaluate the existence of, and to eliminate the harmful effects of:

1. ferro-resonance in the transformer (see Note 1 for details in Appendix 8)
2. sub-synchronous resonance due to the presence of series capacitor banks (see Note 2 in Appendix 8 for details)
3. resonance with other customers' equipment due to the addition of capacitor banks to the distribution system (see Note 3 in Appendix 8).

B) In the event that an induction generator is used by the Power Producer, the adverse effects of self excitation of the induction generator during island conditions should be assessed and mitigated. The intent is to detect and eliminate any self excited condition. (See note 4 in Appendix 8.)

C) The engineering analysis of resonance and the assessment of the effect of self-excitation of induction generators should be submitted to the Wires Owner for their approval or further evaluation.

4.3 INTERCONNECTION

4.3.1 Safety
Safety of personnel, the public and of equipment is of primary concern in the design of the interconnection.

4.3.2 Point of Common Coupling
The Point of Common Coupling will be identified in the design and on the Single Line Diagram. The Wires Owner will coordinate design, construction, maintenance and operation of the facilities on the distribution side of the point of common coupling. The Power Producer is responsible for the design, construction, maintenance and operation of
the facilities on the generation side of the point of common coupling. All voltage and frequency parameters specified in this section, shall be met at the PCC unless otherwise stated.

The Power Producer is responsible for paying any incremental costs to the transmission/distribution systems caused by the generator. The Wires Owner will carry out the engineering, design and construction required for its system, and charge these costs back to the Power Producer. Ongoing O&M costs required on the distribution feeder side will be recovered by the Wires Owner.

### 4.3.3 Point of Disconnection

A disconnecting means to provide a point of disconnection between the Power Producer and the Wires Owner is required. The disconnect switch should be located at the main service entrance or PCC so that it can be easily accessed by Wire Owner’s personnel. The purpose of the disconnecting means is to provide safe isolation between the Wires Owner and the Power Producer.

When the interconnection involves three phase generators, the disconnect switch must be gang operated to simultaneously isolate all three phases.

Power Producers located within the downtown Calgary area should contact the Wire Owner’s Distributed Generation Engineer to confirm any additional requirements.

**High Voltage (greater than 750v) Disconnect Switch – Primary Metered Customers**

A manual ‘visible-break disconnect’ switch is required so that the power system can be isolated in order to work on the facilities. Appendix #4 shows a sample configuration. The Power Producer is responsible for the disconnect switch installation.

All high voltage disconnect switches shall:

- meet the requirements of the Canadian Electrical Code, Part 1, Sections 36 and 84
- meet applicable Canadian Electrical Code Part II standards
- provide safe isolation for the Wire Owner’s facilities and personnel from the generators and all other possible customer sources of power
- be annually inspected and maintained by the Power Producer

High voltage disconnect switches for DG installations that are Grid Interactive and Exporting must be labeled with the AESO Designation Number where applicable.
Low Voltage (750v or less) Disconnect Switch

A manual ‘main disconnect’ switch is required so that the power system can be isolated in order to work on the facilities. Appendix 5 shows a sample configuration. The Power Producer is responsible for the disconnect switch installation.

All low voltage disconnect switches shall:
- meet the requirements of the Canadian Electrical Code, Part 1, Section 84
- meet applicable Canadian Electrical Code Part II standards
- provide safe isolation for the Wire Owner’s facilities and personnel from the generators and all other possible customer sources of power
- be annually inspected and maintained by the Power Producer

Low voltage disconnect switches for DG installations that are Grid Interactive and Exporting must be labeled with the AESO Designation Number.

General
Any deviation from the requirements of the Canadian Electrical Code (e.g. installation of a low voltage disconnect switch whose contacts are NOT verifiable by direct visible means) must be requested by the Power Producer and will require approval from the local Electrical Inspection Authority. A copy of the approved variance from the Electrical Inspection Authority shall be supplied to the Wires Owner and their acceptance obtained.

For a site that interconnects multiple generators, one disconnect switch must be capable of isolating all the generators simultaneously. There may be other means of meeting this requirement. Any other means of disconnection must also be acceptable to the Wires Owner.

The Power Producer shall follow the Wire Owner’s switching, clearance, and tagging procedures which the Wires Owner shall instruct the Power Producer.

4.3.4 Phasing
Phasing is not standardized across distribution facilities. Therefore, the phase sequence and the direction of rotation must be coordinated between the Wires Owner and the generator.

4.3.5 Interconnection Grounding
Grounding configurations shall be designed to provide:
- solidly grounded distribution facilities;
- suitable fault detection to isolate all sources of fault contribution, including the generator, from a faulted line or distribution element;
- a circuit to block the transmission of harmonic currents and voltages; and
- protection of the low voltage side from high fault current damage.
The preferred configuration is delta connection on the generator side of the transformer and a grounded Wye configuration on the Wires Owner’s side of the transformer. If this configuration is not possible, the configuration chosen must still address the above concerns. The winding configuration for distributed generator interconnection transformers shall be reviewed and accepted by the Wires Owner.

4.3.6 Interrupting Device Ratings
The design of the generating facility must consider the fault contributions from both the distribution facility and the generating facility itself, to ensure that all circuit fault interrupters are adequately sized. The Wires Owner will inform the Power Producer of the present and anticipated future fault contribution from the interconnected electric system.

4.3.7 Phase and Ground Fault Protection
The Power Producer must install protective devices to detect and promptly isolate the generating facility for faults occurring either in the generating facility itself or on the distribution system. “Virtual devices” – i.e. computer or programmable-logic-controller systems – are acceptable provided that they meet standard utility practice for system protection and that they have been type tested and approved by an independent testing laboratory.

The generating facility’s protective devices must fully coordinate with protective relays on the electric system unless otherwise agreed. The Power Producer must calculate the protective device settings and submit the relay characteristics and settings to the Wires Owner for review and approval.

The generation facility must be able to detect the following situations and isolate itself from the distribution facility for:
- a short circuit between any phase(s) and ground
- a short circuit between phase(s);
- loss of any phase(s).

