

Technical Considerations Covering Parallel Operations of Customer-Owned PV Solar Generation

**Of Less than 500 KW and Interconnected with
the Town of Clayton System**

July 2008

Amended December 2015

TOWN OF CLAYTON

TECHNICAL CONSIDERATIONS FOR INTERCONNECTION GUIDELINES

Prerequisite

The customer must be first in compliance with the tariff rules and regulations and the applicable tariff classification and rates. The terms and conditions contained herein are in addition to, but do not modify nor negate, the terms of the tariff.

I. Purpose

The purpose of this document (relating to interconnection of on-site distributed generation and parallel generation requirements) is to clearly state the terms and conditions that govern the interconnection and parallel operation of on-site distributed generation in order to:

- A. Establish technical requirements which will promote the safe and reliable parallel operation of distributed generation resources.
- B. Enhance the reliability of electric service.
- C. Facilitate the implementation and use of distributed resources technologies.
- D. Enhance economic efficiency in the production and consumption of electricity and other energy; and
- E. Promote the use of distributed resources in order to provide electric system benefits during periods of capacity constraint.

II. Applicability

Unless otherwise provided, these guidelines apply to all customer generators operating at 500 KW or less which are interconnected at 25kV or below and operated in parallel with the Town's power delivery system. The technical requirements herein are to be consistent with all requirements for customer interconnection including IEEE Standard 1547, *Standard for Interconnecting Distributed Resources with Electric Power Systems*, UL 1741, Underwriters Laboratories Subject 1741-1999, Standards for Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems. (The Town, by reference, adopts the above standards and future updates of these standards as appropriate).

III. Definition

- A. **Account** – An account is one metered or un-metered rate of service classification which normally has one electric delivery point of service. A premise may have more than one account.
- B. **Town** – Town of Clayton.
- C. **Customer** – Any adult person, partnership, association, corporation, or other entity: (1) In whose name a service account is listed. (2) Who occupies or is the ratepayer for a premise, building, structure, etc. and; (3) who is primarily responsible for payment of bills. A customer includes anyone taking electric service from the Town under one service classification for one account, premise, or site. Multiple premises or sites under the same name are considered multiple customers.
- D. **Distributed Generation or On-Site Distributed Generation** – An electrical generating unit of 500 KW or less which may be connected in parallel operation to

the Town's system.

- E. **Generator Owner** – The owner of the generating system that is interconnected to the Town.
- F. **Grid** – The interconnected arrangement of lines and transformers that make up the Town's electric power system.
- G. **IEEE Standard 1547** – IEEE Standard entitled *Standard for Interconnecting Distributed Resources with Electric Power Systems*, dated March 24, 2014, or subsequent approved revision thereof.
- H. **Interconnection** – The physical connection of distributed generation to the Town's system in accordance with these guidelines so that parallel operation can occur.
- I. **Interconnection Application** – The standard form of application which must be submitted by the Generation Owner to the Town for permission to interconnect with the Town system. The approved Interconnection Application sets forth the contractual conditions under which the Town and Generation Owner agree that one or more generating units whose aggregate generation at the Point of Common Coupling is 500 KW or less may be interconnected at 25 kV or less with the Town's system.
- J. **Inverter** – A static power converter with control, protection, and filtering functions that converts direct current input to alternating current output. Inverters must be of the non-islanding type.
- K. **Island** – A portion of the utility system which contains both load and distributed generation and is isolated from the remainder of the utility system.
- L. **Parallel Operation** – Any electrical connection between the Town's system and the General Owner's generating source.
- M. **Point of Common Coupling** – The point where the electrical conductors of the Town system are connected to the customer's conductors and where any transfer of electric power between the Generator Owner and the Town system takes place (such as switchgear near the meter).
- N. **Pre-Approved Equipment** – Specific generating and protective equipment system or systems that have been approved by the Town as meeting the applicable parts of this document.
- O. **Pre-Interconnection Study** – A study or studies which may be undertaken by the Town in response to its receipt of a completed application for parallel operation with the Town's system submitted on the Interconnection Application form prescribed by these guidelines. Pre-Interconnection Studies may include, but are not limited to, service studies, coordination studies, and facilities impact studies.
- P. **Stabilized** – The Town's system following a disturbance which returns to the normal range of voltage and frequency for at least five (5) minutes or longer as coordinated with the Town. The Town may require a longer period upon a reasonable showing that the reconnection after five (5) minutes will adversely affect the safety and reliability of the electric system.
- Q. **Unit** – A distributed generation facility.

