

SPECIFICATION FOR


Limitation of Harmonic Distortion on the Distribution System

**CENTERPOINT ENERGY
HOUSTON ELECTRIC ENGINEERING
P.O. BOX 1700 HOUSTON, TEXAS 77251**

REFERENCE DRAWINGS:

REFERENCE SPECIFICATIONS: (or latest revisions thereof)

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|----------------|---|
| IEEE 519-2014 | IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems |
| PUCT § 25.51 | Power Quality |
| IEC 61000-4-7 | General Guide on Harmonics and Interharmonics Measurements and Instrumentation |
| IEC 61000-4-30 | Testing and Measurement Techniques - Power Quality Measurement Methods |

									
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3	02-27-20	Complete Revision	BL	WSC	MEM	APPROVED	06-01-94	J.D. Darnell	
2	01-11-08	Complete Revision	SLJ	WSC	RKM / LSN		SHEET 1 of 9		
NO.	DATE	ITEMS REVISED	BY	CH	APP		007	231	83

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1.0 SCOPE

- 1.1 This specification covers minimum requirements for any customer, connected to the CenterPoint Energy (CNP) distribution system, who has installed or plans to install equipment capable of distorting the 60 Hertz (Hz) voltage and current waveforms.
- 1.2 Certain loads generate harmonic distortion due to the non-continuous manner in which these loads draw current. This harmonic distortion is injected onto the CNP distribution system. High levels of harmonic current may cause the disruption or failure of customer equipment or CNP distribution system equipment. It is the customer's responsibility to limit harmonic flow into the CNP distribution system.

2.0 GENERAL

- 2.1 Hereafter, CenterPoint Energy will be designated as "CNP" and the Contractor, Customer, or Facility Owner will be designated as "Customer".
- 2.2 Equipment required to meet this specification shall be furnished by the customer unless otherwise noted.
- 2.3 CNP reserves the right to refuse to energize any service which fails to meet this specification or any CNP approved project drawings.
- 2.4 The customer shall indemnify and hold CNP harmless for all damages and injuries to CNP or others arising out of the customer's use, ownership, or operation of their facilities, and caused in whole or in part by the customer's negligence.
- 2.5 Any deviations from this specification or CNP approved project drawings shall require the approval of the Manager of Power Quality or their designated representative. All items requiring CNP approval shall be submitted to the Manager of Power Quality or their designated representative.
- 2.6 Where there is a conflict between this specification and CNP approved project drawings, the drawings shall take precedence.
- 2.7 All customer services and installations shall be in accordance with IEEE Standard 519-2014 *IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems* and the Public Utility Commission of Texas Substantive Rule § 25.51 *Power Quality* (available at www.puc.state.tx.us).

3.0 HARMONIC SOURCES

- 3.1 Harmonic distortion is due to non-linear loads, i.e., loads in which the current drawn is not proportionally related to the supply voltage. There are three major classes of non-linear loads, listed in order of prominence: electronic power converters, arcing devices, and ferromagnetic devices.
 - 3.1.1 Electronic power converters draw intermittent current. The current distortion created is normally in the range of 20-30% of current rating for three phase equipment and 20-100% of current rating for single phase equipment.
 - 3.1.1.1 Adjustable speed and DC drives utilize rectifiers, inverters, converters and pulse width modulation. Example uses of motor drives include chillers, pumps, and plastic extrusion drive applications.
 - 3.1.1.2 Most electronic equipment utilizes switched mode power supplies; these devices include computers and microprocessor-controlled equipment, etc.
 - 3.1.2 Arcing devices clamp the voltage to limit current. These devices include arc furnaces and welders, fluorescent, sodium and mercury vapor lighting (including high efficiency electronic ballast-controlled lighting), etc. Harmonic current content can be high and rapidly changing due to the rapid fluctuations in arcing loads.
 - 3.1.3 The basic design of ferromagnetic devices involves a coil wound around an iron core, commonly used in motors and transformers. The distortion created is in the range of about 1% of current rating.
- 3.2 Capacitors may create parallel or series resonant conditions that divert or amplify the flow of harmonic currents, resulting in the disruption of equipment operation, mis-operation of protective devices, equipment failure and interference with utility operations.
- 3.3 Other types of equipment may have undesirable harmonic characteristics. Customers are encouraged to discuss their unique installation with qualified consultants.