4.3.8 Overvoltage and Undervoltage Protection
The Power Producer will operate its generating equipment in such manner that the voltage levels on the Utility System are in the same range as if the generating equipment were not connected to the Utility system.

The Power Producer must install necessary relays to trip the circuit breaker when the voltage, measured phase to ground, is outside predetermined limits. Under voltage relays should be adjustable and should have a settable time delay to prevent unnecessary tripping of the generator on external faults. Overvoltage relays should be adjustable and may be instantaneous.
The Power Producer’s interconnection device shall cause the generator to cease to energize the Wire Owner’s distribution system within the Trip Times as indicated below. Trip time is the time between the start of the abnormal condition and the interconnection device ceasing to energize the Wire Owner’s distribution system.

### Response to Abnormal Voltages

<table>
<thead>
<tr>
<th>RMS Voltage</th>
<th>Volt %</th>
<th>Trip Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>V=&lt;60</td>
<td>V=&lt;50%</td>
<td>Instantaneous, &lt; 100ms</td>
</tr>
<tr>
<td>60&lt;V&lt;108</td>
<td>50%&lt;V&lt;90%</td>
<td>120 cycles</td>
</tr>
<tr>
<td>108=/&lt;V=/&lt;127</td>
<td>90%&lt;V&lt;106%</td>
<td>Normal Operation</td>
</tr>
<tr>
<td>127&lt;V&lt;144</td>
<td>106%&lt;V&lt;120%</td>
<td>30 cycles</td>
</tr>
<tr>
<td>V&gt;=144</td>
<td>V&gt;=120%</td>
<td>Instantaneous, &lt; 100ms</td>
</tr>
</tbody>
</table>

The Power Producer may reconnect when the Utility System voltage and frequency return to normal range and is stabilized (for a time period greater than 5 minutes).

### 4.3.9 Over frequency and Under frequency Protection

The Power Producer must install frequency selective relays to separate the generator(s) from the electric system in cases of extreme variations in frequency.

Under frequency and over frequency relaying that automatically disconnects generators from the distribution system shall be time delayed in accordance with the AESO (Alberta Electric System Operator)s requirements as per section 4.2.4. The customer may reconnect when the Utility System voltage and frequency return to normal range and is stabilized.

### 4.3.10 Anti-Islanding

The Customer’s generator shall be equipped with protective hardware and software designed to prevent the generator from being connected to a de-energized circuit owned by the Wires Owner.

At the discretion of the Wires Owner, the Distributed Resource Owner may install under-frequency tripping and over frequency tripping for anti-islanding that will not negatively impact the WECC criteria in conjunction with their load shedding schemes.

In most cases, the generating facility will routinely operate as a part of the interconnected system. A problem on the system could lead to the generator becoming islanded, i.e., the sole Power Producer of power to one or more of the Wire Owner’s customers. In turn,
this could lead to damage to those customers caused by irregularities in power quality. To prevent this, the Power Producer must use teleprotection signals from the electric system or other reliable means to separate the generator from the electric system upon islanding. If other means are used to detect islanding the scheme must consist of reliable primary and back up functions using different quantities. The Power Producer is responsible for damage caused as a result of failure to safely separate during an islanding event.

For situations where there could be a reasonable match between the IPP generation and islanded load, conventional methods may not be effective in detecting islanded operation. In this event Wires Owner will require the addition of transfer trip communication facilities to remotely trip off the IPP generation upon opening of the distribution feeder main circuit breaker or circuit recloser.

4.3.11 Telemetry and Targeting
Where a generator could adversely affect the power system – for example by providing inflow into a fault – the Power Producer must have systems in place to inform the Wires Owner what protective operations occurred or failed to occur.

The WECC’s Compliance Monitoring and Operating Practices Subcommittee requires distribution and transmission facilities owners and the System Controller to provide telemetry of MW, MVAR, and breaker-status of all significant generation. “Significant” is presently defined as capacity of greater than 5MW, although in some sensitive areas, the Wires Owner may require telemetry or transfer trip for smaller generators. See Table 2.

4.3.12 Requirements for Transfer Trip
Where transfer trip protection is required, the transfer trip protection shall ensure that the generator does not “island” in the event of substation breaker or intermediate OCR operation. General requirements are:

- Generator lock out within 0.6 seconds of breaker or OCR operation
- Fail safe lock out within 6 seconds of communication loss
- IPP has responsibility for detecting and tripping in the event of communication loss.

Transfer tripping requirements are also applicable to induction generators, unless the Power Producer can demonstrate that there is no potential for self-excitation.

4.3.13 Special Interconnection Protection
In some cases it will be necessary to provide for special generator-specific protection and controls, such as out-of-step or loss of synchronism.
Additionally, the power producer needs to be aware that unbalance conditions can occur in the distribution system, especially under system fault conditions, and the design of the interconnection facilities should take this into account.

For star-delta interconnection transformers, the unbalance fault current could damage the generator interconnection transformer under certain fault conditions, as a result of the circulating current which occurs in the delta winding of the interconnection transformer in an attempt to balance the fault current. The design may therefore require protection for the transformer to address this potential issue.

4.3.14 Flicker
The Power Producer shall not cause excessive voltage flicker on the electric facilities of the Wires Owner. This flicker shall not exceed the Wires Owner’s Flicker Guidelines.

4.3.15 Harmonics
In accordance with IEEE 519, the total harmonic distortion (THD) voltage shall not exceed 5% of the fundamental 60 Hz frequency nor 3% of the fundamental for any individual harmonic when measured on the Wires Owner System side at the Point of Common Coupling with the Wires Owner System.

4.3.16 Inadvertent Energization of Wires Owner Facilities
The Power Producer’s generator shall not energize the Wires Owner facilities when the Wires Owner’s facilities are de-energized.

4.3.17 Protection from Electromagnetic Interference
The influence of electromagnetic interference (EMI) shall not result in a change in state or mis-operation of the interconnection system.

