Distributed Resource
Technical Interconnection Guideline

Prepared by the Northwest Territories Power Corporation

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1.0 INTRODUCTION

This guideline sets out the criteria and technical requirements for interconnection of a Distributed Resource ("DR") operating at a voltage of 25,000 volts or lower (that is not exclusively owned by the Wires Owner) to a Wires Owner's facilities. DR includes both generation and energy storage technology. This guideline provides the requirements across a broad spectrum of matters relevant to performance, operation, testing, safety and maintenance of a DR interconnection. This guideline has been developed with reference to international standards, including the Institute of Electrical and Electronic Engineers ("IEEE"), as well as utility practices in other jurisdictions.

The addition of a DR to a Distribution System may result in a change to the Distribution System configuration and hence system reliability. Achieving and maintaining a technically sound and robust interconnection between a DR and the Distribution System requires diligence on the part of everyone involved in the interconnection, including designers, manufacturers, users, owners and operators of both the DR and the Distribution System. Consequently, the requirements in this guideline need to be understood and cooperatively complied with by all of those parties.

This guideline does not constitute and is not intended to be a comprehensive guide or handbook for designing, constructing or operating a DR. Persons considering the development of a DR should engage the services of qualified individuals to provide electrical design and consulting services. Further, this guideline does not constitute an offer to, or express an interest in, purchasing capacity and energy from DR projects. Commercial arrangements related to the delivery of electrical energy and capacity from DR projects must be discussed and agreed upon with the relevant Wires Owner.

Section 2 of this guideline sets out further cautions respecting the limitation of use of this guideline. Section 3 provides definitions for the terms and references used in this guideline. Section 4 sets out general interconnection and protections requirements. Section 5 addresses construction requirements. Section 6 provides metering requirements. Section 7 addresses inspection and equipment testing matters. Section 8 provides the data requirements for approval of DR projects. Section 9 addresses equipment marking and tagging. Section 10 specifies the maintenance requirements. Section 11 contains various tables which list interconnection protection requirements. Lastly, the Appendices set out (1) the applicable codes and standards, (2) single line drawings illustrating typical interconnection arrangements, (3) metering accuracy tables and (4) reference notes.

2.0 LIMITATIONS

The criteria and requirements in this guideline are applicable to all DR technologies and the primary and secondary voltages of a Distribution System. Installation of a DR on radial primary and secondary Distribution Systems is the main emphasis of this version. In addition, 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 guideline is a minimum requirement for the interconnection of a DR. Additional requirements may have to be met by both the DR 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 intended application.

The Wires Owner shall not be liable for any damage, injury, loss, costs or claims suffered or incurred by the DR Owner, its agents or employees as a result of this standard. The DR Owner shall not be liable for any damage, injury, loss, costs or claims suffered or incurred by the Wires Owner, its agents or employees as a result of this standard. This guideline does not address any liability provisions provided for elsewhere, such as in interconnection and operating agreements between the DR Owner and the Wires Owner, or the Wires Owner's tariff.

The DR Owner is also responsible for making required changes to the DR Owner's facilities as required to meet new or revised standards or due to system changes. In addition, when advised by the Wires Owner, the DR Owner will make changes requested by the Wires Owner to the DR Owner's facilities. Therefore the DR Owner must make provision to accommodate such changes efficiently. The DR Owner shall be responsible for the cost of any required changes, including those changes requested to be made by the Wires Owner.

This guideline does not absolve the DR Owner of responsibility to protect their equipment, the Wires Owner's equipment, and personal and public safety.

3.0 DEFINITIONS

"**Alternating Current**" or "**AC**" means an electric current that reverses direction at regularly recurring intervals of time and has alternating positive and negative values.

"**Anti-Islanding**" means system design to detect and disconnect from a stable unintended Island with matched load and generation. Reliance solely on under/over voltage and frequency trip is not considered sufficient to qualify as Anti-Islanding.

"**ANSI**" means American National Standards Institute.

“**CSA**” means the Canadian Standards Association.

“**Direct Current**” or “**DC**” means a unidirectional electric current in which the changes in value are either zero or so small that they may be neglected.

“**Distributed Generation**” or “**DG**” means electric generation facilities connected to a Distribution System through the PCC. DG is a subset of DR.

“**Distributed Resource**” or “**DR**” means sources of real electric power that are not directly connected to the bulk power transmission system, including both generation and energy storage technology.

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

“**DR Owner**” means anyone interconnected to the Wires Owner’s system for the purpose of generating electric power.

“**Hertz**” or “**Hz**” means the unit of frequency for alternating current.

“**IEEE**” means the Institute of Electrical and Electronic Engineers.

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

“**Parallel Operation**” means, with reference to the Wires Owner, any electrical connection between the Wires Owner and the DR Owner’s generation equipment.

“**Point of Common Coupling**” or “**PCC**” means the point where the electrical facilities or conductors of the Wires Owner are connected to the DR Owner’s facilities or conductors, and where any transfer of electric power between the DR Owner and the Wires Owner takes place.

“**OCR**” means oil circuit re-closure.

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

“**Stabilized**” means the state of the Distribution System after voltage and frequency have returned to normal range for a period of at least five minutes (or another period of time as coordinated with the Wires Owner) following a disturbance.

“**Telemetering**” means the transmission of measurable quantities using telecommunications techniques.

“**Trip Time**” means the time between the start of the abnormal condition and the interconnection device ceasing to energize the Wires Owner’s Distribution System.

“**Visible-break Disconnect**” means a disconnect switch or circuit breaker by means of which the generator and all protective devices and control apparatus can be simultaneously disconnected under full load entirely from the circuits supplied by the generator. The switch or breaker shall be provided with the means for adequate visible inspection of all contacts in the open position, and the blades or moving contacts shall be connected to the generator side.

“**voltage**” means the electrical force or potential that causes a current to flow in a circuit measured in Volts (“V”) or kiloVolts (kV). 1 kV = 1000 V.

“**Wires**” means the electric utility distribution system below 25 kiloVolts to which the generation equipment is interconnected.

“**Wires Owner**” means the electric utility which owns the Distribution System.

4.0 GENERAL INTERCONNECTION AND PROTECTION REQUIREMENTS

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

Any DR Owner may operate 60 Hertz, three phase or single phase generating equipment, in parallel with the Wires Owner’s System and in accordance with interconnection and operating agreements with the Wires Owner, subject to the equipment and DR Owner meeting or exceeding the requirements of this guideline and the Wires Owner’s approval.

The following three sections, 4.1, 4.2, and 4.3, define the system technical requirements. The DR Owner’s equipment must be able to operate within the ranges specified in section 4.1. The technical requirements to be met by the DR Owner are described in section 5.2. Section 5.3 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’s system and its other customers. These guidelines are not intended to provide protection for the DR Owner’s generation equipment. It is the responsibility of the DR Owner to provide such protection. The DR Owner is responsible for protecting the DR Owner's generating equipment in such a manner that Distribution System outages, short circuits or other disturbances, including excessive zero sequence currents and ferro-resonant over-voltages, do not damage the DR Owner's generating equipment. The DR Owner'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 DR Owner 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’s system. Refer to Tables 1, 2 and 3 and Appendix 2 for summary tables & single line diagrams showing typical interconnection protection requirements.