4.0 CURRENT DISTORTION LIMITS

- 4.1 Distorted current injected by the customer into CNP's distribution system shall be limited to values, in percent of the maximum demand load current I_L , listed in the table below. The harmonic current levels allowed are based on the size of the load with respect to the size of the power system to which the load is connected.

$\frac{I_{SC}}{I_L}$	Individual harmonic order, h (odd harmonics)					TDD
	$3 \leq h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h < 50$	
<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

Reference: Table 2 from IEEE Std 519-2014, page 7

4.1.1 I_{SC}/I_L Definition:

I_{SC}/I_L is the ratio of the short circuit current available at the Point of Common Coupling (PCC) to the maximum fundamental demand load current. I_{SC} is available from either the CNP documents providing new or added electrical service or from your CNP representative. I_L is established at the point of common coupling and should be taken as the sum of the currents corresponding to the maximum demand during each of the twelve previous months divided by 12. In cases where this value is not available (new customers), an estimate of the maximum load current must be used based on the predicted load profiles.

4.1.2 TDD Definition:

Total Demand Distortion is the harmonic current distortion in % of maximum demand load current.

4.1.3 Allowable Levels:

As the size of the customer load decreases with respect to the size of the system, the larger the percentage of harmonic current the customer is allowed to inject into the utility system. This protects other customers on the same feeder as well as the utility, which is required to furnish a certain quality of power to its customers.

- 4.2 Even harmonics are limited to 25% of the odd harmonic limits listed under Current Distortion Limits Table, Section 4.1.
- 4.3 All power generation equipment is limited to the values in the <20 category, regardless of actual I_{SC}/I_L .
- 4.4 Current distortions that result in a direct current offset, e.g. half wave converters, are not allowed.

4.5 Recommendations for increasing harmonic current limits:

If a customer reduces the specific harmonic orders listed in the table below to less than 25% of the base limits in Section 4.1, all other harmonic orders may have their limits increased by a multiplying factor. The multipliers given in the second column of the table below are applicable when steps are taken to reduce the harmonic orders given in the first column.

Harmonics orders limited to 25% of base limits given in Section 4.1	Multiplier
5, 7	1.4
5, 7, 11, 13	1.7
5, 7, 11, 13, 17, 19	2.0
5, 7, 11, 13, 17, 19, 23, 25	2.2
↓	↓

Reference: Table 5 from IEEE Std 519-2014, page 9

4.6 Daily and Weekly Percentile Limits:

At the PCC, the customer shall meet all of the following daily and weekly limits:

Using the measurements in Section 6.1.3, there are 28,800 very short time (3s) harmonic current measurements in a day and 1,008 short time (10 min) harmonic current measurements in a week.

- 4.6.1 Daily 99th percentile (28,512 daily) very short time (3s) harmonic current measurement values should be less than 2.0 times the limits defined in Sections 4.1 through 4.5.

This allows for up to 14 minutes and 24 seconds of daily very short time exemptions for values greater than 2.0 times the limits defined in Sections 4.1 through 4.5.

- 4.6.2 Weekly 99th percentile (998 weekly) short time (10 min) harmonic current measurement values should be less than 1.5 times the limits defined in Sections 4.1 through 4.5.

This allows for up to 1 hour and 40 minutes of weekly short time exemptions for values greater than 1.5 times the limits defined in Sections 4.1 through 4.5.

- 4.6.3 Weekly 95th percentile (958) short time (10 min) harmonic current measurement values should be less than the limits defined in Sections 4.1 through 4.5.

This allows for up to 8 hours and 20 minutes of weekly short time exemptions for values greater than the limits defined in Sections 4.1 through 4.5.

5.0 MODELING

- 5.1 CNP requires data pertaining to the customer’s facilities and loads for possible modeling to determine whether a proposed customer’s facility will cause harmonic limits to be exceeded. Customer shall submit the following:
 - 5.1.1 One-line drawing of facilities showing ratings and connections of all electrical equipment.
 - 5.1.2 Location, connection, size and control methods of capacitors.
 - 5.1.3 Conductor sizes and impedances.
 - 5.1.4 Location and type of non-linear loads.
 - 5.1.5 Overall plant load and portion which is non-linear.
 - 5.1.6 Locations, ratings, connections and impedance of transformers.