R. **Utility System or Electric Distribution Facility** – Town’s distribution system operating at 25 kV or below to which the generation equipment is interconnected.

IV. **Interconnection Application**

A proposed Generator Owner will make a formal application to the Town for the interconnection of a generator to the Town system. All applications are to be sent to the Town’s Business Office. The application will be prepared on an application form provided by the Town. Two application forms are available. Generators 25 kW or less will use the shorter application form as less technical data is needed for units within this size range.

V. **Designation of Town Contact Persons for Technical Matters Relating to Distributed Generation Interconnection**

The Town’s electrical engineers will be the designated point of contact for all technical matters related to interconnected generation. The Town will maintain records concerning applications received for interconnection and parallel operation of distributed generation. Such records will include the date of receipt of each such application, documents generated in the course of processing such applications, correspondence regarding such applications, technical evaluation of the application, and the final disposition of such application.

VI. **Pre-Interconnection Studies**

In many instances, the Town will wish to conduct a system study, coordination study, or facilities impact study prior to interconnection of a distributed generation unit. In instances where such studies are deemed necessary the scope of such studies shall be based on the characteristics of the particular distributed generation unit to be interconnected and the proposed point of interconnection.

A. **Completion of Pre-Interconnection Study** – Upon completion of the interconnection study, the Town will notify the Generator Owner that their application has been approved or indicate in sufficient detail why the application cannot be approved. The conducting of such pre-interconnection studies shall not unduly delay the interconnection of the distributed generation. The Town of Clayton will make every effort to complete the pre-interconnection study in a timely manner after receipt of signed customer application and complete customer submittal of all required data.

B. **Pre-Interconnection Study Fee** – For all generators less than 25 kW the Town may do a pre-interconnection study without charge up to the typical and customary cost that the Town would expend for study work of similar type of customer interconnection. If the cost to the Town is expected to exceed this typical and customary amount, or if multiple submittals by the Generator Owner are necessary, or if the application is incomplete and requires subsequent reviews, or if the generators are greater in size than 25 kW, the Town will advise the Generator Owner of the expected cost of such study work by the Town as soon as it becomes known. The Generator Owner will be responsible for payment of any costs prior to the commencement of the pre-interconnection study.

VII. **Pre-Approval of Generation Units, Devices, and Systems**

Upon approval by the Town that certain generating units protective devices and/or system(s) meet the standards set out in these guidelines, such approval may be made available to the appropriate manufacturer upon written request. For subsequent applications using some or all of the identical generating unit’s protective devices and/or systems, the manufacturer

may submit a copy of the approval with the application as proof that its equipment has already been approved for use on the Town's system. Use of pre-approved equipment will not eliminate any applicable requirement for a pre- interconnection study to determine the suitability of the equipment for each application given the unique arrangements and characteristics of both the Generator Owner and Town systems at the point of the interconnection.

VIII. **Connection Approval**

The Generator Owner can connect their generation to the Town system only after the interconnection application has been approved and the Generator Owner has received written approval notification. The Town will make every effort to provide notification in a timely manner following the receipt of the interconnection application and all required data.

IX. **Interconnected Generation Site Warning Label**

The Town will install a warning label in a conspicuous place on their electric meter or meter box to notify the Town personnel that there is a generator source installed on the load side of the meter. The warning label shall not be placed in a location that would interfere with the ability of Town personnel to read the electric meter. The Town will also provide the warning label for the transformer serving the customer. All warning labels must be placed conspicuously before the generation can be interconnected.