4.1 Distribution System

4.1.1 System Frequency

The Northwest Territories interconnected system operates at 60 Hertz (“Hz”) Alternating Current (“AC”). Frequency deviations are typically 59.0 Hz to 61.0 Hz for small contingencies that cause modest disturbances, but where the Northwest Territories interconnected system remains intact.

4.1.2 Voltage Regulation

CSA Standard CAN3 C235 83 - Preferred Voltage Levels for AC Systems 0 to 50,000 V 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 - IEEE Std. 519-1992 IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems; and

- Harmonics - IEEE Std. 519-1992 IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

4.1.4 Voltage Unbalance

Phase to phase voltage unbalance can be expected on the primary distribution system. During normal steady state operation, phase to phase voltage unbalance is normally less than 3%. In some remote locations, unbalances may be higher. The DR Owner should consult with the Wires Owner to obtain site specific details.

Voltage unbalance is defined as follows:

$$\text{Unbalance (\%)} = \frac{\underline{100 \times (\text{maximum deviation from average phase voltage})}}{\text{Average phase to phase voltage}}$$

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 System grounding must conform to the *Alberta Electrical and Communication Utility Code*, 2nd Edition, 2002, declared in force pursuant to the *Electrical Code Regulation*, Alta. Reg. 145/2002, as amended or replaced.

4.1.7 Fault and Line Clearing

To maintain the reliability of the Distribution System, the Wires Owner may use automatic re-closing. The DR Owner needs to take into consideration line re-closing when designing generator protection schemes. This is to ensure that the generator is disconnected from the Distribution System prior to automatic re-close of breakers. The DR Owner may reconnect when the Distribution System voltage and frequency return to normal range and is stabilized. To enhance reliability and safety and with the Wires Owner's approval, the DR Owner may employ a modified relay scheme with tripping or blocking using communications equipment between the DR Owner's and the Wires Owner's 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 DR Owner shall work with the Wires Owner to mitigate any adverse affects.

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

4.2.2 Synchronism

Any generating facility that can create a 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 a voltage while separate from the electric system does 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 DR Owner has the responsibility to synchronize and maintain synchronization to the Wires Owner's system. The Wires Owner cannot synchronize to the generating facility. A proposed synchronizing scheme must be submitted by the DR Owner and outlined in interconnection and operating agreements with the Wires Owner.

Distribution and transmission facilities typically allow for automatic re-closing of electrical circuits after a variable time delay. The DR Owner 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 as agreed to by the Wires Owner. The Wires Owner will coordinate the settings of generator restart time-delays so that generators on any individual feeders restart in staggered order.

4.2.3 Voltage Regulation and Power Factor

The DR Owner shall be responsible for ensuring that the voltage levels at the PCC are maintained within the guidelines prescribed by the Wires Owner and/or at least equal to the voltage levels, during feeder peak 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 set-point shall be stable at and adjustable to any value between 95% and 105% so that the Wires Owner can maintain CSA standard voltage limits on its system.

Induction generators do not have voltage or reactive power control and consume reactive power. In this case, the generator must provide reactive compensation to correct the power factor to ±0.90 at the PCC, unless other terms are negotiated with the Wires Owner.

Inverter-type generating equipment can control the power factor over a wide range, typically ±0.75. An inverter type generator connected to the distribution facility must be capable of adjusting the power factor in the range of +/- 0.9. The DR Owner 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 DR Owner 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 that the generator operate in a power factor control mode (i.e. within a constant power factor set-point 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 PCC 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

A DG must remain synchronously connected for frequency excursions as identified in this guideline and the table below.

For generators connected to the Wires Owner, Islanded operations are not allowed (see section 4.3.10). Generators that serve remote isolated systems must be capable of controlling the frequency of the system to between 59.0 Hz to 61.0 Hz for normal operation. Under certain operating conditions, frequency tolerances may need to be operated within a smaller bandwidth.

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 significant capacity in relation to the current system's installed capacity 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 DR Owner must obtain approval from the Wires Owner for an alternate droop setting.

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:

$$\text{Unbalance (\%)} = \frac{100 \times (\text{maximum deviation from average phase voltage})}{\text{Average phase to phase voltage}}$$

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

Resonance should be considered in the design of the DR Owner's facility, as certain resonance can cause damage to existing electrical equipment, including the electrical equipment of the DR Owner. Engineering analysis by the DR Owner should be a part of the design process to evaluate and eliminate the harmful effects of:

- ferro-resonance in the transformer (see Appendix 4, Note 1);
- sub-synchronous resonance due to the presence of series capacitor banks (see Appendix 4, Note 2); and
- resonance with other customers' equipment due to the addition of capacitor banks to the distribution system (see Appendix 4, Note 3).

In the event that an induction generator is used by the DR Owner, 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 Appendix 4, Note 4).

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 or PCC is the point where the Wires Owner's electrical facilities or conductors are connected to the DR Owner's facilities or conductors, and where any transfer of electric power between the DR Owner and the Wires Owner takes place. The PCC 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 PCC. The DR Owner is responsible for the design, construction, maintenance and operation of the facilities on the generation side of the PCC.

In specific cases, either the Wires Owner or the DR Owner may own equipment located on the other party's side of the PCC. For example, the Wires Owner may own and operate communications, supervisory, or metering equipment, which is located on the DR Owner's side of the PCC.

The DR Owner must provide a site with the necessary space for the Wires Owner to install current transformers, potential transformers, switching equipment, meters and any other controls or communications equipment required to interconnect with the generating facility. The site is to be approved by the Wires Owner and a 120-volt AC power service is to be available at no cost for the use of portable tools.

The DR Owner 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 charges these costs back to the DR Owner. The Wires Owner will recover ongoing O&M costs required on the distribution feeder side.

4.3.3 Point of Disconnection

The disconnect switch can be on the high or low voltage side of the interconnection transformer if required. When the interconnection involves three phase generators the disconnect switch must be gang operated to simultaneously isolate all three phases.

<u>High Voltage - Disconnect Switch</u>

The disconnect switch on the Wires Owner's side of the interconnection transformer (e.g. 25 kV airbreak) will be installed, owned and maintained by the Wires Owner.

<u>Low Voltage - Disconnect Switch</u>

A manual visible disconnect switch is required so that the power system can be isolated in order to work on the facilities. Appendix 2 illustrates sample configurations. The DR Owner is responsible for the disconnect switch installation. All low voltage disconnect switches shall:

- be adequately rated to break the connected generation load;
- be within 5 meters (horizontal) of the interconnection point, or wire owner approved location;

- have contact operation verifiable by direct visible means;
- be readily accessible to the Wires Owner operating personnel;
- have provision for being locked in the “open” position;
- disconnect all ungrounded conductors of the circuit simultaneously;
- be externally operable without exposing the operator to contact with live parts;
- be capable of being closed with safety to the operator with a fault on the system;
- be capable of being energized from both sides;
- plainly indicate whether in the “open” or “closed” position;
- be labeled with a Wires Owner switch number;
- meet applicable CSA Part II standards;
- be installed to meet all applicable codes;
- provide safe isolation for the Wires Owner’s personnel from the generators and all other possible customer sources of power; and
- be annually inspected and maintained.

The disconnect switch on the generation side of the interconnection transformer will be owned and maintained by the DR Owner.

