AEP Ohio Technical Requirements for Interconnection Service of Distributed Generation ≤ 25 kW

APPLICABILITY

All Distributed Generation (DG) requirements are subject to Company's Minimum Requirements for Interconnection Service and Ohio Administrative Code 4901:1-22 (OAC). These Technical Requirements by the Company shall not be in conflict with any requirements in the OAC. The intent is to utilize IEEE 1547 requirements and to supplement those with a minimal number of additional requirements where appropriate. The purpose of a minimal number of Company requirements not included in IEEE 1547 is to add clarity to some IEEE 1547 sections and to specify requirements for issues not addressed in IEEE 1547. These requirements apply to the interconnection and parallel operation of DG equipment that is rated ≤ 25 kW on radially operated, non-networked Company Distribution systems of 35 kV or less.

1.0 CUSTOMER DESIGN REQUIREMENTS

For an interconnection to be safe to Company employees/equipment and to other customers, the following conditions are required to be met on DG equipment.

1.1 Interconnection Service Customer DG facilities must meet all applicable national, state, and local construction, operation and maintenance related safety codes, such as National Electrical Code (NEC), National Electrical Safety code (NESC), Occupational Safety and Health Administration (OSHA).

1.2 Interconnection Service Customer must provide the Company with a one-line diagram showing the configuration of the proposed DG system, including the protection and controls, disconnection devices, nameplate rating of each device, power factor rating, transformer connections, and other information deemed relevant by the Interconnection Service Customer. If the proposed DG system does not pass the screening process for simplified interconnection, additional information may be necessary from the Interconnection Service Customer and Company facilities changes may be required.

1.3 DG Equipment must be equipped with adequate protection and control to trip[1] the unit off line during abnormal[2] system conditions, according to the following requirements:

1.3.1 Under-voltage or over-voltage within the trip time indicated below. By agreement of both the DG operator and the Company, different settings maybe used for the under voltage and over voltage time delays.

Voltage	*Maximum Trip Time*
V<45%	10 cycles
45%≤V<60%	66 cycles
60%≤V<88%	126 cycles
110%<V<120%	78 cycles
V≥120%	10 cycles

1.3.2 For three phase generation, loss of balanced three-phase voltage or a single phasing condition within the trip times indicated in 1.3.1 when voltage on at least one phase reaches the abnormal voltage levels.

[1] To trip is to automatically (without human intervention required) open the appropriate disconnection device to separate the DG equipment from the power system.
[2] Abnormal system conditions include faults due to adverse weather conditions including but not limited to, floods, lightning, vandalism, and other acts that are not under the control of the Company. This may also result from improper design and operation of customer facilities resulting from non-compliance with accepted industry practices.

1.3.3 Under-frequency or over-frequency: All DG shall follow the associated Company frequency within the range 59.5 Hz to 60.5 Hz. DG shall disconnect from the Company within 120 cycles if the frequency goes outside this range. A DG shall (1) disconnect from the Company within 10 cycles if the frequency exceeds the frequency range of < 57 Hz and > 62 Hz, and (2) be capable of time delayed disconnection for frequencies in the range of 56 Hz to 64 Hz. By agreement of both the DG operator and the Company, different settings maybe used for the under frequency and over frequency trip levels or time delays within the ranges of adjustability as prescribed in IEEE 1547a. If there is no statement of specified frequency settings the default indicated in IEEE 1547a, Table 2 is applied.

1.4 DG equipment requires the following additional protection to avoid damage to the Company's system during normal, as well as abnormal system conditions.

1.4.1 Synchronizing controls to insure a safe interconnection with the Company's distribution system. The DG equipment must be capable of interconnection with minimum voltage and current disturbances. Installations must meet the following synchronization parameters: voltage deviation less than ± 10%, phase angle deviation less than ± 10 degrees, and breaker closure time compensation.

A readily accessible, lockable, visible-break isolation device shall be located between the Area EPS and the DER.

