ANSI/AHRI Standard 1210-2023 (SI/I-P)

Performance Rating of Variable Frequency Drives

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ICS Code: 27.200

Note:

This standard supersedes AHRI Standard 1210-2019 (I-P) and AHRI Standard 1211 (SI)-2019.

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Intent

This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors, and users.

Review and Amendment

This standard is subject to review and amendment as technology advances.

2023 Edition

This edition of AHRI Standard 1210 (SI/I-P), *Performance Rating of Variable Frequency Drives*, was prepared by the Power Drive Systems Standards Technical Committee (STC). The standard was approved by the Applied Standards Subcommittee (SCC) on 16 November 2023. This standard was approved as an American National Standard (ANS) on 5 December 2023.

Origin and Development of AHRI Standard 1210

The initial publication was ANSI/AHRI 1210 (I-P)-2011, *Performance Rating of Variable Frequency Drives* and ANSI/AHRI (SI) 1211 (SI)-2011, *Performance Rating of Variable Frequency Drives*. Subsequent revisions were:

ANSI/AHRI Standard 1210 (I-P)-2011 with Addendum 1, *Performance Rating of Variable Frequency Drives*

ANSI/AHRI Standard 1211 (SI)-2011 with Addendum 1, *Performance Rating of Variable Frequency Drives*

AHRI Standard 1210 (I-P)-2011 (with Addendum 1 and 2, *Performance Rating of Variable Frequency Drives*

AHRI Standard 1211 (SI)-2011 (with Addendum 1 and 2), *Performance Rating of Variable Frequency Drives*

AHRI Standard 1210 (I-P)–2017, *Performance Rating of Variable Frequency Drives*

AHRI Standard 1211 (SI)–2017, *Performance Rating of Variable Frequency Drives*

AHRI Standard 1210-2019 (I-P), *Performance Rating of Variable Frequency Drives*

AHRI Standard 1211-2019 (SI), *Performance Rating of Variable Frequency Drives*

Summary of Changes

AHRI Standard 1210-2023 (SI/I-P) contains the following updates to the previous edition:

- Created a joint-unit SI/I-P document by consolidating AHRI Standard 1211 into AHRI Standard 1210
- Updated the standard to the current style guide
- Updated power source requirement section to align with ASHRAE 222
- Added reference for synchronous motors
- Updated drive system efficiency to *power drive system efficiency*
- Updated Test Motor section (Section 5.4)
- Updated utilization voltages
- Updated references
- Updated *motor thermal equilibrium* definition to align with ASHRAE standard

Committee Personnel

Power Drive Systems Standards Technical Committee

Company/Organization	Participant	Voting Role
Voting Organizations		
Danfoss	Joe Horn, Chair	Primary
	Todd Hanson	Alternate
Daikin Applied Americas Inc.	Henry Ernst	Primary
ebm-papst Inc.	Armin Hauer	Primary
Nidec Motor Corporation	Tim Albers	Primary
	Tim Johnson	Alternate
2050 Partners	Nazme Mohsina	Primary
Nonvoting Organization		
Advanced Energy	Michael Lyda	Nonvoter
Greg Kalinyak		AHRI Staff Liaison

Power Drive Systems Standards Technical Committee Scope:

The Power Drive Systems Standards Technical Committee (STC) is responsible for the development and maintenance of AHRI standards and guidelines pertaining to Power drive systems.

Out of scope for this STC are systems/standards that are not related to Power Drive Systems.

