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To: Current Holders of ANSI C84.1-1995
From: NEMA Communications Department
Date: June 13, 2005
Subject: Reaffirmation of ANSI C84.1-1995

The ANSI Board of Standards Review reaffirmed ANSI C84.1-1995 (R2001), "*Electric Power Systems and Equipment-Voltage Ratings (60 Hertz).”*

The new designator for this standard is ANSI C84.1-1995 (R2005), "*Electric Power Systems and Equipment-Voltage Ratings (60 Hertz).”*

Please insert the attached revised title page into your standard.

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**ANSI C84.1-1995 (R2005)**

American National Standard

# Electric Power Systems and Equipment-Voltage Ratings (60 Hertz)

Secretariat:

**National Electrical Manufacturers Association**

Approved as an
**American National Standards Institute, Inc.**

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## Foreword (This Foreword is not part of American National Standard C84.1-1995)

This standard supersedes American National Standard for Electric Power Systems and Equipment - Voltage Ratings (60 Hz), ANSI C84.1-1989. Standard nominal system voltages and voltage ranges shown in the previous standard remain unchanged in this standard. Revisions have been made to the text of clauses 1.2(1), 1.2(6), 2.1.2. 1, 2.1.2.2, 2.3, 3.2(2) and to the equation in D3. As in the previous standard, reference information on extra-high voltage conforms to *American National Standard for Power Systems - Alternating-Current Electrical Systems and Equipment Operating at Voltages above 230 kV Nominal - Preferred Voltage Ratings*, ANSI C92.2-1987.

In 1942, the Edison Electric Institute published the document *Utilization Voltage Standardization Recommendations*, EEI Pub. No. J-8. Based on that early document, a joint report was issued in 1949 by the Edison Electric Institute (EEI Pub. No. R6) and the National Electrical Manufacturers Association (NEMA Pub. No. 117). This 1949 publication was subsequently approved as American National Standard EEI-NEMA Preferred Voltage Ratings for AC Systems and Equipment, ANSI C84.1-1954.

American National Standard C84.1-1954 was a pioneering effort in its field. It not only made carefully considered recommendations on voltage ratings for electric systems and equipment, but also contained a considerable amount of much-needed educational material.

After ANSI C84.1-1954 was prepared, the capacities of power supply systems and customers' wiring systems increased and their unit voltage drops decreased. New utilization equipment was introduced and power requirements of individual equipment were increased. These developments exerted an important influence both on power systems and equipment design and on operating characteristics.

In accordance with American National Standards Institute policy requiring periodic review of its standards, American National Standards Committee C84 was activated in 1962 to review and revise American National Standard C84.1-1954, the Edison Electric Institute and National Electrical Manufacturers Association being named cosponsors for the project. Membership on the C84 Committee represented a wide diversity of experience in the electrical industry. To this invaluable pool of experience were added the findings of the following surveys conducted by the committee:

(1) A comprehensive questionnaire on power system design and operating practices, including measurement of actual service voltages. (Approximately 65,000 readings were recorded, coming from all parts of the United States and from systems of all sizes, whether measured by number of customers or by extent of service areas.)
(2) A sampling of single-phase distribution transformer production by kilovolt-amperes and primary voltage ratings to determine relative uses of medium voltages.
(3) A survey of utilization voltages at motor terminals at approximately twenty industrial locations

The worth of any standard is measured by the degree of its acceptance and use. After careful consideration, and in view of the state of the art and the generally better understanding of the factors involved, the C84 Committee concluded that a successor standard to ANSI C84.1-1954 should be developed and published in a much simplified form, thereby promoting ease of understanding and hence its acceptance and use. This resulted in the approval and publication of American National Standard C84.1-1970, followed by its supplement, ANSI C84.1a-1973, which provides voltage limits established for the 600-volt nominal system voltage.

The 1977 revision of the standard incorporated an expanded Foreword that provided a more complete history of this standard’s development. The 1970 revision included a significantly more useful Table 1 (by designating “preferred” system voltages), the 1977 revision provided further clarity, and the 1982 revision segmented the system voltages into the various voltage classes.