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. The Wires Owner must approve any other means.

The DR Owner shall follow the Wires Owner’s switching, work protection procedures in which the Wires Owner shall instruct the DR Owner.

4.3.4 Phasing

Phasing is not standardized across Distribution Systems. Therefore, the phase sequence and the direction of rotation must be coordinated between the Wires Owner and the DR Owner.

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 DR Owner interconnection transformers should be reviewed and approved by the Wires Owner.

4.3.6 Interrupting Device Ratings

The design of DR must consider the fault contributions from both the Distribution System and the generating facility itself, to ensure that all circuit fault interrupters are adequately sized. The Wires Owner will inform the DR Owner of the present and anticipated future fault contribution from the interconnected electric system.

4.3.7 Phase and Ground Fault Protection

The DR Owner 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 they have been type tested and approved by an independent testing laboratory.

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

The DR must be able to detect the following situations and isolate itself from the distribution system for:

- loss of any phase(s);
- a short circuit between any phase(s) and ground; and

- a short circuit between phase(s).

4.3.8 Over-voltage and Under-voltage Protection

The DR Owner will operate its generating equipment in such manner that the voltage levels on the Wires Owner's system are in the same range as if the generating equipment were not connected to the Wires Owner's system.

The DR Owner 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. Over voltage relays should be adjustable and may be instantaneous.

The DR Owner's interconnection device shall cause the generator to cease to energize the Wires Owner's distribution system within the Trip Time specified in the table below.

<u>Response to Abnormal Voltages</u>

RMS Voltage	**Trip Time**
V=<60 (V=<50%)	Instantaneous
60<V<108 (50%<V<90%)	120 cycles
108=/<V=/<127 (90%<V<106%)	Normal Operation
127<V<144 (106%<V<120%)	30 Cycles
V>=144 (V>=120%)	Instantaneous

The DR Owner may reconnect when the Wires Owner's system voltage and frequency return to normal range and is stabilized as permitted in interconnection and operating agreements.

4.3.9 Over Frequency and Under Frequency Protection

The DR Owner must install frequency selective relays to separate the DR from the Distribution 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 Wires Owner requirements specified in section 4.2.4. The DR Owner may reconnect when the Distribution System voltage and frequency return to normal range and is stabilized as permitted in interconnection and operating agreements.

4.3.10 Anti-Islanding

The DR Owner'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 DR Owner will install under-frequency tripping at 59.0 Hz and over frequency tripping at 61.0 Hz at a time delay as permitted in interconnection and operating agreements.

In most cases, the DR 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 producer of power to one or more of the Wires Owner's customers). In turn, this could lead to damages to those customers caused by irregularities in power quality. To prevent this, the DR Owner must use tele-protection signals from the Distribution System or other reliable means to separate the DG from the Distribution System upon Islanding. The DR Owner is responsible for damages caused as a result of failure to safely separate during an Islanding event.

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

4.3.11 Telemetry and Targeting

Where a DG could adversely affect the power system, the DR Owner must have systems in place to inform the Wires Owner of what protective operations occurred and failed to occur. An example of an adverse effect would be the DR Owner's generator providing inflow into a fault.

4.3.12 Requirements for Transfer Trip

All synchronous generators connected to the Distribution System shall be equipped with transfer trip protection to ensure that these machines do not Island in the event of substation breaker or intermediate oil circuit re-closure ("OCR") operation. General requirements are:

- generator separation within 0.6 seconds of breaker or OCR operation;
- fail safe lock out within 6 seconds of communication loss; and
- the DR Owner has responsibility for detecting and tripping in the event of communication loss.

Transfer tripping requirements are also applicable to induction generators, unless the DR Owner can demonstrate to the satisfaction of the Wires Owner 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.

The DR Owner 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 DR Owner is required to ensure that the operation of the DR Owner's facility will not cause voltage variations on the Wires Owner's system that could result in excessive lamp flicker for the Wires Owner's customers. If the DR Owner's facility utilizes a prime mover that has a fluctuating power output (eg. wind power, slow speed reciprocating engine, etc), the DR Owner must ensure that the fluctuations in power output do not cause voltage variations, which exceed the Wires Owner's acceptable limits. Please refer to IEEE Std. 519-1992 IEEE Recommend Practice and Requirement for Harmonic Control in Electric Power Systems.

4.3.15 Harmonics

Operation of DG must not cause an unacceptable level of harmonics. Maximum harmonic current distortion limits for power generation equipment, measured at the PCC, are as specified in Table 10.3 of IEEE Std. 519-1992 IEEE Recommend Practice and Requirement for Harmonic Control in Electric Power Systems.

The objective of the current distortion limits in IEEE Std. 519 is to limit the harmonic injection from individual customers. This is to ensure that they do not cause unacceptable voltage distortion levels to normal system characteristics. The voltage distortion shall then be limited to 3% of the fundamental frequency for individual harmonic frequencies and 5% voltage total harmonic distortion on the Wires Owner's side of the PCC.

DR Owner's facilities must not inject Direct Current greater than 0.5% of the full rated output current into the Wires Owner's distribution system under normal or abnormal operation conditions.

4.3.16 Protection from Abnormal Conditions

The DR Owner's interconnection facilities shall be adequately protected from or able to withstand abnormal conditions on the Wires Owner's distribution system. This may include, but is not limited to:

- frequency excursions due to disturbances on the Wires Owner's Distribution System;
- partial or complete loss of load as a result of disturbances on the Wires Owner's Distribution System;
- transient over-voltage as a result of lightning or switching events; and
- over-voltage due to resonance conditions, healthy phase voltage rise during faults, self excitation and loss of load.

The DR Owner's facility must be self-protecting to prevent damage as a result of the normal or abnormal operation of the Wires Owner's Distribution System. The DR Owner is accountable for the execution of studies to identify potential abnormal conditions and the cost of mitigating the effects of abnormal conditions.

4.3.17 Self Excitation

Self-excitation of a synchronous generator can occur if the generator plus a portion of the Wires Owner's system become isolated from the rest of the Wires Owner's system, resulting in an Island. In an Island condition, self-excitation of the generator resulting from line capacitance or capacitors on the Wires Owner's system exceeds the capability of the generator and its excitation/voltage regulator system to control the voltage.

Unless the DR Owner can demonstrate through the execution of analytical studies, that there is no risk of self-excitation of the generator, the DR Owner must ensure, to the Wires Owner's satisfaction that:

- the DR Owner's facility has protection systems to detect a self-excitation condition;
- the interrupting device provided by the DR Owner is capable of switching the anticipated leading power factor current at the anticipated elevated voltages; and
- isolation of the DR Owner will occur quickly enough to preclude damage to other customers or the Wires Owner's system from the abnormal voltages that may occur.

4.3.18 Inadvertent Energization of the Wires Owner’s Facilities

The DR’s generator shall not energize the Wires Owner facilities when the Wires Owner’s facilities are de-energized.

4.3.19 Protection from Electromagnetic Interference

The influence of electromagnetic interference shall not result in the change in state or mis-operation of the interconnection system.

4.3.20 Surge Withstand Performance

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

4.3.21 Synchronization

Interconnection shall be prevented when the DR’s synchronous generator and/or powers system is operating outside of the following limits.