Applied Standards Subcommittee

Company/Organization	Participant	Voting Role
Voting Organizations		
Johnson Controls, Inc.	Patrick Marks, Chair	Primary
Carrier Corporation	Jeff deRoos	Primary
Copeland	Jennifer Butsch	Primary
Daikin Applied Americas Inc.	Henry Ernst	Primary
Desert Aire Corp.	Craig Burg	Primary
ebm-papst Inc.	Armin Hauer	Primary
Energistics Laboratory	Brandon Bates	Primary
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Swegon North America Inc.	Tom McDermott	Primary
Trane U.S. Inc.	Darcy Lee	Primary
Karl Best		AHRI Staff Liaison

Applied Standards Subcommittee Scope:

The scope of the Applied Standards Subcommittee is standards and guidelines related to the end products that are part of the AHRI Applied Industry Sector. (The definition of and list of products associated with each sector are found on AHRI's website.)

These lists represent the membership at the time the Standards Technical Committee and Standards Subcommittee were balloted on the final text of this edition. Since that time, changes in the membership may have occurred. Membership on these committees shall not in and of itself constitute an endorsement by the committee members or their employers of any document developed by the committee on which the member serves.

Applied Consensus Body

Participant	Voting Member Role	Interest Category Classification
Joe Pessa Dynamic Air Quality Solutions	Primary	Component Manufacturer
Sebastian Wejchert Swiss Rotors Inc.	Primary	Component Manufacturer
Aniruddh Roy Energy Solutions	Primary	General Interest
Douglas Mischley APV North America Heat Transfer (SPX Flow Inc.)	Primary	Product Manufacturer
Satheesh Kulankara Johnson Controls, Inc.	Primary	Product Manufacturer
Doug Tucker Mitsubishi Electric Cooling & Heating	Primary	Product Manufacturer
James Lee Zhongshan Saiver-Welaire Air Conditioning Equipment Co., Ltd.	Primary	Product Manufacturer
Ronald Balneg California Energy Commission	Primary	Regulatory Agency
Aaron Gunzner Air Movement and Control Association International, Inc.	Primary	Testing Laboratory
Curtis Eichelberger Eichelberger Acoustics LLC	Primary	Testing Laboratory
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PERFORMANCE RATING OF VARIABLE FREQUENCY DRIVES

Section 1. Purpose

This standard establishes definitions, classifications, test requirements, rating requirements, minimum data requirements for *published ratings*, marking and nameplate data, and conformance conditions for *variable frequency drives* (*VFDs*).

Section 2. Scope

2.1 Scope

This standard applies, within the heating, ventilating, air conditioning, and refrigeration (HVACR) context, to 60 Hz *VFDs* used in the control of asynchronous induction motors. The range includes all those found within a building including low voltage (≤ 600 V) and drives that are stand alone, not mechanically integrated into motors.

2.2 Exclusions

This standard does not apply to *VFDs* applied to motors other than those listed in Section 2.1.

Section 3. Definitions

All terms in this document shall follow the standard industry definitions in the ASHRAE Terminology website unless otherwise defined in this section.

3.1 Expression of Provisions

Terms that provide clear distinctions between requirements, recommendations, permissions, options, and capabilities.

3.1.1 "Can" or "cannot"

Express an option or capability.

3.1.2 "May"

Signifies a permission expressed by the document.

3.1.3 "Must"

Indication of unavoidable situations and does not mean that an external constraint referred to is a requirement of the document.

3.1.4 "Shall" or "shall not"

Indication of mandatory requirements to strictly conform to the standard and where deviation is not permitted.

3.1.5 "Should" or "should not"

Indication of recommendations rather than requirements. In the negative form, a recommendation is the expression of potential choices or courses of action that is not preferred but not prohibited.

3.2 Standard Specific Definitions

3.2.1 Carrier Switching Frequency

The frequency where the power output devices of a *VFD* are switched on and off.

3.2.2 Constant Torque (CT)

Applications where the torque requirement of the driven load remains constant or nearly so over the normal speed range of use. Positive-displacement pumps and reciprocating compressors are examples of constant-torque loads.

3.2.3 Fundamental Current

Root mean square (RMS) current of the first harmonic.

3.2.4 Impedance

The measure of the opposition that a circuit presents to current.