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Suggestions for improvement of the standard will be welcome. They should be sent to the National Electrical Manufacturers Association, 1300 N. 17th Street, Rosslyn, Virginia 22209.

This standard was processed and approved for submittal to ANSI by Accredited Standards Committee on Preferred Voltage Ratings for AC Systems and Equipment, C84. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the C84 Committee had the following members:

**Daniel J. Ward, Chairman**
Walter J. Ros, Vice-Chairman
Lawrence F. Miller, Secretary

| *Organizations Represented* | *Name of Representative* |
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| Accredited Standards Committee on Industrial Gas Equipment, Installations and Utilization, Z83 (Liaison) | Gordon E. Willert |
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# for Electric Power Systems and Equipment— Voltage Ratings (60 Hertz)

## 1 Scope and purpose

### 1.1 Scope

This standard establishes nominal voltage ratings and operating tolerances for 60-hertz electric power systems above 100 volts and through 230 kilovolts. It also makes recommendations to other standardizing groups with respect to voltage ratings for equipment used on power systems and for utilization devices connected to such systems.

NOTE—For completeness, information on extra-high voltage systems (345 kilovolts and higher) from *American National Standard for Power Systems – Alternating-Current Electrical Systems and Equipment Operating at Voltages above 230 kV Nominal – Preferred Voltage Ratings*, ANSI C92.2-1987, is also included as a footnote to table 1.

### 1.2 Purpose

The purposes of this standard are to:

(1) Promote a better understanding of the voltages associated with power systems and utilization equipment to achieve overall practical and economical design and operation
(2) Establish uniform nomenclature in the field of voltages
(3) Promote standardization of nominal system voltages and ranges of voltage variations for operating systems
(4) Promote standardization of equipment voltage ratings and tolerances
(5) Promote coordination of relationships between system and equipment voltage ratings and tolerances
(6) Provide a guide for future development and design of equipment to achieve the best possible conformance with the needs of the users
(7) Provide a guide, with respect to choice of voltages, for new power system undertakings and for changes in old ones

## 2 Voltage ratings for 60-hertz electric power systems

### 2.1 Definitions

**2.1.1 system or power system:** The connected system of power apparatus used to deliver electric power from the source to the utilization device. Portions of the system may be under different ownership, such as that of a supplier or a user.

### 2.1.2 System voltage terms

**2.1.2.1 system voltage:** The root-mean-square (rms) phase-to-phase voltage of a portion of an alternating-current electric system. Each system voltage pertains to a portion of the system that is bounded by transformers or utilization equipment. (All voltages hereafter are rms phase-to-phase or phase-to-neutral voltages.)

**2.1.2.2 nominal system voltage:** The voltage by which a portion of the system is designated, and to which certain operating characteristics of the system are related. Each nominal system voltage pertains to a portion of the system bounded by transformers or utilization equipment.



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**2.1.2.3 maximum system voltage:** The highest system voltage that occurs under normal operating conditions, and the highest system voltage for which equipment and other components are designed for satisfactory continuous operation without derating of any kind. In defining maximum system voltage, voltage transients and temporary overvoltages caused by abnormal system conditions such as faults, load rejection, and the like are excluded. However, voltage transients and temporary overvoltages may affect equipment operating performance and are considered in equipment application.

**2.1.2.4 service voltage:** The voltage at the point where the electrical system of the supplier and the electrical system of the user are connected.

**2.1.2.5 utilization voltage:** The voltage at the line terminals of utilization equipment.

**2.1.2.6 nominal utilization voltage:** The voltage rating of certain utilization equipment used on the system.

The nominal system voltages contained in table 1 apply to all parts of the system, both of the supplier and of the user. The ranges are given separately for service voltage and for utilization voltage, these normally being at different locations. It is recognized that the voltage at utilization points is normally somewhat lower than at the service point. In deference to this fact, and the fact that integral horsepower motors, or air conditioning and refrigeration equipment, or both, may constitute a heavy concentrated load on some circuits, the rated voltages of such equipment and of motors and motor-control equipment are usually lower than nominal system voltage. This corresponds to the range of utilization voltages in table 1. Other utilization equipment is generally rated at nominal system voltage.