Aggregate Rates of Generation (kVA)	Frequency difference (Hz)	Voltage Difference (%)	Phase Angle Difference (degrees)
0-500	0.3	10	20
>500-1500	0.2	5	15
>1500	0.1	3	10

4.4 Typical Interconnection Requirements

While the typical interconnection requirements for safely operating the DR Owner’s equipment in parallel with the Wires 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’s Distribution System. The Wires Owner shall make these deviations known to the DR Owner as soon as possible, subject to review on an individual basis.

Protective relays, electric conversion devices, or other devices may comply with this guideline by the DR Owner demonstrating that such devices can accomplish the required protective function specified as applicable in section 12, Tables 1, 2 or 3.

4.4.1 Single-Phase Generators

Section 12, Table 1 shows the protective functions required to meet this guideline. 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

Section 12, Table 2 shows the protective functions required to meet this guideline.

The DR Owner's generator circuit breakers shall be three-phase devices with electronic or electromechanical control. The DR Owner is solely responsible for properly synchronizing its generator with the Wires Owner's system. The DR Owner is also responsible for ensuring that the interconnection protection device settings coordinate with the Wires Owner's protective device settings.

4.4.3 Three-Phase Induction Generators and Inverter Systems

Section 12, Table 2 shows the protective functions versus generator size required to meet this guideline.

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 PCC is within the flicker limits. Otherwise, the DR Owner 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. This also applies to induction generators and self-commutation inverters.

Line-commutated inverters do not require synchronizing equipment. Self-commutated inverters (whether of the utility-interactive type or stand-alone type) shall be used in parallel with the Wires Owner's system only with synchronizing equipment. Direct current generation shall not be directly paralleled with the Wires Owner's system.

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

Section 12, Table 3 shows the protective functions required by this guideline for generators, which parallel with the Wires Owner for 6 cycles or less.

Generators meeting this requirement shall apply for Parallel Operation, shall enter into interconnection and operating agreements with the Wires Owner and shall otherwise meet the requirements of this guideline.

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 Wires Owner's engineers to ensure that the self-diagnostic check 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 the self-diagnostic check 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 DG capacity exceeds the load carrying capacity of the generator interconnection at the PCC or exceeds the capacity of the Wire Owner's Distribution System connected to the generator, the DR 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. The maximum limit on the amount of power to be exported shall be set out in an interconnection and operating agreement.

4.5 Interconnection Protection Approval

The DR Owner shall provide to the Wires Owner complete documentation on the proposed interconnection protection for review against the requirements of this guideline and 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 DR Owner shall revise and re-submit the protection information for any proposed modification.

5.0 CONSTRUCTION

5.1 General

The DR Owner's 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 PCC.

All single line diagrams (original or electronic versions) 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 Measurement Canada requirements and shall:

- 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; and
- be approved by the Wires Owner.

The primary side of the interconnection transformer, which is the side connected to the Distribution System, is the metering billing point for the DR Owner's generation export conditions. The low side of the interconnection transformer, which is the side connected to the DR Owner's facilities, is the metering billing point for the DR Owner's 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.

6.2 Meter Requirements

The meter must:

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

- be verified and sealed in accordance with the *Electricity and Gas Inspections Act*, as amended or replaced, subject to the terms and conditions of any applicable dispensation(s);

- be a bi-directional four quadrant meter;

- 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 Northwest Territories;

- 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 3, Schedule 1, for non-dispensated metering equipment and Appendix 3, Schedule 2 for dispensated metering equipment;

- have an accuracy class rating for reactive energy measurement that equals or exceeds the values specified in Appendix 3, Schedule 1 for non-dispensated metering equipment and Appendix 3, Schedule 2 for dispensated metering equipment; and

- if the meter is internally compensated for line or transformer losses, shall have "LOSS COMPENSATED" indelibly marked in red on the nameplate.

6.3 Measurement Transformers

The applicable winding(s) of the current and potential instrument transformers must:

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

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

- have an accuracy class rating that equals or exceeds the values specified in Appendix 3, Schedule 1 for non-dispensated metering equipment.

6.4 Remote Communications Equipment

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 Quadrants to be Measured

DR Owners exporting power onto the Distribution System shall be equipped with bi-directional meters with four quadrant measurement capability. Six channels are required for four quadrant meters to separately record active power, leading power and lagging reactive power in both the export and the import directions. Where export of power is not required, unidirectional two quadrant metering with three channels is required to separately record active power, leading power and lagging reactive power. A reverse power relay shall also be installed to ensure blocking of any power exports.

6.6 Safety Requirements

The installation shall conform to the requirements of:

- Measurement Canada Standard Drawings;

- CSA Standard - C22.2; and

- ANSI/IEEE C57.13-1983 IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.

7.0 INSPECTION AND TESTING

The DR Owner shall maintain a quality control and inspection program satisfactory to and approved by the Wires Owner.

In addition to the DR Owner's normal inspection procedures, the Wires 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. The DR Owner shall supply the Wires Owner with a complete set of detailed drawings, which will be used by the Wires Owner to assist in the inspection during the testing of the equipment.

7.1 General

The DR Owner shall notify the Wires Owner in writing at least 2 weeks before the initial energizing and start-up testing of the DR 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 a single time 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’s 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 C62.4 1 - 19 1 9-Recommended

Practices on Surge Voltages in Low Voltage AC Power Circuits or C37.90.1 1989, IEE 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 174 1 shall also be met.

7.2 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.

7.3 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 DR Owner, which are agreed to by the Wires Owner shall be performed. The DR Owner 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 DR Owner's facility automatically shuts down and does not restart for five minutes after the switch is closed as permitted in interconnection and operating agreements.

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

7.3.1 Protective Function Tests

Protection settings that have been changed after factory testing shall be field-tested. 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.

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.

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.

7.3.2 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 Owner shall confirm all devices are set to the Wires Owner’s 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/VT 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.

7.3.3 Hardware or Software Changes

Whenever interconnection system hardware or software is changed, the functions listed below may be affected. A retest shall be made of the potentially affected functions:

- over-voltage and under-voltage;
- over-frequency and under-frequency;

- non-islanding function (if applicable);
- reverse or minimum power function (if applicable);
- inability to energize dead line;
- time delay restart after the Wires Owner's outage;
- fault detection, if used; and
- 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 test results.

7.4 Switchgear and Metering

The Wires Owner reserves the right to witness the testing of installed switchgear, and metering. The DR Owner shall notify the Wires Owner at least ten days prior to any testing.

8.0 DATA REQUIREMENTS

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

Drawing/Data	Proposal	Approval*	Verified
Manufacturer' s Equipment Data Sheet			X
Control schematic		X	X
Single Line Diagram indicating proposed protection settings	X	X	X
Description of Protection Scheme	X	X	X
Generator Nameplate schedule		X	X
Fuse and protective relay coordination study & settings		X	X
Current transformer characteristic curve		X	X
Commissioning Report c/w Protection Settings			X
Plot plan showing location of lockable "visible" disconnect device	X	X	X

*The minimum time requirement for review of information will generally be in the order of 10 working days.

9.0 MARKING AND TAGGING

The nameplate on switchgear shall include the following information:

- manufacturer's name;
- manufacturer's serial number; and
- the disconnect switch shall be clearly marked "DG Disconnect Switch" and tagged with approved identification number from the Wires Owner.