- AEP standards require a single isolation device between the Area EPS and all DER Facilities at a customer's premise. This is to allow the company to isolate all DER Facilities with a single operation.
    - Exceptions to the single isolation device standard are at the discretion of the Area EPS Operator and require prior approval. Exceptions will only be considered following a written request from a Professional Engineer stating the necessity for multiple isolation devices.
- The isolation device shall be installed in addition to any other disconnect type devices that may be required by other applicable codes or standards.
- The isolation device may be required to be fused or non-fused by the Area EPS Operator. It may be required to be properly fused for the size (ampacity) of the wires in a "line side tap" connection configuration, or to be non-fused when the disconnect is not intended to provide overcurrent protection.

Note: AEP strongly encourages all customers to ensure that their important loads are not electrically behind the DER isolation switch so that the load can continue to be served by AEP even when the DERs must be isolated by opening this switch.

- AEP standards require that the isolation device should be immediately adjacent to the AEP meter (within 6 feet and between 4 to 6 feet above grade) and be clearly marked with labeling that easily identifies the DER Disconnect Switch which will isolate energized equipment from the utility grid. Figures 3, 4, and 5 below are presented as examples for consideration.
    - Exceptions to the standard location for the isolation device requires prior approval by the Area EPS Operator and will only be considered following a written request stating the necessity for an exception.

- If the Area EPS Operator approves an exception for the location of the disconnect, a permanent plaque must be placed next to the existing meter clearly stating the location of the isolation device at the premise.

Figure 3: Sample Labeling

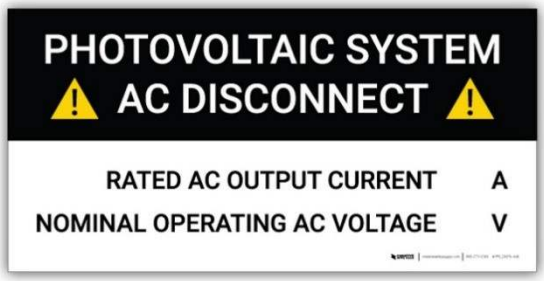


Figure 4: Sample Labeling

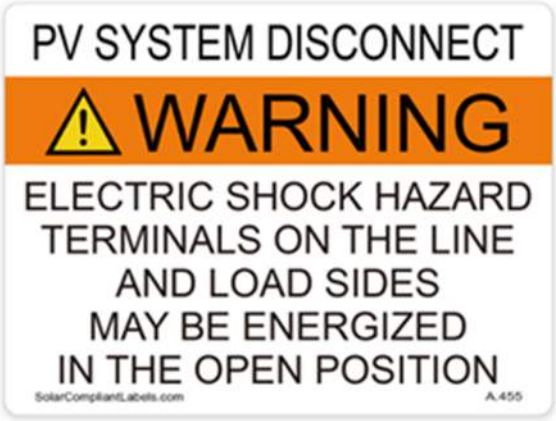


Figure 5: Sample Labeling

- AEP expects this isolation device to be properly maintained in good working condition by the interconnecting DER Customer. Where used for isolation of a DER unit that continues

to produce voltage after isolation from the Area EPS, the isolation device shall be capable of withstanding 220% of the DER rated voltage across the device for an indefinite duration.

- A knife-blade switch that conforms with the National Electric Code and has a visible break/open is an example of an appropriate isolation device for overhead installations.
- The disconnect switch itself must be readily accessible, lockable, visible-break isolation device such that AEP Ohio can lock the position of the switch in place using a padlock (a lockable cover on the switch does not meet this requirement), and plainly indicate whether it is in the open (off) or closed (on) position.

1.5 DG equipment must have adequate fault interruption and withstand capacity, and adequate continuous current and voltage rating to operate properly[3] with the Company's system. A three-phase device shall interrupt all three phases simultaneously. The tripping control of the circuit interrupting device shall be powered independently of the utility AC source in order to permit operation upon loss of the Company distribution system connection.