3.2.4.1 Source Impedance

The short-circuit power at the point of common coupling (PCC), divided by the rated apparent power of the drive and as defined in Section 3.14 Subsection C of IEC 61000-3-12.

3.2.5 Individual Harmonic Current

The ratio between the RMS value of the individual harmonic and the *fundamental current*.

3.2.6 Motor Insulation Stress

The voltage stress placed on a motor's insulation due to high *peak voltages* and short-rise times that occur when the motor is driven by a *VFD*.

3.2.7 Motor Thermal Equilibrium

The condition when the observed average temperature is in accordance with ASHRAE 222. The temperature rise for winding is measured over a period of thirty minutes, or when the observed motor frame or core temperature is measured over a period of sixty minutes.

3.2.8 Peak Voltage (V_{peak})

The maximum instantaneous voltage measured at a motor's terminals when operated from a *VFD*.

3.2.9 Percent Speed

The ratio of the measured speed to motor nameplate speed, %.

3.2.10 Percent Torque

The ratio of the measured torque to the rated motor torque, %.

3.2.11 Power Drive System Efficiency

Ratio of the output power from the motor to the input power of the *VFD* including motor and *VFD* losses.

3.2.12 Power Line Harmonics

Components of the power line voltage and current at the input of the *VFD* that are integer multiples of the fundamental sinusoidal frequency of the power source (example 60 Hz).

3.2.13 Published Rating

A rating of the assigned values of those performance characteristics, under stated *rating conditions*, where a unit can be chosen to fit the application. These values apply to all units of the same nominal size and type (identification) produced by the same manufacturer. This includes the rating of all performance characteristics shown on the unit or published in specifications, advertising, or other literature controlled by the manufacturer, at stated *rating conditions*.

3.2.13.1 Application Rating

A rating based on tests performed at *rating conditions* other than *standard rating conditions*.

3.2.13.2 Standard Rating

A rating based on tests performed at *standard rating conditions*.

3.2.14 Rating Conditions

Any set of operating conditions where a single level of performance results and that causes only that level of performance to occur such as line voltage or ambient temperature).

3.2.14.1 Standard Rating Conditions

Rating conditions used as the basis of comparison for performance characteristics.

3.2.15 Supply Voltage (V_s)

The line to line input voltage to the equipment at time of testing.

3.2.16 System Loss ($Loss_{sys}$)

The combination of electrical and mechanical losses represented by the difference between input power to the drive and output power from the motor.

3.2.17 Total Harmonic Current Distortion (THD_i)

A measure of power line current distortion that sums the contributions of the *individual harmonic currents*.

3.2.18 Variable Frequency Drive (VFD)

A power electronic device that regulates the speed of an alternating current (AC) motor by adjusting the frequency and the voltage of the electrical power supplied to the motor.

3.2.19 Variable Torque (VT)

Applications where the torque requirement of the driven load is reduced as speed is reduced. Examples include centrifugal fans and pumps.

3.2.20 Voltage Rise Time

The time required for the voltage to increase, measured at the motor terminals when operated from a *VFD*, from 10% to 90% of the *VFD* steady state DC bus voltage.

Section 4. Classifications.

VFDs falling within the scope of this standard are defined in Table 1.

Table 1 Voltage and Power Classifications

VFD Voltage Rating, V	200 to 240	380 to 480	550 to 600
Supply Voltage V_s, V	208	460	575
VFD Power, kW (hp)	0.75 (1.0)	0.75 (1.0)	0.75 (1.0)
	1.50 (2.0)	1.50 (2.0)	1.50 (2.0)
	2.25 (3.0)	2.25 (3.0)	2.25 (3.0)
	3.75 (5.0)	3.75 (5.0)	3.75 (5.0)
	5.60 (7.5)	5.60 (7.5)	5.60 (7.5)
	7.45 (10.0)	7.45 (10.0)	7.45 (10.0)
	11.20 (15.0)	11.20 (15.0)	11.20 (15.0)
	14.90 (20.0)	14.90 (20.0)	14.90 (20.0)
	18.65 (25.0)	18.65 (25.0)	18.65 (25.0)
	—	22.35 (30.0)	22.35 (30.0)
	—	29.80 (40.0)	29.80 (40.0)
	—	37.30 (50.0)	37.30 (50.0)
	—	44.75 (60.0)	44.75 (60.0)
	—	—	55.90 (75.0)