10.0 MAINTENANCE

The DR Owner has full responsibility for routine maintenance of the DR Owner's generator, control and protective equipment and the keeping of records for such maintenance.

All of the equipment from the generator up to and including the visible point of isolation is the responsibility of the DR Owner. The DR Owner is responsible to maintain the equipment to accepted industry standards.

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

Failure to maintain CEC and industry acceptable facilities and maintenance standards can result in disconnection of the generator.

11.0 TABLES

Table 1

Protection for Single-Phase Generators

Interconnection Control, Protection and Safety Equipment		
	Single-Phase Connected to Secondary System	**Inverter**
Interconnect Disconnect Device	X	
Generator Disconnect Device	X	
Undervoltage Trip	X	
Overvoltage Trip	X	
Over & Under Frequency Trip	X	
Overcurrent	X	
Synchronizing Control	Manual or Automatic	
Synch-Check (At PCC)	X	
Anti-Islanding Protection		X

"X" denotes a requirement for this Guideline.

Notes:

1. Exporting to the Wires Owner system may require additional operational/protection devices and will require coordination of operations with the Wires Owner.

2. For synchronous and other types of generators with stand alone capability.

3. For single-phase generators larger than 50 kW, consult with the Wires Owner on the required interconnection control, protection and safety equipment.

Table 2

Protection for Three Phase Generators

Interconnection Control, Protection and Safety Equipment Three-Phase Connected to Primary or Secondary System

		Generator Size Classification		
Device Number	**Device**	**<50 kW**	**50-499 kW**	**500-2,000 kW**
	Interconnect Disconnect Device	X	X	X
	Generator Disconnect Device	X	X	X
	Synchronizing Control[1] Manual (M) or Automatic (A)	M or A	M or A	A
25	Synch-Check[1] (At PCC)	X	X	X
	Automatic Voltage Regulation (AVR)[1]		X	X
27	Undervoltage	X	X	X
59	Overvoltage	X	X	X
59N	Neutral Overvoltage[2]	X[3]	X	X
50/51	Instantaneous/Timed Overcurrent	X[4]	X[4]	X[4]
50/51N	Instantaneous/Timed Neutral Overcurrent	X[3]	X	X
81	Over & Under Frequency	X	X	X
32	Directional Power	X[5]	X[5]	X[5]
TT	Transfer Trip or Equivalent Relay		X[6]	X[6]
	Telemetry Data Communication			X[7]
	Anti-Islanding for Inverters (IEEE Std. 929, UL 1741)	X	X	X

“X” denotes a requirement for this guideline.

All devices are three-phase unless otherwise specified.

Notes:

For synchronous and other types of generators with stand alone capability.

1. Only required for generators that have their interconnection transformer's primary winding ungrounded. Used in conjunction with three PT's in broken delta configuration rated for line to line voltage. For detecting ground faults on the distribution system.

2. May not be required if the generator is an inverter type voltage-following system of less than 50 kW aggregate. In this case, the Wires Owner will inform the DR Owner if this protection is required.

3. A timed overcurrent relay with voltage restraint (51 V) may also be required to prevent nuisance trips.

4. Only required for non-exporting or export limited generators.

5. Transfer trip or equivalent protective relay function required for all synchronous generators rated 500 kW and larger with export capability. May also be required for exporting synchronous generators under 500 kW, depending upon characteristics of the distribution circuit. The Wires Owner will advise.

6. System controller requirement for all generators 5 MW and larger. The Wires Owner may also require telemetry for smaller generators depending upon location and distribution circuit characteristics.

7. Exporting to the Wires Owner's system may require additional operational/protection devices and will require coordination of operations with the Wires Owner.

8. Three directional overcurrent relays may be substituted for a reverse power relay.

9. Above to be in accordance with the *Canadian Electrical Code*.

Table 3

Protection for Closed Transition Switching

Interconnection Control, Protection and Safety Equipment Single-Phase Connected to Secondary System	**For 30 Cycles or Less (Closed Transition Switching)**
Interconnect Disconnect Device	X
Generator Disconnect Device	X
Undervoltage Trip	X
Overvoltage Trip	X
Over & Under Frequency Trip	X
Overcurrent	X
Neutral Overvoltage Trip[1]	X
Directional Power Trip	X
Synchronizing Control[2]	Manual or Automatic
Synch-Check (At PCC)[2]	X

“X” denotes a requirement for this Guideline.

Notes:

1. Selection depends upon grounding connection of interconnection transformer.

2. For synchronous and other types of generators with stand alone capability.

Appendix 1

Applicable Codes and Standards

The DR interconnection shall conform to this guideline and to the applicable sections of the following codes and standards. When the stated version of the following standards is superseded by an approved revision, then that revision shall apply.

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

Power Quality Standards

- ANSI C84.1-1989 American National Standards for Electric Power Systems and Equipment Ratings (60 Hertz). Establishes nominal voltage ratings and operating tolerances for 60 Hz electric power systems from 100 V through 230 kV.

- IEEE Std. 493-1900 IEEE Recommended Practice for Design of Reliable Industrial and Commercial Power Systems (IEEE Gold Book). Chapter 9 deals specifically with voltage sags analysis and methods of reporting sag characteristics graphically and statistically.

- IEEE Std 519-1992 IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems.

- IEEE Std. 1100-1992 IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (IEEE Emerald Book).

- IEEE Std 1159-1995 IEEE Recommended Practice for Monitoring Electric Power Quality.

- IEEE Std 1250-1995 IEEE Guide for Service to Equipment Sensitive to Momentary Voltage Disturbances.

In addition to the power quality standards, the following standards are applicable to the interconnection of distributed generation resources on the Wires Owner's system:

- IEEE Std. 100-1997 IEEE Standard Dictionary of Electrical and Electronics Terms

- IEEE Std 315-1975 (Reaffirmed 1993) ANSI Y32.3- 1975 (Reaffirmed 1989) CSA Z99-1975 Graphic Symbols for Electrical and Electronics Diagrams (Including Reference Designation Letters)

- IEEE Std 929-1988 IEEE Recommended Practice for Utility Interface of Residential and Intermediate Photovoltaic (PV) Systems

- C37.1 ANSVIEEE Standard Definitions, Specifications and Analysis of Systems Used for Supervisory Control, Data Acquisition, and Automatic Control

- C37.2 IEEE Standard Electrical Power System Device Function Numbers

- C37.18 ANSI/IEEE Standard Enclosed Field Discharge Circuit Breakers for Rotating Electric Machinery

- C37.20.1 ANSUIEEE Standard for Metal-Enclosed Low-voltage Power Circuit Breakers Switchgear

- C37.20.3 ANSUIEEE Standard for Metal-Enclosed Interrupter Switchgear

- C37.24 ANSUIEEE Standard for Radiation on Outdoor Metal-Enclosed Switchgear

- C37.27 ANSIAEEE Standard Application Guide for Low-voltage AC Nonintegrally Fused Power Circuit Breakers (Using Separately Mounted Current-Limiting Fuses)

- C37.29 ANSI/IEEE Standard for Low-voltage AC Power Circuit Protectors Used in Enclosures

- C37.50 ANSI Standard Test Procedures for Low-voltage AC Circuit Breakers Use In Enclosures

- C37.51 ANSI Standard Conformance Test Procedure for Metal Enclosed Low-voltage AC Power Circuit-Breaker Switchgear Assemblies

- C37.52 ANSI Standard Test Procedures for Low-voltage AC Power Circuit Protectors Used in Enclosures

- C57.12 IEEE Standard General Requirements for Liquid Immersed Distribution, Power and Regulating Transformers

- C57.12.13 Conformance Requirements for Liquid Filled Transformers Used in Unit Installations including Unit Substations.