X. **Disconnection and Reconnection**

The Town may disconnect a distributed generation unit under the following conditions:

- A. **Application Termination** – Upon termination of the approved interconnection application.
- B. **Non Compliance** – For non-compliance with the technical guidelines specified in this document or other requirements contained in the applicable Customer Tariff provided that the Town has given notice to the Generator Owner and provided the Generator Owner reasonable time (consistent with the condition) to correct such non-compliance. The Town will reconnect the unit only upon receipt of certification from the Generator Owner and verification by the Town that the unit is in compliance. The Town will determine at the Town's sole judgment if the customer's generation is in compliance. The Town will provide verification within a reasonable time period.
- C. **In Case of a System Emergency Outage of the Town's Primary Electrical Sources** – The Generator Owner's generation equipment must be installed and configured so that parallel operation must automatically cease immediately and automatically during outages or loss of the Town's electric source in accordance with these guidelines. The Generator Owner must also cease parallel operation upon notification by the Town of a system emergency, abnormal condition, or in cases where such operation is determined to be unsafe, interferes with the supply of service to other customers, or interferes with the Town's system maintenance or operation. In addition the Town may disconnect the generator from the system for system emergencies without notice. However, the Town will use reasonable efforts to notify the Generator Owner prior to disconnecting.
- D. **For Routine Maintenance and Repairs** – The Town may disconnect a Generator Owner for routine maintenance and repairs on the Town's system consistent with applicable tariffs and agreements. The Town will make reasonable efforts to provide advance notice to the Generator Owner of service

interruptions resulting from routine maintenance.

The Town will reconnect the Generator Owner as quickly as possible following completion of any such service interruptions.

XI. Termination

The Generator Owner may terminate the approved interconnection application at any time upon thirty (30) days of providing written notice to the Town. The Town may terminate the interconnection application for cause after thirty (30) days written notice to the Generator Owner of a material violation of the terms of the approved interconnection application and after the Generator Owner has had a reasonable opportunity to remedy the violation. The Generator Owner must give the Town notice if it intends to permanently shut down its generation. In no respect will notice to terminate preclude the Town from taking any and all immediate actions necessary, including temporary or permanent disconnection of customer's generation, if the town is aware of safety or reliability concerns as a result of interconnection of the customer's generation.

XII. Technical Guidelines for Parallel Operation of On-Site Distributed Generation Units

This subsection describes minimum requirements and procedures for safe and effective connection and operation of distributed generation. A Generator Owner may operate 60 Hertz, three-phase, or single-phase generating equipment in parallel with the Town's system pursuant to an approved interconnection application provided that the equipment and Generator Owner meet or exceed the requirements of these guidelines and that the Town has approved the Generator Owner's application to interconnect. This subsection describes typical interconnection requirements. Certain specific interconnection locations and conditions may require the installation of additional protective settings or hardware especially when exporting power to the system. If the Town concludes that an application for parallel operation requires additional protective settings or hardware, the Town shall make those requirements known to the Generator Owner in a timely fashion after all pertinent studies are completed.

Approval to connect to the Town system indicates only that the minimum requirements for a safe proper interconnection have been satisfied. Such approval does not imply that the Generator Owner's facility meets all federal, state, and local standards or regulations. The Town accepts no responsibility for activities or events on the customer's side of the interconnection.

A. General Interconnection and Protection Requirements

1. The Generator Owner's generation and interconnection installation must meet all applicable national, state, and local construction and safety codes.
2. The Generator Owner's generator shall be equipped with protective hardware and software designed to prevent the generator from energizing one of the Town's de-energized circuits. The Generator Owner's generator must automatically disconnect from the Town's distribution system if the grid source is lost irrespectively of connected loads, or other generators.
3. The generator shall be equipped with the necessary protective hardware and software designed to prevent sustained parallel operation of the generating equipment with the Town's system unless the system service voltage and frequency are within acceptable magnitudes as defined in Section XIV, B.