4.3.18 Surge Withstand Performance
The interconnection system shall have the capability to withstand voltage and current surges in accordance with the environments described in IEEE/ANSI C62.41 or C37.90.1

4.3.19 Synchronization
Connection shall be prevented when the Power Producer’s synchronous generator and/or power system is operating outside of the following limits:

<table>
<thead>
<tr>
<th>Aggregate Ratings of Generation (kVA)</th>
<th>Frequency Difference (Hz)</th>
<th>Voltage Difference (%)</th>
<th>Phase Angle Difference (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-500</td>
<td>0.3</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>&gt;500 - 1500</td>
<td>0.2</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>&gt;1500</td>
<td>0.1</td>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>
4.4 Typical Interconnection Requirements
While the typical interconnection requirements for safely operating the Power Producer’s generating equipment in parallel with the Wire Owner’s System are specified below, specific interconnection locations and conditions may require more restrictive protective settings or hardware especially when exporting power to the Wires Owner System. The Wires Owner shall make these deviations known to the Power Producer as soon as possible. An example of one such restrictive area for DG interconnection is with Utility secondary NETWORK systems. The customer will need to work closely with the Wires Owner to determine whether interconnection and operation within a specific NETWORK system is possible.

Protective relays, electric conversion devices, or other devices can comply with this Guide by demonstrating that they can accomplish the required protective function specified in the applicable Table 1, Table 2, and Table 3.

4.4.1 Single-Phase Generators
Table 1 shows the protective functions required to meet this Guide. Inverter type generators must meet the criteria in IEEE 929 - Recommended Practice for Utility Interface of Photovoltaic (PV) Systems and be certified to UL 1741 and CSA 22.2 #107.1

4.4.2 Three-Phase Synchronous Generators
Table 2 shows the protective functions required to meet this Guide.

The Power Producer’s generator circuit breakers shall be three-phase devices with electronic or electromechanical control.

The Power Producer is solely responsible for properly synchronizing its generator with the Wires Owner’s system.

The Power Producer is responsible for ensuring that the interconnection protection device settings coordinate with the Wires Owner protective device settings.

4.4.3 Three-Phase Induction Generators and Three-Phase Inverter Systems
Table 2 shows the protective functions versus generator size required to meet this Guide.

Induction generation may be connected and brought up to synchronous speed (as an induction motor) if it can be demonstrated that the initial voltage drop measured on the Wires Owner’s side at the Point of Common Coupling is within the flicker limits. Otherwise, the Power Producer may be required to install hardware or other techniques to bring voltage fluctuations to acceptable levels.

Inverter type generators must meet the applicable criteria in IEEE 929 and be certified to UL 1741 and CSA 22.2 #107.1
Line-commutated inverters do not require synchronizing equipment. Self-commutated inverters whether of the Utility-interactive type or Standalone type shall be used in parallel with the Wires Owner system only with synchronizing equipment. Direct current generation shall not be directly paralleled with the Wires Owner system.

4.4.4 Generators Paralleling for 6 cycles or less (Closed Transition Switching)

Table 3 shows the protective functions required by this Guide for generators 10 MW or less which parallel with the Wires Owner for 6 cycles or less.

Generators meeting this requirement shall apply for Parallel Operation, shall sign an Interconnection Agreement, shall sign an Operating Schedule A (required only if anti-exporting protection is not installed), and shall otherwise meet the requirements of this Guide.

4.4.5 Mitigation of Protection System Failure

Relays with self-diagnostic check features provide information on the integrity of the protection system and should be used whenever possible. The design of protection should be done by a qualified engineer, or a competent technical person, working with the engineers of the Wires Owner to ensure that this self checking feature be integrated into the overall protection system for the safe and reliable operation of the power system.

Dependent on the system and its design, where relays with this self-diagnostic feature do not trip the appropriate breaker(s), sufficient redundant or backup protection should be provided for the power system. The malfunctioning relay should also send a signal to notify operating personnel to initiate investigation of the malfunction.

Older electro-mechanical relays do not generally come with such self-diagnostic features. Design of protection and control systems in this case should generally be of a fail-safe nature to maintain the integrity of the protection system under protection system malfunction conditions.

4.4.6 Maximum Generator Power to be Exported

Where the Power Producer’s generation capacity exceeds the load carrying capacity of the generator interconnection at the Point of Common Coupling, or exceeds the capacity of the Wire Owner’s distribution system connected to the generator, the Power Producer shall install protection to limit the amount of export power to the rated capacity of the distribution system or the contracted export amount, whichever is less.

4.5 Interconnection Protection Approval

The Power Producer shall provide to the Wires Owner complete documentation on the proposed interconnection protection for review against the requirements of this Guide and for potential impacts on the Wires Owner’s System.
The documentation should include:

- a completed application form,
- an overall description on how the protection will function,
- a detailed single line diagram,
- the protection components details (manufacturer, model),
- the protection component settings (trigger levels and time values), and
- the disconnect switch details (i.e. manufacturer, model and associated certification.)

The Power Producer shall revise and re-submit the protection information for any proposed modification.

5.0 CONSTRUCTION

5.1 General
The Power Producer’s generating facility shall be constructed and installed to meet all applicable regulations. All permitting and safety codes compliance must be completed and copies of inspection reports provided to the Wires Owner prior to energizing the Point-of-Common Coupling.

All Single Line Diagrams provided to the Wires Owner shall be drawn in accordance with IEEE standards and conventions, and shall be stamped by a professional engineer assuming responsibility for the design.

6.0 METERING

6.1 General
Metering shall comply with Measure Canada requirements and the latest revision of the AESO (Alberta Electric System Operator) Measurement System Standard where applicable, and approved by the Wires Owner.

The primary side (i.e. side connected to the Wires Owner’s system) of the interconnection transformer is the Measuring Billing point for Power Producer generation export conditions and the low side (i.e. side connected to the Power Producer facilities) of the interconnection transformer is the Measuring Billing point for the Power Producer import conditions. On all installations where the metering equipment is installed on the low side of the interconnecting transformer, transformer loss compensation shall be installed in the meter for generation export conditions.