- C57.13.1 IEEE Guide for Field Testing of Relaying Current Transformers

- C57.13.2 IEEE Standard Conformance Test Procedures for Instrument Transformers

- C37.58 ANSI Standard Conformance Test Procedures for Indoor AC Medium Voltage Switches for use in Metal-Enclosed Switchgear

- C37.90 ANSUIEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus

- C37.90.1 ANSI/IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems

- C37.90.2 ANSUIEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers

- C37.95 IEEE Guide for Protective Relaying of Utility Consumer Interconnections

- C37.98 ANSI/IEEE Standard for Seismic Testing of Relays

- IEC 1000-3-3 Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current less than 16A

- IECl000-3-5 Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current greater than 16A

- UL1008 Transfer Switch Equipment

- IEEE P1547, DRAFT Standard for Distributed Resources Interconnected with Electric Power Systems

- Canadian Electrical Code, CSA no. C22-1, latest version

- C22.2 No. 31-M89 (R1995) - Switchgear Assemblies

- CadCSA - C22.2 No. 107.1-95 - Commercial and Industrial Power Supplies
- CadCSA - C22.2 No. 1010.1-92 - Safety Requirements For Electrical Equipment for Measurement, Control and Laboratory Use
- CadCSA - C22.2 No. 144-M91 (R1997) - Ground Fault Circuit Interrupters
- C22.2 No. 193-M1983 (R1992) - High Voltage Full-Load Interrupter Switches
- C22.2 No. 201-M 1984 (R1992) - Metal Enclosed High Voltage Busways
- C22.2 No. 229-M1988 (R1994) - Switching and Metering Centres
- CSA Standard CAN3 C235 83 - Preferred Voltage Levels for AC Systems 0 to 50,OOOV
- *Alberta Electrical and Communication Utility Code*, 2nd Edition, 2002, declared in force pursuant to the *Electrical Code Regulation*, Alta. Reg. 145/2002
- C37.04-1999 IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (ANSI/DoD)
- C37.04i-1991 Supplement to IEEE C37.04-1979
- C37.06-1997 American National Standard for Switchgear-AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities
- C37.09-1999 IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (ANSI/DoD)
- C37.09a-1991 Supplement to IEEE C37.09-1979
- C37.09g-1991 (R1991) Supplement to IEEE C37.09-1979
- C37.010-1999 IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- C37.010b-1985 (R1988) Supplement to IEEE C37.010-1979
- C37.010e-1985 (R1988) Supplement to IEEE C37.0 10-1979 I Supersedes:

- C37.0 11-1994 IEEE Application Guide for Transient Recovery Voltage for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

- C37.012-1979 (R1988) IEEE Application Guide for Capacitance Current Switching for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

- C37.013-1997 IEEE Standard for AC High-Voltage Generator Circuit Breaker Rated on a Symmetrical Current Basis

- C37.015-1993 IEEE Application Guide for Shunt Reactor Switching

- C37.081-1981 (Reaff 1988) Guide for Synthetic Fault Testing of AC High-Voltage Circuit Breakers Rated on a Symmetrical Current basis

- C37.11-1997 IEEE Standard Requirements for Electrical Control for High-Voltage Circuit Breakers Rated on A Symmetrical Current Basis

- C37.13-1990 (R1995) IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures

- C37.14-1992 IEEE Standard for Low-Voltage DC Power Circuit Breakers Used in Enclosures

- C37.16-I997 American National Standard for Switchgear - Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations

- C37.20.2-1999 IEEE Standard for Metal-Clad and Station-Type Cubicle switchgear

- C37.20.2b-1994 Supplement to IEEE Standard for Metal-Clad and Station-Type Cubicle Switchgear: Current Transformer Accuracies

- C37.20.6-1997 IEEE Standard for 4.76 to 38kV Rated Grounding and Testing Devices used in Enclosures

- C37.23-1987 (R1991) IEEE Standard for Metal-Enclosed Bus and Calculating Losses in Isolated-Phase Bus

- C37.30-1997 IEEE Standard Requirements for High-Voltage Switches

- C37.32-1996 American National Standard for Switchgear—High-Voltage Air Switches, Bus Supports, and Switch Accessories—Schedules of Preferred Ratings, Manufacturing Specifications, and Application Guide

- C37.34-1994 IEEE Standard Test Code for High-Voltage Air Switches

- C37.35-1995 IEEE Guide for the Application, Installation, Operation, and Maintenance of High-Voltage Air Disconnecting and Load Interrupter Switches

- C37.36b-1990 IEEE Guide to Current Interruption with Horn-Gap Air Switches

- C37.37-1996 IEEE Standard for Loading Guide for AC High-Voltage Air Switches (in Excess of 1000 V)

- C37.38-1989 IEEE Standard for Gas-Insulated, Metal-Enclosed Disconnecting, Interrupter, and Grounding Switches

- C37.42-1996 American National Standard for Switchgear—Distribution Cutouts and Fuse Links—Specifications

- C37.44-1981 (R1987) American National Standard Specifications for Distribution Oil Cutouts and Fuse Links

- C37.54-1996 American National Standard for Switchgear—Indoor Alternating-Current High-Voltage Circuit Breakers Applied as Removable Elements in Metal-Enclosed Switchgear Assemblies—Conformance Test Procedures

- C37.55-1989 American National Standard for Switchgear—Metal-Clad Switchgear Assemblies--Conformance Test Procedures

- C37.57-1990 American National for Switchgear—Metal-Enclosed Interrupter Switchgear Assemblies—Conformance Testing

- C37.66-1969 (Reaff 1988) American National Standard for Requirements for Oil-Filled Capacitor Switches for Alternating-Current Systems

- C37.81-1989 (R1992) IEEE Guide for Seismic Qualification of Class 1E Metal-Enclosed Power Switchgear Assemblies

- C37.85-1989 (R1998) American National Standard for Switchgear—Alternating-Current High-Voltage Power Vacuum Interrupters-Safety Requirements for X-Radiation Limits

- ANSI/IEEE C37.90-1989 - Surge Withstand And Fast Transient Tests

- 120-1989 (Reaff-1997) IEEE Master Test Guide for Electrical Measurements in Power Circuits

- 1291-1993 IEEE Guide for Partial Discharge Measurement in Power Switchgear Application Guide for Surge Protection of Electric Generating Plants - IEEE Std

- C62.23-1995 (37.13-1993 IEEE Standard Requirements for Instrument Transformers.