Note:

- Nominal horsepower ranges are determined for applied motors that fall within Section 430.250 of the *NEC Handbook* full load current ratings table in amps.

Section 5. General Test Requirements

5.1 Test Requirements

VFDs shall be tested in accordance with the procedures set forth in ASHRAE 222 and in this section.

5.2 Electrical Conditions

Tests shall be performed at the voltages listed in Table 1 in accordance with the rated *supply voltage* (V_s) and frequency of the motor drive systems unless otherwise specified in this standard.

Because motor drive systems with a 230V rating are commonly operated at a utilization voltage of 208V, then all 230V rated motors shall be tested at 208V Class.

5.3 Power Source Requirements

Follow power source requirements outlined in ASHRAE 222.

5.4 Test Motor

The motor selected for testing shall be a NEMA Premium™ MG 1 design B four-pole matching the *VFD* voltage and power.

5.5 Speed/Load Testing Points

Table 2 lists the four points for speed/load combinations where measurements are taken for *power drive system efficiency*. *Motor insulation stres*s and *power line harmonics* shall be tested at 100% speed and torque. Details of the procedure for each test are presented in ASHRAE 222.

Table 2 Speed/Torque Test Points for Power Drive System Efficiency Test

	Test Point	Percent Speed	Percent Torque
Variable Torque	1	40%	16%
	2	50%	25%
	3	75%	56%
	4	100%	100%
Constant Torque	1	40%	100%
	2	50%	100%
	3	75%	100%
	4	100%	100%

5.6 Drive Settings

The *VFD* shall be set up in accordance with the manufacturer's instructional and operational manual included with the product. Manufacturers shall provide a parameter set-up summary including as a minimum:

1) *Carrier switching frequency*, Hz
2) Max frequency, Hz
3) Max output voltage, V
4) Motor control method such as V/f ratio or sensor less vector
5) Load profile setting such as *CT* or *variable torque*
6) Saving energy mode (if used)

One summary sheet shall be supplied for *CT* and a separate summary sheet for *variable torque* testing. There shall not be deviation from the resulting settings, such as *carrier switching frequency* or load torque curves, for the purpose of optimizing test results. For example, parameters dealing with carrier frequency shall be unchanged from one test to the other.

5.7 Motor Wires

The three load current carrying conductors between the *VFD* and motor shall be part of a shielded cable intended for *VFD*/motor applications. This cable shall be a symmetrical type having copper conductors, type XHHW with two spiral insulations on the current carrying conductors, three smaller ground wires, and an overall jacket made of type XLPE insulation. The cable shall be sized in accordance with Table 3. When a cable with the current carrying conductors in the sizes shown in Table 3 is not used, the next larger size shall be used.

Table 3 VFD to Motor Conductor Sizes (AWG)

VFD Power, kW (hp)	Supply Voltage (Vs), V					
	208		460		575	
	Wire Gauge (AWG)	Diameter, mm	Wire Gauge (AWG)	Diameter, mm	Wire Gauge (AWG)	Diameter, mm
0.75 (1)	14	1.63	14	1.63	14	1.63
1.5 (2)	14	1.63	14	1.63	14	1.63
2.25 (3)	14	1.63	14	1.63	14	1.63
3.75 (5)	12	2.05	14	1.63	14	1.63
5.6 (7.5)	10	2.59	14	1.63	14	1.63
7.45 (10)	8	3.26	14	1.63	14	1.63
11.2 (15)	6	4.11	10	2.59	12	2.05
14.9 (20)	4	5.19	8	3.26	10	2.59
18.65 (25)	3	5.83	8	3.26	8	3.26
22.35 (30)	2	6.54	6	4.11	8	3.26
29.8 (40)	—	—	4	5.19	6	4.11
37.3 (50)	—	—	3	5.83	4	5.19
44.75 (60)	—	—	2	6.54	3	5.83
55.9 (75)	—	—	—	—	2	6.54