The metering equipment must:

- be suitable for use in the environmental conditions reasonably expected to occur,
at the installation site, over the course of a typical year;

- be appropriate for the power system characteristics reasonably expected to exist at the installation site under all power system conditions and events;

### 6.2 Meter Requirements

The meter must:

- be Measurement Canada approved under Section 9(1), Section 9(2) or Section 9(3) of the *Electricity and Gas Inspection Act*;

- be verified and sealed in accordance with the Electricity and Gas Inspections Act subject to the terms and conditions of any applicable dispensation(s).

- include an *interval time-stamping clock*, if the meter provides the *interval data* time-stamping function, capable of maintaining the *interval* boundaries within 60 seconds of the hour and every quarter hour thereafter according to *Mountain Standard Time* or *Mountain Daylight Time* whichever is then in effect in the province of Alberta;

- measure all quantities required to determine *active energy* and *reactive energy* transferred in the required directions at the *metering point*;

- provide a separate register to maintain the continuously cumulative readings of the *active energy* and *reactive energy* transferred in the required directions at the *metering point*;

- retain *readings* and, if applicable, all clock functions for at least fourteen (14) days in the absence of line power;

- have an *accuracy class* rating for *active energy* measurement that equals or exceeds the values specified in Appendix 7, Schedule 1, for *non-dispensated metering equipment* and Schedule 2 for *dispensated metering equipment*;

- have an *accuracy class* rating for *reactive energy* measurement that equals or exceeds the values specified in Schedule 1 for *non-dispensated metering equipment* and Schedule 2 for *dispensated metering equipment*;

- Meters which are internally compensated for line or transformer losses shall have "LOSS COMPENSATED" clearly indicated.

- Interval meters shall be installed on all DG sites, with exceptions as outlined in the Settlement System Code of Alberta.
6.3 Measurement Transformers
The applicable winding(s) of the current and potential instrument transformers must:

- be Measurement Canada approved under Section 9(1), Section 9(2) or Section 9(3) of the *Electricity and Gas Inspection Act*;

- be burdened to a degree that does not compromise the accuracy required by this *Guide*;

- have an *accuracy class* rating that equals or exceeds the values specified in Schedule 1 for *non-dispensated metering equipment*;

6.4 Remote Communications Equipment
The remote communications equipment may or may not be an integral part of the *meter* or the *recorder* but must incorporate protocol schemes suitable for the type/nature of the communications media/path that will prevent the corruption of data during *interval data* transmission;

6.5 Password Protection
Two or more levels are required. One for each meter data collection agency for full access to set time functions, read-only access to interval data, event log and meteorological quantities.

6.6 Safety Requirements
The installation shall conform to the requirements of:

- *CSA Standard* – C22.2; and


7.0 INSPECTION
The Power Producer shall maintain a quality control and inspection program satisfactory to and approved by the Wire Owner.

In addition to the Power Producer’s normal inspection procedures, the Wire Owner reserves the right to witness the manufacturing, fabrication or any part of work which concerns the subject equipment; to inspect materials, documents and manufacturing operations and installation procedures, to witness tests and to evaluate results of non-destructive examinations.

Power Producer shall supply the Wire Owner with a complete set of detailed drawings, which will be used by the Wire Owner to assist in the inspection during the testing of the
equipment.

8.0 TESTING

8.1 General
The Power Producer shall notify Wires Owner in writing at least 2 weeks before the initial energizing and start-up testing of the Power Producer’s generating equipment and the Wires Owner may witness the testing of any equipment and protective systems associated with the interconnection. The tests and testing procedures shall generally align with the requirements specified in IEEE P1547.

This section is divided into type testing and verification testing. Type testing is performed or witnessed once by an independent testing laboratory for a specific protection package. Once a package meets the type test criteria described in this section, the design is accepted by the Wires Owner. If any changes are made to the hardware, software, firmware, or verification test procedures, the manufacturer must notify the independent testing laboratory to determine what, if any, parts of the type testing must be repeated. Failure of the manufacturer to notify the independent test laboratory of changes may result in withdrawal of approval and disconnection of units installed since the change was made. Verification testing is site-specific, periodic testing to assure continued acceptable performance.

These test procedures apply only to devices and packages associated with protection of the interface between the generating system and the Wires Owner facilities. Interface protection is usually limited to voltage relays, frequency relays, synchronizing relays, reverse current or power relays, and anti-islanding schemes. Testing of relays or devices associated specifically with protection or control of generating equipment is recommended, but not required unless they impact the interface protection.

Testing of protection systems shall include procedures to functionally test all protective elements of the system up to and including tripping of the generator and/or interconnection point. Testing will verify all protective set points and relay/breaker trip timing.

At the time of production, all interconnecting equipment and discrete relays shall meet or exceed the requirements of ANSI /IEEE C62.41-1991- Recommended Practices on Surge Voltages in Low Voltage AC Power Circuits or C37.90.1 1989, IEEE standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems. If C62.41-1991 is used, the surge types and parameters shall be applied, as applicable, to the equipment’s intended insulation location.

The manufacturer’s verification test and the appropriate dielectric test specified in UL 1741 shall also be met.
8.2 Type Testing
All interface equipment must include a type test procedure as part of the documentation. The type test must determine if the protection settings meet these guidelines.

Prior to testing, all batteries shall be disconnected or removed for a minimum of ten (10) minutes. This test is to verify the system has a non-volatile memory and that the protection settings are not lost. A test shall also be performed to determine that failure of any battery used to supply trip power will result in an automatic shutdown.

All inverters shall be non-islanding as defined by IEEE 929. Inverters shall at the time of production meet or exceed the requirements of IEEE 929 and UL 1741.