4. Pre-approved equipment shall be accepted as part of an interconnection proposal without the need to re-review the equipment itself. However, the application, design, and setting of pre-approved units and/or equipment must be reviewed and coordinated according to the unique needs of the specific location of the proposed installation. Where a complete unit or system has been pre-approved, only location-specific issues will typically need to be reviewed.
5. The Generator Owner will be responsible for protecting its own generating and interconnection equipment in such a manner so that Town system outages, short circuits, single-phasing conditions or other disturbances including zero sequence currents and ferroresonant over-voltages do not damage the Generator Owner's generating equipment. The protective equipment shall also prevent excessive or unnecessary tripping that would adversely affect the Town's service reliability or power quality to other Generator Owners and customers.
6. The generator and interface protection schemes shall be continuously monitored and functioning and the generator shall immediately disconnect from the Town's system for any condition that would make the protection scheme inoperable.
7. The operating power required for the protection and control schemes for the generator and the control power used to disconnect the generator from the Town must not be dependent on local Town grid power or must provide a "fail-safe" method to an "open" disconnected position upon loss of grid.
8. Where multiple generators are connected to the system through a single point of common coupling, the sum of the ratings of the generators will be used to determine the applicability of these guidelines. Protection scheme performance with one or more units off line will have to be considered.
9. Applicable circuit breakers or other interrupting devices at the Generator Owner's facility must be capable of interrupting the maximum available fault current at the site including any contribution from the owner's generator(s).
10. The Generator Owner will furnish and install a manual disconnect device which, when opened, will have the effect of isolating the generator from the Town's system. The disconnect device shall have a visual break (an AC Safety disconnect switch or a draw-out breaker as appropriate to the voltage and capacity level) and will, at all times, be accessible to the Town's personnel and shall be capable of being locked in the open position via a Town padlock. The Town shall use reasonable efforts to utilize padlocks of a size consistent with typical manufacturer's specifications. The Generator Owner shall follow the Town's switching, clearance, and tagging procedures which the Town shall provide and attach the warning label noted in Section IX.
11. The design, procurement, installation, and maintenance of the equipment at the Generator Owner's site are the responsibility of the Generator Owner and at the Generator Owner's expense.

12. Any necessary enhancements or improvements needed within the Town's system and/or at the customer sites to accommodate the parallel interconnection of the Generator Owner's generation will be at the Generator Owner's expense.
13. The Generator Owner has full responsibility and liability for the safe and proper operation of their equipment and the power originating from their generator. The Generator Owner is also responsible for synchronizing their generator(s) with the Town's system and maintaining a synchronous operation.
14. The Generator Owner must immediately cease parallel operation upon notification by the Town if such operation is determined to be unsafe, interferes with the supply of service to other customers, or interferes with the Town's system maintenance or operation.
15. The Town reserves the right to specify the type of transformer connection (e.g. delta-delta, wye-delta, wye-wye) that will be employed for all multi-phase interface transformers consistent, where reasonable, with the Generator Owner's power system.

B. Prevention of Generator Owner Generation Interference with Town System To eliminate undesirable interference caused by operation of the Generator Owner's generating equipment, the Generator Owner's generator shall meet the following criteria:

1. **Voltage** – The generating equipment will be operated in such a manner that the voltage levels on the Town's system are in the same range as if the generating equipment were not connected to the Town's system. The Generator Owner shall provide an automatic method of initiating a disconnect sequence of their generating equipment from the Town system with set points noted in the table below.

Generating Systems with Inverters Up to 25 kW	Generating Systems with Inverters Greater than 25 kW
Trip in 0.1 second for $V < 50\%$	Trip in 0.1 second for $V < 50\%$
Trip in 2 seconds for $50\% \leq V < 88\%$	Trip within 0.1 to 30 seconds for $50\% \leq V < 88\%$
Trip in 2 seconds for $106\% < V < 137\%$	Trip within 0.1 to 30 seconds for $106\% < V < 137\%$
Trip in 0.03 second for $137\% \leq V$ (above times and voltages taken directly from IEEE 929)	Trip in 0.03 second for $137\% \leq V$ (specific voltage and time delay set points will be determined for each installation)

Note: Trip time refers to the time between when the abnormal voltage condition occurs and the generator being disconnected from the Town's electric system.

On three-phase generator installations, full three-phase voltage sensing should be employed. Voltages must be sensed on the high side of any interface transformer if the transformer high voltage winding is ungrounded.

The Generator Owner may reconnect to the grid when the system voltage returns to normal range and is stabilizing as defined in Section III, Definitions "Stabilized."

2. **Flicker** – The Generator Owner shall not cause excessive voltage flicker on the Town’s system. This flicker shall not exceed the “Borderline of Irritation” curve, Fig. 10.3, as defined in IEEE Std 519-1992, *Recommended Practices and Requirements for Harmonic Control in Electric Power Systems* (See Appendix I). Lower levels of flicker may be required in areas where equipment such as computers and instrumentation are impacted.
3. **Frequency** – The operating frequency of the generating equipment shall not deviate more than the values noted in the table below.