### 2.1.3 System voltage classes

**2.1.3.1 low voltage:** A class of nominal system voltages 1000 volts or less.

**2.1.3.2 medium voltage:** A class of nominal system voltages greater than 1000 volts and less than 100 000 volts.

**2.1.3.3 high voltage:** A class of nominal system voltages equal to or greater than 100 000 volts and equal to or less than 230 000 volts.

## 2.2 Selection of nominal system voltages

When a new system is to be built or a new voltage level introduced into an existing system, one (or more) of the preferred nominal system voltages shown in boldface type in table 1 should be selected. The logical and economical choice for a particular system among the voltages thus distinguished will depend upon a number of factors, such as the character and size of the system.

Other system voltages that are in substantial use in existing systems are shown in lightface type. Economic considerations will require that these voltages continue in use and in some cases may require that their use be extended; however, these voltages generally should not be utilized in new systems or in new voltage levels in existing systems.

The 4160-volt, 6900-volt, and 13 800-volt three-wire systems are particularly suited for industrial systems that supply predominantly polyphase loads, including large motors, because these voltages correspond to the standard motor ratings of 4000 volts, 6600 volts, and 13 200 volts, as is explained further in 2.1.2.6. Two of these system voltages are shown in boldface type to indicate that they should be used for this purpose. It is not intended to recommend the use of these system voltages for utility primary distribution, for which four-wire voltages of 12 470Y/7200 volts or higher should be used.

## 2.3 Explanation of voltage ranges



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For any specific nominal system voltage, the voltages actually existing at various points at various times on any power system, or on any group of systems, or in the industry as a whole, usually will be distributed within the maximum and minimum voltages shown in table 1. The design and operation of power systems and the design of equipment to be supplied from such systems should be coordinated with respect to these voltages so that the equipment will perform satisfactorily in conformance with product standards throughout the range of actual utilization voltages that will be encountered on the system. To further this objective, this standard establishes, for each nominal system voltage, two ranges for service voltage and utilization voltage variations, designated as Range A and Range B, the limits of which are given in table 1. These limits shall apply to sustained voltage levels and not to momentary voltage excursions that may remit from such causes as switching operations, motor starting currents, and the like.

### 2.4 Application of voltage ranges

#### 2.4.1 Range A—service voltage

Electric supply systems shall be so designed and operated that most service voltages will be within the limits specified for Range A. The occurrence of service voltages outside of these limits should be infrequent.

#### 2.4.2 Range A—utilization voltage

User systems shall be so designed and operated that with service voltages within Range A limits, most utilization voltages will be within the limits specified for this range.

Utilization equipment shall be designed and rated to give fully satisfactory performance throughout this range.

#### 2.4.3 Range B—service and utilization voltages

Range B includes voltages above and below Range A limits that necessarily result from practical design and operating conditions on supply or user systems, or both. Although such conditions are a part of practical operations, they shall be limited in extent, frequency, and duration. When they occur, corrective measures shall be undertaken within a reasonable time to improve voltages to meet Range A requirements.

Insofar as practicable, utilization equipment shall be designed to give acceptable performance in the extremes of the range of utilization voltages, although not necessarily as good performance as in Range A.

It should be recognized that because of conditions beyond the control of the supplier or user, or both, there will be infrequent and limited periods when sustained voltages outside Range B limits will occur. Utilization equipment may not operate satisfactorily under these conditions, and protective devices may operate to protect the equipment.

When voltages occur outside the limits of Range B, prompt, corrective action shall be taken. The urgency for such action will depend upon many factors, such as the location and nature of the load or circuits involved, and the magnitude and duration of the deviation beyond Range B limits.