1.6 Harmonics and Flicker: The DG equipment shall not be a source of excessive harmonic voltage and current distortion and/or voltage flicker. Limits for harmonic distortion (including inductive telephone influence factors) will be as published in the latest issues of ANSI/IEEE 519, "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems." Flicker occurring at the point of compliance shall remain below the Border Line of Visibility curve on the IEEE/GE curve for fluctuations less than 1 per second or greater than 10 per second. However, in the range of 1 to 10 fluctuations per second, voltage flicker shall remain below 0.4%. Refer to Exhibit 1. When there is reasonable cause for concern due to the nature of the generation and its location, the Company may require the installation of a monitoring system to permit ongoing assessment of compliance with these criteria. The monitoring system, if required, will be installed at the DG owner's expense. Situations where high harmonic voltages and/or currents originate from the distribution system are to be addressed in the Interconnection Agreement.

1.7 DC Injection from inverters shall be maintained at or below 0.5% of full rated inverter output current into the point of common coupling.

1.8 The Distributed Generation's generated voltage shall follow, not attempt to oppose or regulate, changes in the prevailing voltage level of the Company at the point of common coupling, unless otherwise agreed to by the operators of the Distributed Generation and the Company. Distributed Generation installed on the downstream (load) side of the Company's voltage regulators shall not degrade the voltage regulation provided to the downstream customers of the Company to service voltages outside the limits of ANSI 84.1, Range A

1.9 System Grounding: The DG system should be grounded in accordance with applicable codes. The interconnection of the DG equipment with the Company's system shall be compatible with the neutral grounding method in use on the Company's system. For interconnections through a transformer to Company system primary feeders of multi-grounded, four-wire construction, or to tap lines of such systems, the maximum un-faulted phase (line-to-ground) voltages on the Company system primary feeder during single line-to-ground fault conditions with the Company system source disconnected, shall not exceed those voltages which would occur during the fault with the Company system source connected and no DG equipment.

[3] Properly, in this context, means within the acceptable utility or applicable industry established practices.

1.10 System Protection: The DG owner is responsible for providing adequate protection to Company facilities for conditions arising from the operation of generation under all Company distribution system operating conditions. The owner is also responsible for providing adequate protection to their facility under any Company distribution system operating condition whether or not their DG is in operation. Conditions may include but are not limited to:

1. Loss of a single phase of supply,
2. Distribution system faults,
3. Equipment failures,
4. Abnormal voltage or frequency,
5. Lightning and switching surges,
6. Excessive harmonic voltages,
7. Excessive negative sequence voltages,
8. Separation from supply,
9. Synchronizing generation,
10. Re-synchronizing the Owner's generation after electric restoration of the supply.

1.11 Feeder Reclosing Coordination. In the case of a Company protection function initiating a trip of a Company protective device in reaction to a fault on the Company system, the DG unit protection and controls must be designed to coordinate with the Company protective device reclosing settings.

1.12 Unintentional islanding: For an unintentional island in which the DG and a portion of the Company's system remain energized through the point of common coupling, the DG shall cease to energize the Company's system within two seconds of the formation of an island.

1.13 The DG shall be designed to prevent the DG from being connected to a de-energized Company circuit. The customer should not reconnect DG to the Company's system after a trip from a system protection device, until the Company's system is re-energized for a minimum of five minutes. If the customer were to connect a backup generator, in the event to serve a critical load, he must open his main breaker or utilize a transfer switch prior to generator hook up, in order to ensure no back feed into the Company's distribution system. This is a critical safety requirement.

1.14 Voltage unbalance at the point of common coupling caused by the DG equipment under any condition shall not exceed 3% (calculated by dividing the maximum deviation from average voltage by the average voltage, with the result multiplied by 100).

1.15 Test results shall be supplied by the manufacturer or independent testing lab that verify, to the satisfaction of the Company, compliance with the following requirements contained in this document[4]:

1.3.1 Over/Under Voltage Trip Settings
1.3.3 Over/Under Frequency Trip Settings
1.4.1 Synchronization
1.6 Harmonic Limits (tested at 25%[5] of full load rating or at a level as close to the minimum level of rated output the unit is designed to operate as practical and at a level as close to 100% of full load rating as practical)
1.7 DC Current Injection Limits (Inverters)

[4] For photovoltaic systems, a certification that the testing requirements of UL 1741 have been met may be used in place of these tests.
[5] If the device is not designed to operate at this level, then the test should be at the lowest level at which it is designed to operate.