5.8 Motor Thermal Equilibrium

Apply the rated voltage and frequency to the drive and full load torque and 60 Hz to the motor until the *motor thermal equilibrium* is reached as defined in Section 3.2.7.

5.9 Ambient Temperatures

The ambient temperature, as measured by ASHRAE 41.1, at the *VFD* vicinity (1 m away and not in the exhaust air stream of the *VFD*) during testing shall be maintained within the range of 21°C to 27°C.

5.10 Reference Equations

The following equations are used in ASHRAE 222.

5.10.1 Total Harmonic Current Distortion (THD_i)

The *total harmonic current distortion* (THDi) shall be calculated using Equation 1:

$$THD_i = \sqrt{\sum_{n=2}^{50} \left(\frac{I_n}{I_1}\right)^2} \cdot 100 \qquad \textbf{1}$$

Where:

I_1 = *Fundamental current*

I_n = The value of an *individual harmonic current*, A (amps)

THD_i = *Total harmonic current distortion*, %

5.10.2 Output power (P_{out}) (SI)

The output power (P_{out}) in kW shall be calculated using Equation 2:

$$P_{out} = \frac{\tau \cdot \omega}{K} \quad \textbf{2}$$

Where:

P_{out} = Output power, kW
K = 9549 N · m rpm / kW
τ = Torque, N · m
ω = Shaft rotational speed, rpm

5.10.3 Output power (P_{out}) (I-P)

The output power (P_{out}) in hp shall be calculated using Equation 3:

$$P_{out} = \frac{\tau \cdot \omega}{K} \quad \textbf{3}$$

Where:

P_{out} = Output power, hp
K = 5252 ft · lb rpm / hp
τ = Torque, ft · lb
ω = Shaft rotational speed, rpm

5.10.4 Power Drive System Efficiency (η_{sys}) (SI)

The *power drive system efficiency* (η_{sys}) shall be calculated using Equation 4:

$$\eta_{sys} = \frac{P_{out}}{P_{in}} . 100 \quad \textbf{4}$$

Where:

P_{in} = Input power, kW
P_{out} = Output power, kW
η_{sys} = *Power drive system efficiency*, %

5.10.5 Power Drive System Efficiency (η_{sys}) (I-P)

The *power drive system efficiency* (η_{sys}) shall be calculated using Equation 5:

$$\eta_{sys} = \frac{P_{out}}{P_{in}} . 100 \quad \textbf{5}$$

Where:

P_{in} = Input power, hp

P_{out} = Output power, hp

η_{sys} = *Power drive system efficiency*, %

5.10.6 Rated motor torque (τ_{mtr}) (SI)

The rated motor torque (τ_{mtr}) shall be calculated using Equation 6:

$$\tau_{mtr} = \frac{P_{mtr} \cdot \mathrm{K}}{\omega} \quad \textbf{6}$$

Where:

K = 9549 N · m rpm / kW

P_{mtr} = Motor nameplate output power, kW

τ_{mtr} = Rated motor torque, N · m

ω_{mtr} = Motor nameplate speed, rpm

5.10.7 Rated motor torque (τ_{mtr}) (IP)

The rated motor torque (τ_{mtr}) shall be calculated using Equation 7:

$$\tau_{mtr} = \frac{P_{mtr} \cdot \mathrm{K}}{\omega} \quad \textbf{7}$$

Where:

K = (5252 ft · lb rpm / hp)