- 5.2 Customer will be responsible for modeling their system to project harmonic levels and determine whether limits will be exceeded. Modeling will be required to design or otherwise engineer their facilities to meet CNP’s harmonic limits.

- 5.3 On written request, CNP will supply local power system information deemed necessary for customer modeling efforts. This information may include the following:
 - 5.3.1 Available fault duty and existing system impedance at customer’s location.
 - 5.3.2 Ultimate available fault current.
 - 5.3.3 CNP transformer impedance and ratings.
 - 5.3.4 Possible voltage range variation.

- 5.4 IEEE 519 allows for values of Total Harmonic Distortion with no single harmonic exceeding the values listed in the table below. Filter modeling should include this allowable distortion. Failure to include this allowable distortion may result in filter designs with overloaded components. All values should be in percent of the rated power frequency voltage at the PCC. The table below applies to voltage harmonics whose frequencies are integer multiples of the power frequency.

Bus voltage V at PCC	Individual Harmonic Limit (%)	Total Harmonic Distortion THD Limit (%)
$V \leq 1.0 \text{ kV}$	5.0	8.0
$1 \text{ kV} \leq V \leq 69 \text{ kV}$	3.0	5.0

Reference: Table 1 from IEEE Std 519-2014, page 6

- 5.5 CNP may require copies of customer’s harmonic analysis to review prior to approving customer’s proposed facilities.

- 5.6 When required by CNP, the customer shall submit manufacturer’s documentation and test data demonstrating the harmonic content of non-linear loads.

6.0 MEASUREMENTS

- 6.1 CNP reserves the right to measure the amount of customer's harmonic current injection at any time.
- 6.1.1 These measurements will be taken at the PCC, normally designated at the CNP meter.
- 6.1.2 These measurements will normally be spot checks; however, at CNP's discretion, additional monitoring may be required.
- 6.1.3 For the purposes of assessing harmonic levels for comparison with the recommended limits in this document, any instrument used will comply with the specifications of IEC 61000-4-7 and IEC 61000-4-30.
- 6.1.3.1 The width of the measurement window used by digital instruments employing Discrete Fourier Transform techniques will be 12 cycles (approximately 200 ms).
- 6.1.3.2 Very short time harmonic values are assessed over a 3-second interval based on an RMS aggregation of 15 consecutive 12 cycle windows for a specific frequency component.
- 6.1.3.3 Short time harmonic values are assessed over a 10-minute interval based on an RMS aggregation of 200 consecutive very short time values for a specific frequency component.
- 6.1.3.4 Very short and short time harmonic values will be accumulated over periods of one day and one week, respectively. For very short time harmonic measurements, the 99th percentile value (i.e., the value that is exceeded for 1% of the measurement period) should be calculated for each 24-hour period for comparison with the recommend limits in the table in Section 4.1. For short time harmonic measurements, the 95th and 99th percentile values (i.e., those values that are exceeded for 5% and 1% of the measurement period) should be calculated for each 7-day period for comparison with the recommended limits in the table in Section 4.1. These statistics will be used for both voltage and current harmonics with the exception that the 99th percentile short time value is not recommended for use with voltage harmonics.

7.0 MITIGATION DEVICES AND METHODS

- 7.1 Customer shall be responsible for the design, installation, operation and maintenance of mitigation devices required to meet IEEE 519 harmonic limits.
- 7.2 Mitigation devices may include current limiting reactors, passive traps and filters, active power line conditioners or other devices that minimize the flow of harmonic currents onto the distribution circuit.
- 7.3 Customer shall submit mitigation device maintenance records to CNP upon request.
- 7.4 The installation and testing of these devices shall be subject to the approval of CNP's Manager of Power Quality or their designated representative.
- 7.5 Customer shall design mitigation devices with the appropriate power rating to handle acceptable distortion levels in the utility supply voltage (refer to Section 5.4 of this specification).
- 7.6 CNP regularly reconfigures the distribution system in response to load changes and in resolution of outages. Customer should design their mitigation device to be independent in its operation from characteristics of the CNP supply system.