Generating Systems with Inverters Up to 25 kW	Generating Systems with Inverters Greater than 25 kW
Trip in 0.1 second for $F < 59.3$ Hz	Trip in 0.1 second for $F < 59.3$ Hz
Trip in 0.1 second for $F > 60.5$ Hz (Set points taken from IEEE 929)	Trip in 0.1 second for $F > 60.5$ Hz (Other frequency and time delay set points may be necessary for a specific installation)

Note: Trip time refers to the time between when the abnormal frequency condition occurs and the generator being disconnected from the Town’s electric system.

The Generator Owner may reconnect when the system frequency returns to normal range and is stabilized as defined in Section III, Definitions “Stabilized.”

4. **Harmonics** – Non-linear circuit elements such as inverters can produce harmonics. Per IEEE Std. 519, *Recommended Practices and Requirements for Harmonic Control in Electric Power Systems*, Table 11.1 (See Appendix 1), the total harmonic distortion (THD) voltage shall not exceed 5% of the fundamental 60 Hz frequency nor 3% of the fundamental for any individual harmonic as measured at the location where the customer interfaces with the Town’s system (Point of Common Coupling). In addition, the level of harmonic current that the customer is allowed to inject into the Town’s system shall not exceed that specified in Table 10.3 in IEEE Std. 519 (See Appendix 1). Furthermore, any communication notch should be limited as defined by Table 10.2 in IEEE Std. 519 (See Appendix 1). The preceding requirements apply to all types of generation systems.

The Generator Owner is responsible for the installation of any necessary controls or hardware to limit the voltage and current harmonics generated by their equipment to defined levels.

5. **Power Factor** – The generator must not adversely impact the power factor of the Generator Owner site. Most inverters are designed to operate close to unity power factor. The operating power factor of the generator shall be contained within the limits defined in the table below.

Generating Systems with Inverters Up to 25 kW	Generating Systems with Inverters Greater than 25 kW

0.85 Lagging or Leading when output exceeds 10% of inverter rating. (From IEEE 929-1999)	0.85 Lagging or Leading when output exceeds 10% of inverter rating.
---------------------------------------------------------------------------------------------	---------------------------------------------------------------------

However, to the extent that a Generator Owner's power factor at the Point of Common Coupling falls below 0.9 lagging as a direct result of the installation of the generating unit(s), the Generator Owner must obtain, install, and maintain at their expense corrective apparatus that compensates for the drop in power factor caused by the installation of the generator.

6. **Current** – In some cases directional over-current protection may be required to limit fault current flowing onto the grid in the event of a line fault. DC inverters that are incapable of producing fault current do not require directional over-current protection.

Inverter systems should not inject DC current greater than 0.5% of rated inverter output in the AC interface point under either normal or abnormal conditions.

7. **Fault and Line Clearing** – The Generator Owner shall automatically disconnect from the Town's system during electrical faults on the Town's electrical system and upon loss of the Town's electric source. The Generator Owner may reconnect when the system voltage and frequency return to normal range and is stabilized as defined in Section III, Definitions. Detection of the loss of the Town's primary electric system where the Generator Owner is operating in an island with other customer loads becomes increasingly difficult as the level of dispersed generation on a feeder approaches the connected load. For generating units 25 kW and below, the over/under voltage and over/under frequency settings described previously along with the anti-islandizing provisions of IEEE 1547/UL 1746 inverters should be sufficient to satisfy this provision. For units greater than 25 kW, the voltage and frequency set-points are to be adjustable with the actual setting determined by the Town based on the electrical characteristics of the generator and the Town's electrical system. In addition, additional protection such as power directional or directional over current functions may be required. For units 500 kW or larger, a direct tripping scheme to trip the generator upon loss of the Town's feeder may be required by the Town. This decision will be based on the saturation of distributed generation on a particular feeder circuit and in those cases where under voltage or under frequency sensing may not adequately detect loss of the Town source.