1.12 Anti-Islanding (Inverters)
1.13 Prevent Connection or Reconnection to De-energized System

If test results are acceptable to the Company and if requested by a manufacturer, the Company will supply a letter indicating the protective and control functions for a specific DG model are approved for interconnection with the Company's distribution system, subject to the other requirements in this document.

The Interconnection Service Customer must provide the Company a reasonable opportunity to witness site testing of any other protective and control functions required in this document, but not listed above. The Interconnection Service Customer must provide the Company a reasonable opportunity to perform an inspection prior to the first paralleling of the generation equipment to install and/or verify correct protective settings and connections to the system.

2.0 CUSTOMER OPERATING PROCEDURES

2.1 If high-voltage, low-voltage, or voltage flicker complaints arise from other customers due to the operation of customer DG, the customer may be required to disconnect his or her generation equipment from the Company's system until the problem has been resolved.

2.2 The operation of the DG equipment must not result in harmonic currents or voltages at the point of common coupling that will interfere with the Company's metering accuracy and/or proper operation of facilities and/or with the loads of other customers. Such adverse effects may include, but are not limited to heating of wiring and equipment, over voltage, communication interference, etc.

2.3 The Interconnection Service Customer must discontinue parallel operation when requested by the Company after reasonable prior notice except in an emergency, so that maintenance and/or repairs can be performed on the Company's facilities.

3.0 DEFINITIONS

Distributed Generation (DG) Equipment – Includes any distributed generation facility, small electric generation facility, or generation facility of a self-generator or customer generator, all as defined in O.A.C. 4901:1-22-02.

Flicker – A variation of input voltage sufficient in duration to allow visual observation of a change in electric light source intensity.

Harmonic Distortion – Continuous distortion of the normal sine wave; typically caused by nonlinear loads or by inverters.

Networked System - One that is normally operated with more than one distribution feeder connected to a load. Examples are spot networks and secondary networks. Open loop underground residential distribution systems and open loop primary feeder systems are not considered networks in this context.