8.3 Verification Testing
Prior to parallel operation of a generating system, or any time interface hardware or software is changed, a verification test must be performed. A licensed professional engineer or otherwise qualified individual must perform verification testing in accordance with the manufacturer’s published test procedure. Qualified individuals include professional engineers, factory trained and certified technicians, and licensed electricians with experience in testing protective equipment. The Wires owner reserves the right to witness verification testing or require written certification that the testing was performed.

Verification testing shall be performed annually. All verification tests prescribed by the manufacturer or developed by the Power Producer which are agreed to by the Wires Owner shall be performed. The Power Producer shall maintain verification test reports for inspection by the Wires Owner.

Inverter generator operation shall be verified annually by operating the load break disconnect switch and verifying that the power producing facility automatically shuts down and does not restart for five minutes after the switch is closed.

Any system that depends upon a battery for trip power shall be checked and logged once per month for proper voltage. Once every four (4) years the battery must be either replaced or a discharge test performed.

8.3.1 Protective Function Tests
(i) Protection settings that have been changed after factory testing shall be field verified. Tests shall be performed using secondary injection, applied waveforms, a simulated utility, or, if none of the preceding tests can reasonably be done, a settings adjustment test, if the unit provides discrete readouts of the settings, to show that the device trips at the measured (actual) voltage and frequency.
(ii) The non-islanding function, if provided, shall be checked by operating a load break switch to verify that the interconnection equipment ceases to energize its output terminals and does not restart for the required time delay after the switch is closed.

(iii) A reverse-power or minimum power function, if used to meet the interconnection requirements, shall be tested using secondary injection techniques. Alternatively this function can be tested by means of a local load trip test or by adjusting the DR output and local loads to verify that the applicable non-export criterion (i.e., reverse power or minimum power) is met.

8.3.2 Verification of Final Protective Settings Test
If protective function settings have been adjusted as part of the commissioning process, then, at the completion of such testing, the DR operator shall confirm all devices are set to the Wires Owner approved settings.

Interconnection protective devices that have not previously been tested as part of the interconnection system with their associated instrument transformers or that are wired in the field shall be given an in-service test during commissioning.

This test shall verify proper wiring, polarity, sensing signals, CT/PT ratios, and proper operation of the measuring circuits.

For protective devices with built-in metering functions that report current and voltage magnitudes and phase angles, or magnitudes of current, voltage, and real and reactive power, the metered values can be compared to the expected values. Alternatively, calibrated portable ammeters, voltmeters, and phase-angle meters may be used.

8.3.3 Hardware or Software Changes
Whenever interconnection system hardware or software is changed that can affect the functions listed below, a retest shall be made of the potentially affected functions.

1. Over-voltage and under-voltage
2. Over-frequency and under-frequency
3. Non-islanding function (if applicable)
4. Reverse or minimum power function (if applicable)
5. Inability to energize dead line
6. Time delay restart after Wires Owner outage
7. Fault detection, if used
8. Synchronizing controls (if applicable)
To ensure that commissioning tests are performed correctly, it may be appropriate for the Wires Owner to witness the tests and receive written certification of the results.

Refer to Appendix 6 for an example protective settings commissioning document.

**8.4 Switchgear and Metering**

The Wires Owner reserves the right to witness the testing of installed switchgear, and metering.

The Power Producer shall notify the Wires Owner at least 10 days prior to any testing.
9.0 DATA REQUIREMENTS

The following lists the drawings and data required for the approval of the project:

<table>
<thead>
<tr>
<th>Drawing/Data</th>
<th>Proposal</th>
<th>Approval*</th>
<th>Verified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer’s Equipment Data Sheet</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Control schematic</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Single Line Diagram indicating proposed protection settings</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Description of Protection Scheme</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Generator Nameplate schedule</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Fuse and protective relay coordination study &amp; settings</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Current transformer characteristic curve</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Commissioning Report c/w Protection Settings</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plot plan showing location of lockable disconnect device</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

*The minimum time requirement for review of information will generally be of the order of 10 working days.*
10.0 MARKING AND TAGGING

The nameplate on switchgear shall include the following information:

- Manufacturer’s name
- Manufacturer’s serial number
- The generator disconnect switch shall be clearly marked “Generator Disconnect Switch” and tagged with an AESO identification number when applicable.
- The main disconnect switch shall be clearly marked “Main Disconnect Switch” and tagged with an AESO identification number when applicable.
- Each disconnect switch shall be uniquely identified.

11.0 MAINTENANCE

The Power Producer has full responsibility for routine maintenance of the Power Producer’s generator, control and protective equipment and the keeping of records for such maintenance.

Maintenance procedures for the distribution system up to the Point of Common Coupling (PCC) shall be in compliance with the Wire Owner’s published “Guidelines for Connecting Generators to the Wires Owner’s Distribution System”.

All of the equipment from the generator up to and including the visible point of isolation is the responsibility of the Power Producer. The Power Producer is responsible to maintain the equipment to accepted industry standards, in particular Canadian Electrical Code (CEC) Part 1, paragraph 2-300.

The Power Producer shall present the planned maintenance procedures and a maintenance schedule for the interconnection protection equipment to the Wires Owner.

Failure to maintain Canadian Electrical Code (CEC) and industry acceptable facilities and maintenance standards can result in disconnection of the generator.
### TABLE 1

**Interconnection Control, Protection and Safety Equipment**

**Single Phase Connected to Secondary or Primary System**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Disconnect Device</td>
<td>X</td>
</tr>
<tr>
<td>Generator Disconnect Device</td>
<td>X</td>
</tr>
<tr>
<td>Over-Voltage Trip</td>
<td>X</td>
</tr>
<tr>
<td>Under-Voltage Trip</td>
<td>X</td>
</tr>
<tr>
<td>Over/Under Frequency Trip</td>
<td>X</td>
</tr>
<tr>
<td>Overcurrent</td>
<td>X</td>
</tr>
<tr>
<td>Synchronizing Check</td>
<td>Manual or Automatic</td>
</tr>
</tbody>
</table>