8. **Automatic Reclosing** – The Generator Owner is responsible for protecting his equipment from the effects of switching or automatic reclosing of the Town's feeder circuit. The Generator Owner may request the Town to delay high speed reclosing on the Town's feeder to allow the interconnected generator sufficient time to remove itself from an islandized or de-energized feeder prior to automatic reclose. Since delaying the automatic reclose time degrades the level of service provided to other customers on the circuit, the Town will limit the automatic reclose time delays to a few seconds or less. The Generator Owner may also request that a direct transfer trip scheme be added to remove the interconnected generator from service prior to automatic reclosing by using communications equipment between the generator site and the Town. Similarly, the Generator Owner may request that a synchronizing check or reclose blocking scheme be installed on the Town's feeder to prevent out of phase reclosing. The Generator Owner is responsible for all costs

associated with the installation and maintenance of these requested modifications.

C. Control, Protection, and Safety Equipment Requirements Specific to Generators of 25 kW or Less

All Generator Owners 10 kW or less can be single phase. Customer-owned generators greater than 10 kW must be evaluated by the Town to determine if it can be single phase. The following table describes necessary control, protection, and safety equipment specific to generators of 25 kW or less connected to secondary or primary voltage systems:

Control, Protection, and Safety Equipment for Generators of 25 kW¹ or Less Connected to Secondary or Primary System			
	Control Equipment	Protection Equipment	Safety Equipment
Generator Disconnect Devices ²			X
Over-Current Trip	X		
Over-Voltage Trip	X		
Under Voltage Trip		X	
Over/Under Frequency Trip		X	
Synchronizing Check ²		Manual or Automatic	

Notes:

1. Exporting to the Town system may require additional operational/protection devices.
2. For synchronous and other type of generators with stand-alone capability however not necessary with IEEE 1547 compliant inverters.

D. Control, Protection, and Safety Requirement Specific to Three-Phase Inverter Systems. Generators greater than 25 kW may be required to be three-phase machines connected to three-phase circuits.

E. Inverter Type
DC Generation installations using inverters for interconnection with the Town must use non-islanding type inverters as defined in IEEE 1547 *Standard for Interconnecting Distributed Resources with Electric Power Systems* and UL Subject 1741, May 1999, *Standard for Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems*.

F. Inspection and Start-Up Testing
The Generator Owner shall provide the Town with reasonable prior notice at least two (2) weeks before the initial energizing and start-up testing of the Generator Owner's generating equipment; and the Town, at its discretion, shall witness the testing of any equipment and protective systems associated with the interconnection. The Generator Owner shall revise and resubmit the application information for any proposed modification that may affect the safe and reliable operation of the Town's system. The generator may be reconnected to the Town system only after the modified application has been reviewed, testing has been confirmed, and the Town has given approval to reconnect.

G. Site Testing and Commissioning
Testing of protection systems shall include procedures to functionally test all protective elements of the installation up to and including tripping of the

generator and interconnection point. Testing and testing intervals should be in accordance with manufacturer and industry recommendations. Testing will verify all protective set points and relay/breaker trip timing. The Town may witness the testing of installed switchgear, protection systems, and generator. The Generator Owner is responsible for all maintenance of the generator, control, and protective equipment. The Generator Owner will maintain records of such maintenance activities which the Town may review at reasonable times. For generation greater than 50 KW real-time production metering may be required and production data in electronic format provided to Town.

H. **Metering**

Metering requirements will be reviewed on each specific installation.

I. **Suggested References**

The following references can supply technical support and insight into the safe, reliable interconnection of distributed generation with the Town's system. These references or the succession references should be reviewed by those individuals or firms contemplating parallel operation of generation with the Town.

IEEE C37.95 (1989) *IEEE Guide for Protective Relaying of Utility Customer Interconnections*

IEEE Std. 1001 (1988) *IEEE Guide for Interfacing Dispersed Storage and Generation Facilities with Electric Utility Systems*

IEEE Std. 929 *Practices for Utility Interface of Photovoltaic (PV) Systems*

IEEE Std. 1021 (1988) *IEEE Recommended Practices for Utility Interconnection of Small Wind Energy Conversion Systems*

IEEE Std. 519 (1992) *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*

APPENDIX 1

Selected Tables from IEEE Std. 519 - 1992

Recommended Practices and Requirements for Harmonic Control in Electric Power Systems