P_{mtr} = Motor nameplate output power, hp

τ_{mtr} = Rated motor torque, ft · lb

ω_{mtr} = Motor nameplate speed, rpm

5.10.8 Impedance (Z):

The *impedance* (Z) shall be calculated using Equation 8:

$$\mathrm{Z} = \frac{\mathrm{Irated}_{VFD}}{\mathrm{Iscc}_{source}} \cdot 100 \quad \textbf{8}$$

Where:

Irated_{VFD} = VFD rated current, A

Iscc_{source} = Source short circuit current, A

Z = *Impedance*, %

5.10.9 System Losses of the Power Drive System Efficiency

The *system losses* of the *power drive system efficiency* shall be calculated using Equation 9:

$$\mathrm{Loss}_{sys} = 100 - \eta_{sys} \quad \textbf{9}$$

Where:

Loss_{sys} = *System losses*, %

η_{sys} = *Power drive system efficiency*, %

Section 6. Rating Requirements

6.1 Published Ratings

Published ratings shall include *power drive system efficiency*, *motor insulation stress*, and *power line harmonics* as follows:

- *Power drive system efficiency* shall be expressed in terms of % and stated to the nearest 0.5 %.
- *Motor insulation stress* shall be expressed in terms of *peak voltage* and *voltage rise time* stated to the nearest 10 V_{peak} and 0.01 µs, respectively.
- THD_i shall be expressed in terms of % and stated to the nearest 1%.

6.2 Standard Ratings

All *standard ratings* shall be based on combinations of *VFDs* and motors where the motor voltage and horse power are analogous to the *VFD* voltage and horse power in Table 1 and shall be verified by tests in accordance with Section 5.

6.3 Application Ratings

Ratings for non-standard combinations of *VFDs* and motors shall be based on data determined by test requirements prescribed in Section 5 and conducted in accordance with the method of testing described in ASHRAE 222.

Note: Individual harmonics are not covered by this standard. See IEC 61000-4-7, IEEE 519, and ISO/IEC 17025.

6.4 Tolerances

To comply with this standard, measured results of any single sample production audit shall be within the following tolerances of the *standard rating*.

6.4.1 Power Drive System Efficiency

The *system losses* of the measured result of the *power drive system efficiency* rating shall be less than 120% of the *system losses* of the published *power drive system efficiency* rating in percent. For example, if the published *power drive system efficiency* rating is 90%, the *system losses* of the published *power drive system efficiency* is 10% as determined using Equation 6. The measured result of the *power drive system efficiency* rating shall be greater than 88% or the *system losses* of the measured result of the *power drive system efficiency* rating shall be less than 12%.

6.4.2 Motor Insulation Stress

The measured result of *peak voltage* rating shall be less than 110% of the published *peak voltage* rating and the measured result of the *voltage rise time* rating shall not be less than 0.03 µs below the published *voltage rise time* rating. For example, if the *peak voltage* rating is 1,000V, the measured result of the *peak voltage* rating shall be less than 1,100V. If the published *voltage rise time* rating is 0.10 µs, the measured result of the *voltage rise time* rating shall be greater than 0.07 µs.

6.4.3 Power Line Harmonics

The measured result of the *THDi* rating at maximum load ratings shall be less than 2% the published value. For example, if the published current distortion at the *THDi* is 40%, the measured shall be less than 42%. All *power line harmonics* shall be recorded with a *source impedance* of 1%.