#### Generator Size - 50 kW or less

**Notes:**
1. X means required
2. For synchronous and other type of generators with Standalone capability.
3. Exporting to the Wires Owner system may require additional operational/protection devices and will require coordination of operations with the Wire Owner.
## TABLE 2

### Interconnection Control, Protection and Safety Equipment

#### Three Phase Connected to Secondary or Primary System

<table>
<thead>
<tr>
<th>Generator size classifications:</th>
<th>SMALL</th>
<th>MEDIUM</th>
<th>LARGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 kW or less</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>10 kW - 200 kW</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>200 kW - 500 kW</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>500 kW - 2,000 kW</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2,000 kW - 12,500 kW</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>12,500 kW - 50,000 kW</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

### Device #

<table>
<thead>
<tr>
<th>Device #</th>
<th>SMALL</th>
<th>MEDIUM</th>
<th>LARGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Disconnect Device</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>(See Section 4.3.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generator Disconnect Device</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>(See Section 4.3.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2: Interconnection Control, Protection and Safety Equipment

<table>
<thead>
<tr>
<th>Device #</th>
<th>SMALL</th>
<th>MEDIUM</th>
<th>LARGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronizing Check (note 1)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Man. or Auto.</td>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Qty: (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under-Voltage Trip</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Qty: (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Direction/Reverse Power</td>
<td>Y(note 2)</td>
<td>Y(note 2)</td>
<td>X(note 3)</td>
</tr>
<tr>
<td>Qty: (1)</td>
<td></td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Y(note 2)</td>
<td></td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Negative Phase Sequence Overcurrent (Phase unbalance, reverse phase sequence)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Qty: (1)</td>
<td></td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Overcurrent, voltage restrained</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Qty: (1)</td>
<td></td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Over/Under Frequency Trip</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Qty: (3)</td>
<td></td>
<td>(3)</td>
<td>(3)</td>
</tr>
<tr>
<td>Over/Under Frequency Trip (note 4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qty: (1)</td>
<td></td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Automatic Voltage Regulation (AVR)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Qty: (1)</td>
<td></td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Instantaneous Over-Voltage Trip</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Qty: (3)</td>
<td></td>
<td>(3)</td>
<td>(3)</td>
</tr>
<tr>
<td>Instantaneous Over-Voltage Trip (For ferroresonance conditions)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Qty: (3)</td>
<td></td>
<td>(3)</td>
<td>(3)</td>
</tr>
<tr>
<td>Over-Voltage Trip</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Qty: (3)</td>
<td></td>
<td>(3)</td>
<td>(3)</td>
</tr>
<tr>
<td>Voltage Balance Relay</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Qty: (1)</td>
<td></td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Directional Overcurrent</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Qty: (3)</td>
<td></td>
<td>(3)</td>
<td>(3)</td>
</tr>
<tr>
<td>Over/Under Frequency Trip</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Qty: (3)</td>
<td></td>
<td>(3)</td>
<td>(3)</td>
</tr>
<tr>
<td>Anti-islanding for inverters</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Qty: (3)</td>
<td></td>
<td>(3)</td>
<td>(3)</td>
</tr>
<tr>
<td>IEEE 929 and UL 1741</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 2 (continued)

**Interconnection Control, Protection and Safety Equipment**

**Three Phase Connected to Secondary or Primary System**

**Notes:**
1. For synchronous and other types of generators with standalone capability.
2. Only required on synchronous generators that are not exporting power and running in parallel with wires owner.
   - If NOT exporting and the generator is less than minimum load of Customer, or if always exporting, then relay not required except as noted.
3. If exporting, frequency blocks under trip with agreement of Wire Owner.
4. Transfer Trip required for synchronous machines and to be failsafe design
5. Exporting to the Wire Owner may require additional operational/protection devices and will require coordination of operations with the Wire Owner.
6. Selection depends on grounding system, if required by Wire Owner.
7. **Quantity** shown in brackets below, e.g. (3)
8. Both X and Y are required by this guideline. **X** is IEEE Std 242 protection requirement.
9. Three Directional Overcurrent Relays may be substituted for Reverse Power Relay
10. Above to be in accordance with the Canadian Electrical Code.
TABLE 3

Interconnection Control, Protection and Safety Equipment
Generators Connected to Secondary or Primary System
For 6 cycles or less

(Closed Transition Switching)

Generator Size - 10 MW or less

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Disconnect Device</td>
<td>X</td>
</tr>
<tr>
<td>Generator Disconnect Device</td>
<td>X</td>
</tr>
<tr>
<td>Over-Voltage Trip</td>
<td>X</td>
</tr>
<tr>
<td>Under-Voltage Trip</td>
<td>X</td>
</tr>
<tr>
<td>Over/Under Frequency Trip</td>
<td>X</td>
</tr>
<tr>
<td>Overcurrent</td>
<td>X</td>
</tr>
</tbody>
</table>

Ground Over-Voltage Trip\(^1\)
\[\text{or}\]
Ground Over-Current Trip\(^1\)

Synchronizing Check\(^2\)     Manual or Automatic

Notes:
1. Selection depends on grounding system, if required by the Wire Owner
2. For synchronous and other type of generators with Standalone capability.
APPENDIX 1

APPLICABLE CODES AND STANDARDS

The generator or distributed resource interconnection shall conform to this Guide and to the latest revision of the applicable standards from the following organizations.

Specific types of interconnection schemes, DR technologies, and Distribution Systems may have additional requirements, standards, recommended practices, or Guide documents external to this Guide. The applicability and hierarchy of those with respect to the requirements herein are beyond the scope of this Guide. Users of this Guide shall address those concerns. This list of indicated standards organizations is therefore not to be regarded as all-inclusive.