Figure 10-3 Maximum Permissible Voltage Fluctuations

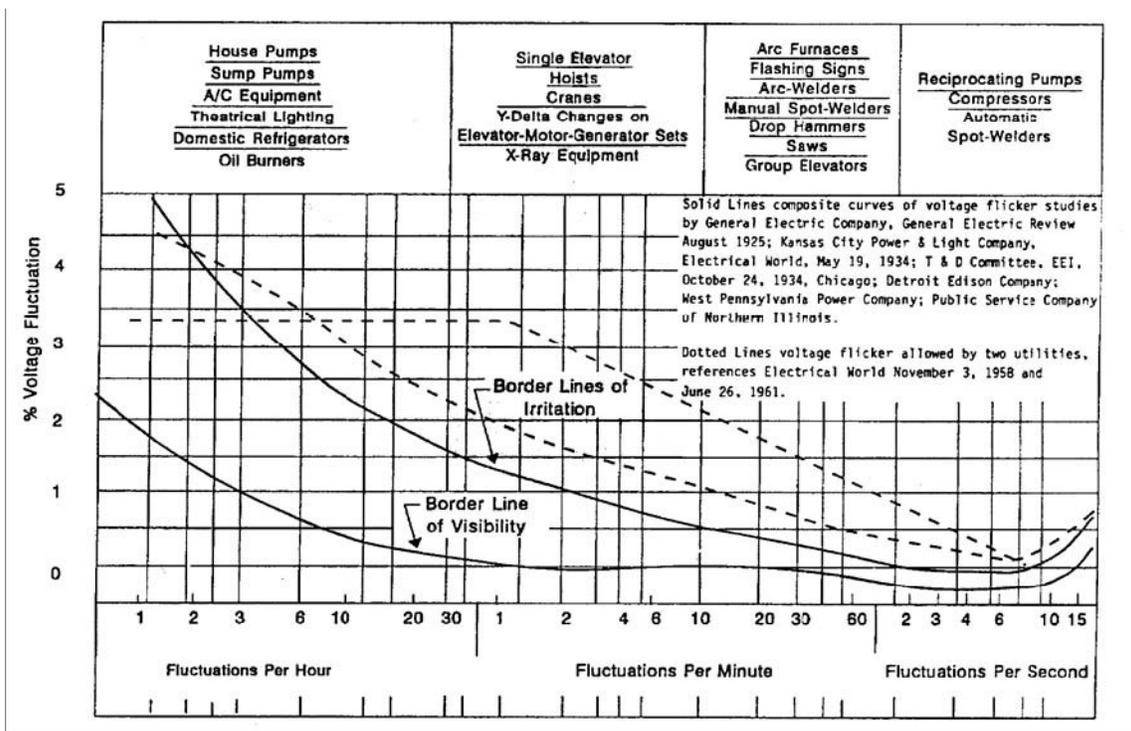


Table 10-2—Low-Voltage System Classification and Distortion Limits

	Special Applications*	General System	Dedicated System†
Notch Depth	10%	20%	50%
THD (Voltage)	3%	5%	10%
Notch Area (A_N)‡	16 400	22 800	36 500

NOTE — The value A_N for other than 480 V systems should be multiplied by $V/480$

*Special applications include hospitals and airports.

†A dedicated system is exclusively dedicated to the converter load.

‡In volt-microseconds at rated voltage and current.

From IEEE Std. 519-1992. Reprinted with permission from IEEE.

Table 10-3—Current Distortion Limits for General Distribution Systems (120 V Through 69 000 V)

Maximum Harmonic Current Distortion in Percent of I_L						
Individual Harmonic Order (Odd Harmonics)						
I_{sc}/I_L	<11	11≤h<17	17≤h<23	23≤h<35	35≤h	TDD
<20*	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

Even harmonics are limited to 25% of the odd harmonic limits above.

Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.

* All power generation equipment is limited to these values of current distortion, regardless of actual I_{sc}/I_L .

where
 I_{sc} = maximum short-circuit current at PCC.
 I_L = maximum demand load current (fundamental frequency component) at PCC.

Table 11-1—Voltage Distortion Limits

Bus Voltage at PCC	Individual Voltage Distortion (%)	Total Voltage Distortion THD (%)
69 kV and below	3.0	5.0
69.001 kV through 161 kV	1.5	2.5
161.001 kV and above	1.0	1.5

NOTE — High-voltage systems can have up to 2.0% THD where the cause is an HVDC terminal that will attenuate by the time it is tapped for a user.

From IEEE Std. 519-1992. Reprinted with permission from IEEE.