- C57.13.3-1983 (R1991) IEEE Guide for the Grounding of Instrument Transformer Secondary Circuits and Cases

- C57.98-1993 IEEE Guide for Transformer Impulse Tests

- C57.19.100-1995 (R1997) IEEE Guide for Application of Power Apparatus Bushings

- C57.1 10-1986 (R1992) IEEE Recommended Practice for Establishing Transformer Capability When Supplying Nonsinusoidal Load Currents

- C62.92.4-1991 IEEE Guide for the Application of Neutral Grounding in Electrical Utility Systems, Part IV - Distribution

- ANSI C12.20 - Electricity Meters 0.2 And 0.5 Accuracy Classes

- ANSI C62.1 - Surge Arresters for AC Power Circuits

- ANSI C62.11 - Metal-Oxide Surge Arresters for AC Power Circuits

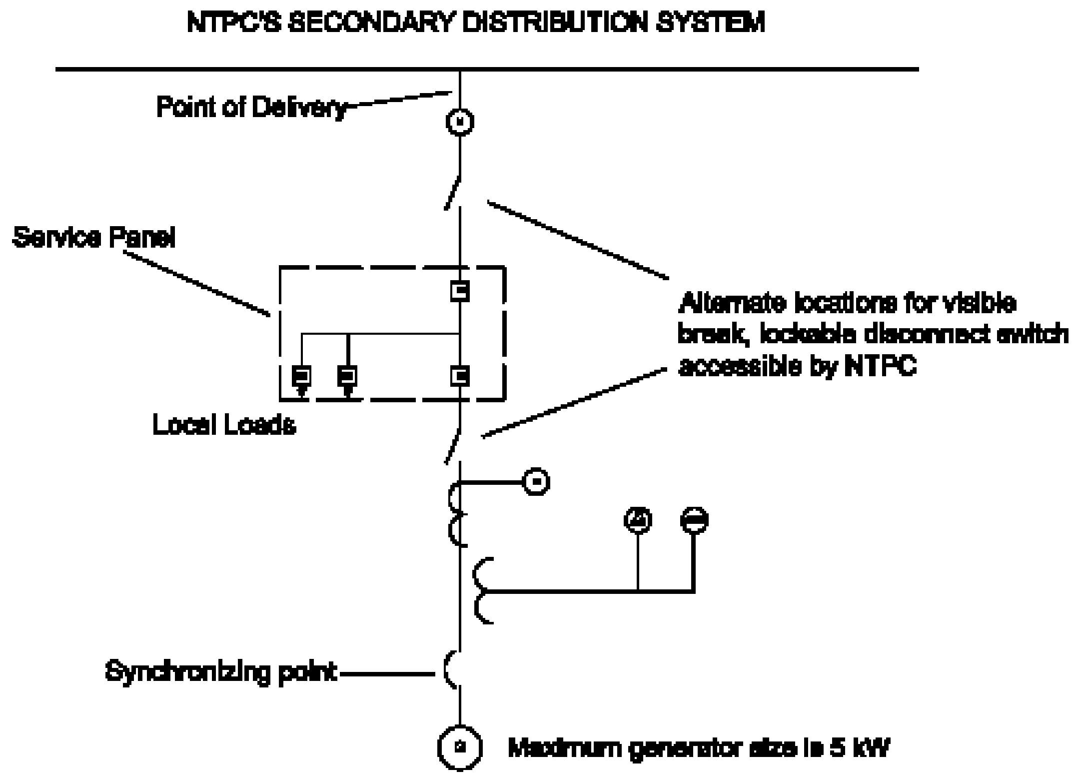
- NEMA CC-1 - Electric Power Connectors for Substations

- NEMA LA-1 - Surge Arresters

- NEMA MG- 1 - Motors

Appendix 2

Typical Arrangements

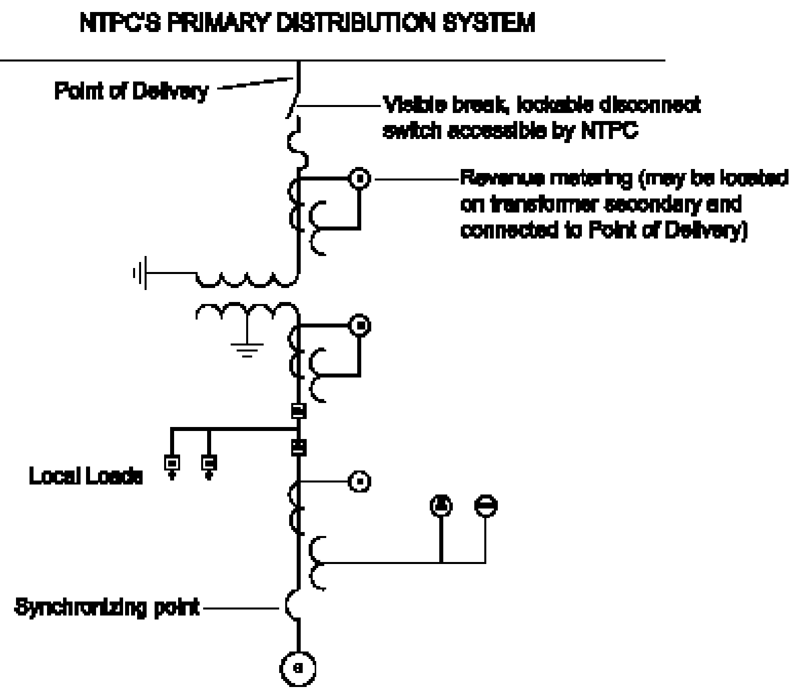


<u>Protection Functions</u>

52	Circuit Breaker
51	Overcurrent protection
81O/U	Over / under frequency protection
27/59	Under / over voltage proctection
M	Revenue metering

Note: Typical requirements shown. DG shall evaluate requirements for further protection

FIGURE #1
TYPICAL SINGLE PHASE GENERATOR INSTALLATION CONNECTED TO NTPC's SECONDARY SYSTEM



<u>Protection Functions</u>

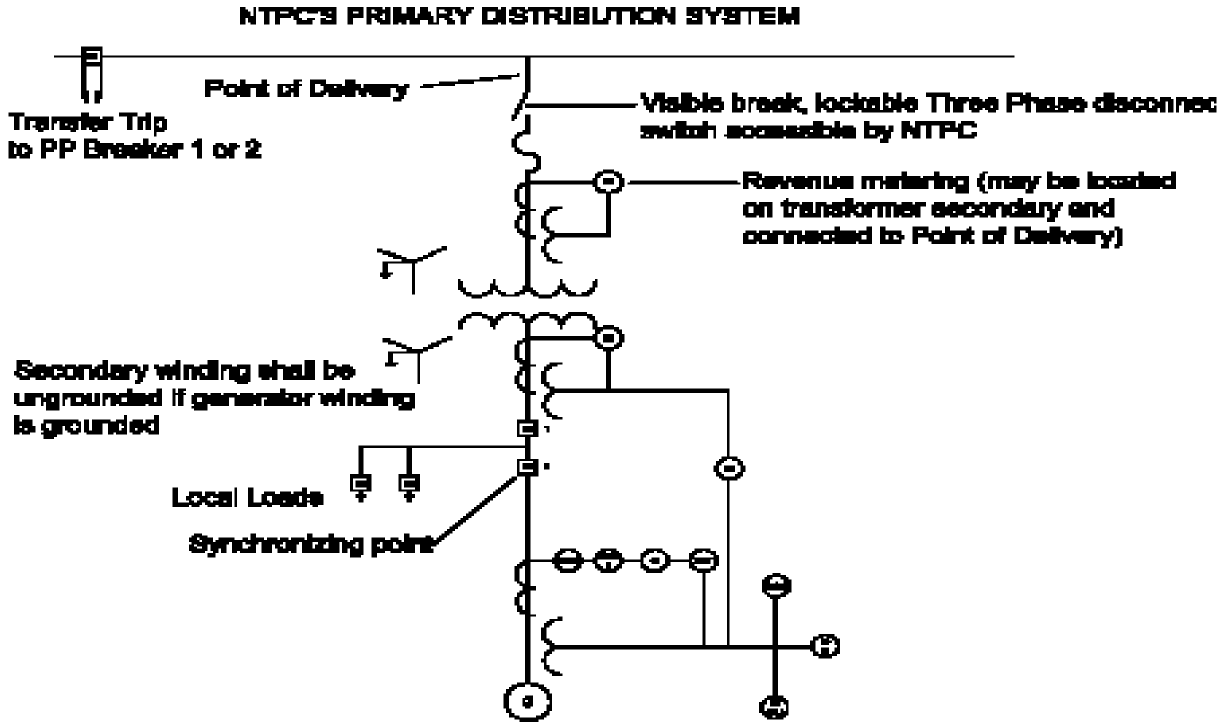
52 Circuit Breaker
51 Overcurrent protection
32 Reverse Power protection (required if customer does not