Section 7. Minimum Data Requirements for Published Ratings

7.1 Minimum Data Requirements for Published Ratings

As a minimum, *published ratings* shall include *standard ratings*. The following information shall be published for all *standard ratings*:

1) Power Classification, hp, as determined by Table 1
2) *Supply voltage* (V_s), V, as determined by Table 1
3) *Power drive system efficiency*, %, as determined by Section 5.10.3 and measured at points defined in Table 2
4) *Motor insulation stress peak voltage* (V_{peak}), V, as defined by Section 3.2.8

5) *Motor insulation stress voltage rise time*, μs, as defined by Section 3.2.20

6) *Power line harmonics, total harmonic current distortion*, %, as defined by Section 3.2.17 and Section 5.10.1

7.2 Rating Claims

All claims to ratings within the scope of this standard shall include the statement "Rated in accordance with AHRI Standard 1210 (SI/I-P)". All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of AHRI Standard 1210 (SI/I-P)". *Application ratings* shall include a statement of the conditions under which the ratings apply.

Section 8. Marking and Nameplate Data

As a minimum, the nameplate shall display the manufacturer's name, model designation, and electrical characteristics. Nameplate voltages for 60 Hz systems shall include one or more of the equipment nameplate voltage ratings shown in Table 1 of AHRI 110.

Section 9. Conformance Conditions

While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within the standard's Purpose (Section 1) and Scope (Section 2) unless such product claims meet all the requirements of the standard and all of the testing and rating requirements are measured and reported in complete compliance with the standard. Any product that has not met all the requirements of the standard cannot reference, state, or acknowledge the standard in any written, oral, or electronic communication.

APPENDIX A. REFERENCES – NORMATIVE

Listed here are all standards, handbooks, and other publications essential to the formation and implementation of the standard. All references in this appendix are considered as part of the standard.

A.1. AHRI Standard 110-2016, *Air-Conditioning and Refrigerating Equipment Nameplate Voltages*, 2016, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A.2. ANSI/ASHRAE Standard 222-2018, *Standard Method of Test for Electrical Power Drive Systems*, 2018, ASHRAE, 180 Technology Parkway NW, Peachtree Corners, Georgia 30092, USA.

A.3. ANSI/ASHRAE Standard 41.1-2020, *Standard Method for Temperature Measurement*, 2020, ASHRAE, 180 Technology Parkway NW, Peachtree Corners, Georgia 30092, USA.

A.4. ASHRAE Terminology. ASHRAE. Accessed July 13, 2023. https://www.ashrae.org/technical-resources/free-resources/ashrae-terminology.

A.5. IEC 60038-2009, *IEC Standard Voltages*, 2009, International Electrotechnical Commission, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

A.6. IEC 61000-3-2-2018, *Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*, 2018, International Electrotechnical Commission, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

A.7. IEC 61000-3-12-2011, *Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and ≤75 A per phase*, 2011, International Electrotechnical Commission, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

A.8. IEEE 141-1993, *IEEE Recommended Practice for Electric Power Distribution for Industrial Plants*, 1993, IEEE, 3 Park Avenue, 17th Floor, New York, NY 10016-5997, USA.

A.9. *National Electrical Code Handbook (NEC)*, 2023, National Fire Prevention Association, 1 Batterymarch Park, Quincy, Massachusetts, 02169-7471, USA.

A.10. NEMA MG 1-2021, *Motors and Generators*, 2021, National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1752, Rosslyn, Virginia 22209, USA.

APPENDIX B. REFERENCES – INFORMATIVE

Listed here are standards, handbooks, and other publications which may provide useful information and background but are not considered essential. References in this appendix are not considered part of the standard.

B.1. IEC 61000-4-7-2002+AMD1 (2008), *Testing and measurement techniques – General guide on harmonics and inter harmonics measurements and instrumentation, for power supply systems and equipment connected thereto*, 2002, International Electrotechnical Commission, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

B.2. IEEE 519-2022, *IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems*, 2022, IEEE, 3 Park Avenue, 17th Floor, New York, NY 10016-5997, USA.

B.3. ISO/IEC 17025:2017, *General Requirements for the Competence of Testing and Calibration Laboratories*, 2017, International Organization for Standardization, ISO Central Secretariat, Chemin de Blandonnet 8, CP 401 – 1214 Vernier, Geneva, Switzerland.