- CSA (Canadian Standards Association)
- AESO (Alberta Electric System Operator)
- ECUC (Alberta Electrical and Communication Utility Code)
- Measurement Canada Standards
- IEEE (Institute of Electrical and Electronics Engineers)
- ANSI (American National Standards Institute)
- IEC (International Electrotechnical Commission)
- UL (Underwriters Laboratories)
- NEMA (National Electrical Manufacturers Association)
APPENDIX 2

SINGLE LINE DIAGRAM FOR WYE-DELTA INTERCONNECTION

NOTES:
1. Use one or other for simultaneous 3-phase switching. Simultaneous 3-phase switching is not required for non-export static power converters or induction generators not susceptible to self-excitation.
2. Required only if ferroresonance is possible.
3. Required if 27 operating time is too slow for feeder faults.
4. Use one or other only if feeder unbalance can cause transformer overloading.
5. FOR EXPORT ONLY. For synchronous generators and generator susceptive to self-excitation (induction or static power converters).
6. FOR NON-EXPORT ONLY: must sense both real and reactive power. Three 67 relays and one 687 relay may be required, as well.
7. To suppress a possible ferroresonance condition when the low voltage system is operated, generator must be effectively grounded, or solidly grounded.
8. Number and location of the metering points by commercial parameters.
9. Required if feeder load unbalance will overload transformer.

PROTECTION LEGEND:
- S - Synchronism Check
- 27 - Under Voltage
- 27R - Instantaneous Under Voltage
- 38 - Reverse Power
- 46 - Loss of Field
- 46R - Negative Phase Sequence Overcurrent
- 67 - Reverse Phase Voltage
- 49 - Stator Winding Temperature
- 50/51 - Instantaneous/Timed Overcurrent
- 52I - Ground Overcurrent
- 51G - Neutral Overcurrent
- 51Y - Torque Controlled Overcurrent
- 51H - High Speed Overvoltage
- 51T - Time Overvoltage
- 54 - Voltage Balance Relay
- 64F - Generator Field Ground
- 67 - Directional Overcurrent
- 67N - Neutral Directional Overcurrent
- 81/G - Over Frequency
- 81/U - Under Frequency
- 87(C) - Differential Relay (Ground)

LEGEND:
- [x] - Number Required
- M - Metering
- F - Fuse
- NE - Neutral Grounding Resistor (NGR)
- CB - Circuit Breaker
- MA - Manual Air Break
- TR - Transformer

NOTE:
PROTECTION SCHEMATIC SHOWN IS FOR LARGE 3 PHASE GENERATORS OVER 1250 KVA.
REFER TO TABLE 2 FOR REQUIREMENTS ON SPECIFIC GENERATORS.
APPENDIX 3

SINGLE LINE DIAGRAM FOR WYE-WYE INTERCONNECTION

**NOTES:**

1. Use one or other for simultaneous 3 phase switching. Simultaneous 3 phase switching is not required for non-expert static power converters or induction generators not susceptible to self-excitation.
2. Required only if ferroresonance is possible.
3. Required if 27 operating time is too slow for feeder faults.
4. Use one or other if feeder imbalance can cause transformer overloading.
5. FOR EXPORT ONLY. For synchronous generators and generator susceptible to self-excitation (induction & static power converters).
6. FOR NON-EXPORT ONLY, must sense both real and reactive power. Three 67 relays and one 69 relay may be required. as well.
7. To suppress a possible ferroresonance condition when the low voltage system is operated, generator must be effectively grounded, or solidly grounded.
8. Number and location of the metering points by commercial parameters.
9. Required if feeder load imbalance will overload transformer.

**PROTECTION LEGEND:**
- 25 - Synchronization Check
- 27 - Under Voltage
- 27R - Instantaneous Under Voltage
- 42 - Reverse Power
- 46 - Negative Phase Sequence Overcurrent
- 47 - Reverse Phase Voltage
- 49 - Stator Winding Temperature
- 50/51 - Instantaneous/Time Overcurrent
- 50N - Ground Overcurrent
- 51G - Neutral Overcurrent
- 51V - Torque Controlled Overcurrent
- 59 - High Speed Overvoltage
- 59T - Time Overvoltage
- 60 - Voltage Balance Relay
- 64F - Generator Field Overcurrent
- 67 - Directional Overcurrent
- 67N - Neutral Directional Overcurrent
- 81/F - Over Frequency
- 81/W - Under Frequency
- 87/G - Differential Relay (Ground)

**LEGEND:**
- (x) - Metering Required
- (x) - Metering Fused
- (x) - Neutral Grounding Resistor (NVR)
- (x) - Circuit Breaker
- (x) - Manual Air Breaker
- (x) - Transformer

**NOTE:**
Protection schematic shown is for large 3 phase generators over 12,500 kVA. Refer to Table 2 for requirements on specific generators.
APPENDIX 4

HIGH VOLTAGE DISCONNECT SWITCH

**LEGEND**
- PRIMARY METERING
- FUSE
- VISIBLE BREAK DISCONNECT
- MANUAL AIR BREAK

*See Section 4.3.3 of this Guide*
APPENDIX 5

LOW VOLTAGE DISCONNECT SWITCH

[Diagram of low voltage disconnect switch with legend]

ENMAX POWER CORPORATION

GENERATOR INTERCONNECTION REQUIREMENTS

SEE SECTION 4.3.3 OF THIS GUIDE
### APPENDIX 6

**EXAMPLE OF PROTECTIVE SETTINGS COMMISSIONING DOCUMENT**

**Generator Nameplate Information**

<table>
<thead>
<tr>
<th>Number of Units</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Over-Voltage Protection Parameters**

<table>
<thead>
<tr>
<th>Phase Voltage (RMS Values) to Trip</th>
<th>Adjustable Range</th>
<th>As Set</th>
<th>Test Req</th>
<th>Guideline Limit</th>
<th>Adjustable Range</th>
<th>As Set</th>
<th>Test Req</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Trip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fast Trip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Primary Trip: 106% to 120%
- Fast Trip: >120%

**Under-Voltage Protection Parameters**

<table>
<thead>
<tr>
<th>Phase Voltage (RMS Values) to Trip</th>
<th>Adjustable Range</th>
<th>As Set</th>
<th>Test Req</th>
<th>Guideline Limit</th>
<th>Adjustable Range</th>
<th>As Set</th>
<th>Test Req</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Trip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fast Trip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Primary Trip: 50% to 90%
- Fast Trip: <=50%

**Non-Islanding Function Test**

- Loss of utility supply, time to disconnect from utility
- Generator restart delay after utility voltage is stabilized

**Frequency Protection Parameters**

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Adjustable Range</th>
<th>As Set</th>
<th>Test Req</th>
<th>Guideline Limit</th>
<th>Adjustable Range</th>
<th>As Set</th>
<th>Test Req</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under Frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over Frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Under Frequency: 59.4 Hz to 60.6 Hz
- Over Frequency: 60.6 Hz to 61.6 Hz
- Frequency band: 61.6 Hz to 61.7 Hz

**Note**: Systems that have generators that do not meet the above requirements must automatically trip load to match the anticipated generation loss, at compatible frequency levels.