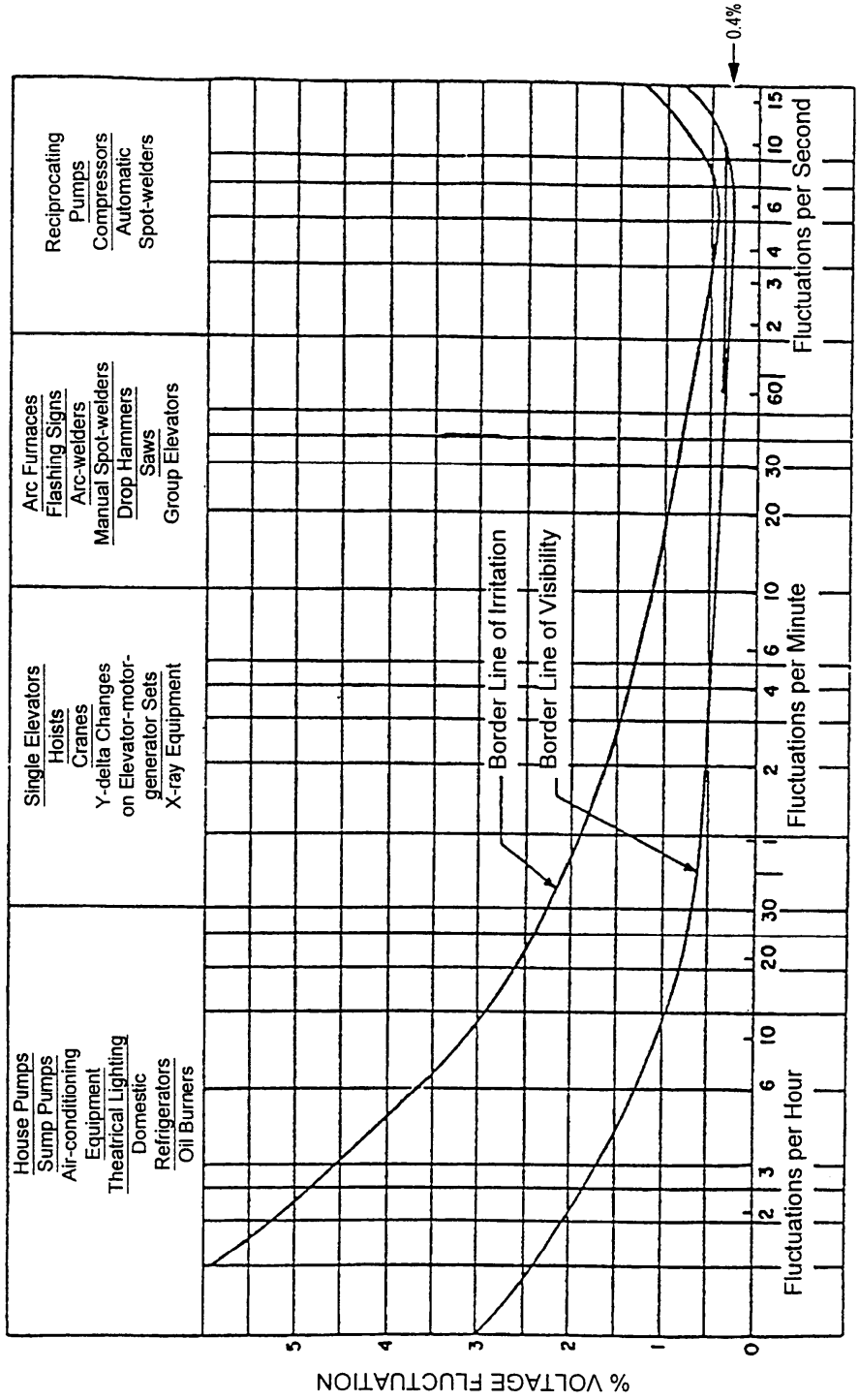
Point of Common Coupling – The point at which the DG facility is connected to the shared portion of the Company's system.

Radially Operated System – One that is normally operated with only one distribution source connected to a load at any one time.

Single Phasing Condition – Occurs when one phase of the three phase supply line is disconnected.

Unintentional Island - An unplanned condition where one or more DG's and a portion of the electric utility grid remain energized through the point of interconnection.

Exhibit 1



Composite curve of voltage flicker studies by General Electric Company, *General Electric Review*, August 1925; Kansas City Power & Light Company, *Electrical World*, May 19, 1934; T&D Committee, EEI, October 24, 1934, Chicago; Detroit Edison Company; West Pennsylvania Power Company; Public Service Company of Northern Illinois.

Relations of Voltage Fluctuations to Frequency of Their Occurrence (Incandescent Lamps)

Please note: The following electric industry standards, as applicable, will guide the electric utility in the course of interconnecting the customer's distributed generation equipment:

- IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems
- UL 1741 Inverters, Converters, and Controllers for Use in Independent Power Systems
- IEEE Standard 929-2000, *IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems*
- NFPA 70 (2014), *National Electrical Code*
- IEEE Standard C37.90.1-1989 (R1994), *IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems*
- IEEE Standard C37.90.2 (1995), *IEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers*
- IEEE Standard C37.108-1989 (R2002), *IEEE Guide for the Protection of Network Transformers*
- IEEE Standard C57.12.44-2000, *IEEE Standard Requirements for Secondary Network Protectors*
- IEEE Standard C62.41.2-2002, *IEEE Recommended Practice on Characterization of Surges in Low Voltage (1000V and Less) AC Power Circuits*
- IEEE Standard C62.45-1992 (R2002), *IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits*
- ANSI C84.1-1995 *Electric Power Systems and Equipment – Voltage Ratings (60 Hertz)*
- IEEE Standard 100-2000, *IEEE Standard Dictionary of Electrical and Electronic Terms*
- NEMA MG 1-1998, *Motors and Generators, Revision 3*
- IEEE Standard 519-1992, *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*