purchase stand-by)
81O/U Over / under frequency protection
27/59 Under / over voltage proctection
M Revenue metering

Note: Typical requirements shown. DG shall evaluate requirements for further protiction

(b)

FIGURE #2
TYPICAL SINGLE PHASE NON SYNCHRONOUS GENERATOR INSTALLATION UP TP 50 KW



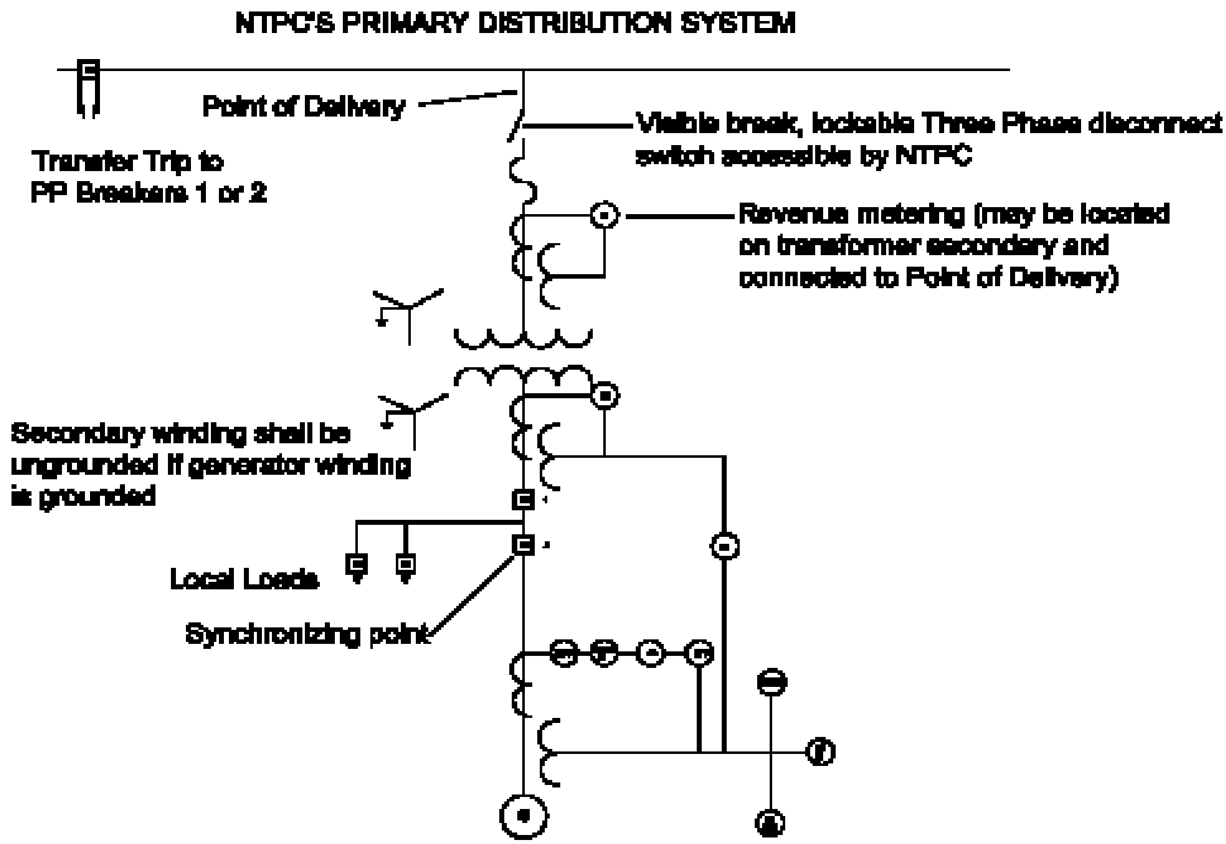
<u>Protection Functions</u>

52 Circuit Breaker
50/51 Instantaneous/Timed Overcurrent
50/51N Instantaneous/Timed Neutral Overcurrent
51V Voltage restraint overcurrent protection
32 Reverse Power protection
81O/U Over / under frequency protection
27/59 Under / over voltage prodection
59 N Neutral Overvoltage
46 Phase unbalance protection
25 Synch - Check
M Revenue metering

Note: Typical requirements shown. DG shall evaluate requirements for further protcion

FIGURE #3
TYPICAL THREE PHASE NON SYNCHRONOUS GENERATOR INSTALLATION
UP TO 50 KW

(c)



<u>Protection Functions</u>

52	Circuit Breaker
50/51	Instantaneous/Timed Overcurrent
50/51N	Instantaneous/Timed Neutral Overcurrent
51V	Voltage restraint overcurrent protection
32	Reverse Power protection
81O/U	Over / under frequency protection
27/59	Under / over voltage prodection
59 N	Neutral Overvoltage
46	Phase unbalance protection
25	Synch - Check
M	Revenue metering

Note: Typical requirements shown. DG shall evaluate requirements for further protetion

FIGURE #4
TYPICAL THREE PHASE NON SYNCHRONOUS GENERATOR INSTALLATION

Appendix 3

Schedule 1

Schedule of Accuracies for Metering Equipment Approved Under Section 9(1) of the *Electricity And Gas Inspection Act*

Metering Point Capacity (MVA)	Watt-hour Meter Accuracy Class	Varhour Meter Accuracy Class	Measurement Transformers Accuracy Class
10 and Above	0.2%	0.5%	0.3%
Below 10	0.5%	1.0%	0.3%

Notes:

1. The columns apply to requirements set out in the 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 Subsections 9(2) or 9(3) of the *Electricity And Gas Inspection Act*

Meter Accuracy		
Metering Point Capacity (MVA)	**Points of Delivery**	**Points of Supply**
10 and Above	1.0%	1.0%
Below 10	1.0%	1.0%

Notes:

1. The columns apply to requirements set out in the 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 4

Notes

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.