**Reverse AC Current Protection Function (not required for exporting)**

- Generator is [ ] exporting  [ ] non-exporting

**Reverse AC Current Protection**

<table>
<thead>
<tr>
<th>Current to Trip</th>
<th>Adjustable Range</th>
<th>As Set</th>
<th>Test Req</th>
<th>Guideline Limit</th>
<th>Adjustable Range</th>
<th>As Set</th>
<th>Test Req</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Trip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes**: This function may not be required in all cases, please refer to the attached supporting document.
APPENDIX 6 (CONT.)

Phase & Ground Fault Overcurrent Protection Function

<table>
<thead>
<tr>
<th>RELAY TYPE</th>
<th>CT RATIO</th>
<th>RELAY SETTINGS</th>
<th>GUIDELINE LIMIT</th>
<th>TESTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase</td>
<td></td>
<td>TAP TD INST</td>
<td></td>
<td>A B C</td>
</tr>
<tr>
<td>Current</td>
<td></td>
<td>Minimum 300 ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td></td>
<td>Minimum 300 ms</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please submit coordination study (including TCC curves & single-line diagram) to ENMAX.

Transfer Trip Protection

<table>
<thead>
<tr>
<th></th>
<th>GUIDELINE LIMIT</th>
<th>ADJUSTABLE RANGE</th>
<th>AS SET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator lockout after utility breaker operation</td>
<td>Maximum 0.6 seconds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fail safe lockout on loss of communication</td>
<td>Maximum 6 seconds</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On loss of utility supply, please describe the generator operation procedures (including isolation & connection, open or close transition, synchronizing scheme details, auto-start scheme details, etc.)

Test Certification and Historical Data

<table>
<thead>
<tr>
<th>TYPE OF TEST</th>
<th>ORIGINAL COMMISSIONING TEST</th>
<th>PROTECTION SYSTEM</th>
<th>DATE OF TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPANY REPRESENTATIVE</td>
<td>TITLE</td>
<td>DATE</td>
<td></td>
</tr>
<tr>
<td>GENERATOR LOCATION NUMBER</td>
<td>GENERATOR IDENTIFICATION NUMBER</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Return completed form to address above, or fax to: 514-2649, or e-mail to: bdreyer@enmax.com

Page 2 of 2
## APPENDIX 7

### Schedule 1

**SCHEDULE OF ACCURACIES FOR METERING EQUIPMENT APPROVED UNDER SECTION 9(1) OF THE ELECTRICITY AND GAS INSPECTION ACT**

<table>
<thead>
<tr>
<th>Metering Point Capacity (MVA)</th>
<th>Watthour Meter Accuracy Class</th>
<th>Varhour Meter Accuracy Class</th>
<th>Measurement Transformers Accuracy Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 and Above</td>
<td>0.2%</td>
<td>0.5%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Below 10</td>
<td>0.5%</td>
<td>1.0%</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

**Notes:**
1. The columns apply to requirements set out in Metering Section.
2. If an alternate measurement is used to determine reactive energy, the accuracy class of the alternate measurement must be equal to or better than the accuracy class set out for reactive energy.

### Schedule 2

**SCHEDULE OF ACCURACIES FOR METERS APPROVED UNDER SECTION 9(2) OR 9(3) OF THE ELECTRICITY AND GAS INSPECTION ACT**

<table>
<thead>
<tr>
<th>Meter Accuracy</th>
<th>Metering Point (MVA)</th>
<th>Points of Delivery</th>
<th>Points of Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 and Above</td>
<td>1.0 %</td>
<td>1.0 %</td>
<td></td>
</tr>
<tr>
<td>Below 10</td>
<td>1.0 %</td>
<td>1.0 %</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. The columns apply to requirements set out in Metering Section.
2. If an alternate measurement is used to determine reactive energy, the accuracy class of the alternate measurement must be equal to or better than the accuracy class set out for reactive energy.
APPENDIX 8

Note 1:
   a) Refer to “chapter 11, Connecting Small Generators to Utility Distribution Systems” by A. B. Sturton.
   b) Refer to “Transformer concepts and application course notes” by Power Technologies Inc., Schenectady, New York.
   c) Refer to “Electrical Transients in Power Systems” by Allan Greenwood.
   d) Refer to “Electrical Transmission & Distribution Reference Book” by Westinghouse.

Note 2:
   a) Refer to “Protective Relaying, Principles and Applications” by J. Lewis Blackburn on details on sub-synchronous resonance.
   b) Refer to “Electrical Transmission & Distribution Reference Book” by Westinghouse

Note 3:
   a) Refer to “Chapter 8, Harmonic and Resonant Effects on Application of Capacitors, Distribution Systems, Electric Utility Reference Book” by Westinghouse.
   b) Refer to “Chapter 11 & 12, Connecting Small Generators to Utility Distribution Systems” by A. B. Sturton
   c) Refer to “Chapter 10, Electric Power Systems, on switching surges-interruption of capacitive circuits” by B. M. Weedy.

Note 4:
   a) Refer to “chapter 4, Connecting Small Generators to Utility Distribution Systems” by A. B. Sturton for details.