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# 3 Voltage ratings for 60-hertz electric equipment

## 3.1 General

Voltage ratings and other characteristics of the various classes of 60-hertz electric equipment are established in other standards. A partial list of these standards is given in Annex E.

For the principal types of electric utilization equipment, nameplate voltage ratings and the corresponding nominal system voltages to which they are applicable are listed in tables C1, C2, and C3 in Annex C. Detailed tables for electric equipment other than utilization equipment are not included. Those requiring detailed information on voltage ratings of these other types of equipment should consult the appropriate standards or the manufacturers to ensure proper application.

Review of the nameplate voltage ratings in Annex C and in current equipment standards listed in Annex E indicates many inconsistencies in the relationships among equipment nameplate ratings and between these ratings and nominal system voltages to which the equipment is applicable. For 120-volt base systems, equipment voltage ratings are variously based upon 115 volts, 120 volts, and 125 volts. The same one of these bases is not always used consistently for all equipment of the same general class.

This standard includes information, as given in Annex D, to assist in the understanding about the effects of unbalanced voltages on utilization equipment applied in polyphase systems.

## 3.2 Recommendation

Insofar as practicable, whenever electric equipment standards are revised:

(1) Nameplate voltage ratings should be changed as needed in order to provide a consistent relationship between the ratings for all equipment of the same general class and the nominal system voltage on the portion of the system on which they are designed to operate
(2) The voltage ranges for which equipment is designed should be changed as needed in order to be in accordance with the ranges shown in table 1.

The voltage ratings in each class of utilization equipment should be either the same as the nominal system voltages or less than the nominal system voltages by the approximate ratio of 115 to 120.



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## Table 1 – Standard nominal system voltages and voltage ranges (Preferred system voltages in bold-face type)

| VOLTAGE CLASS | Nominal System Voltage (Note a) | | | Nominal Utilization Voltage (Note i) | Voltage Range A (Note b) | | | Voltage Range B (Note b) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Maximum | Minimum | | Maximum | Minimum | |
| | Two-wire | Three-wire | Four-wire | Two-wire Three-wire Four-wire | Utilization and Service Voltage (Note c) | Service Voltage | Utilization Voltage | Utilization and Service Voltage | Service Voltage | Utilization Voltage |
| Low Voltage (Note 1) | **Single-Phase Systems** | | | | | | | | | |
| | 120 | | | **115** | 126 | 114 | 110 | 127 | 110 | 106 |
| | | **120/240** | | **115/230** | **126/252** | **114/228** | **110/220** | **127/254** | **110/220** | **106/212** |
| | **Three-Phase Systems** | | | | | | | | | |
| | | | **208Y/120** | **200** | **218Y/126** | **197Y/114** | **191Y/110** | **220Y/127** | **191Y/110** | **184Y/106** |
| | | | (Note d) | | | | | | (Note 2) | (Note 2) |
| | | | **240/120** | **230/115** | **252/126** | **228/114** | **220/110** | **254/127** | **220/110** | **212/106** |
| | | 240 | | **230** | 252 | 228 | 220 | 254 | 220 | 212 |
| | | | **480Y/277** | **460** | **504Y/291** | **456Y/263** | **440Y/254** | **508Y/293** | **440Y/254** | **424Y/245** |
| | | **480** | | **460** | **504** | **456** | **440** | **508** | **440** | **424** |
| | | 600 | | **575** | 630 | 570 | 550 | 635 | 550 | 530 |
| | | (Note e) | | | (Note e) | | | (Note e) | | |
| Medium Voltage | | 2400 | | | 2520 | 2340 | 2160 | 2540 | 2280 | 2080 |
| | | | 4160Y/2400 | | 4370/2520 | 4050Y/2340 | 3740Y/2160 | 4400Y/2540 | 3950Y/2280 | 3600/2080 |
| | | **4160** | | | **4370** | **4050** | **3740** | **4400** | **3950** | **3600** |
| | | 4800 | | | 5040 | 4680 | 4320 | 5080 | 4560 | 4160 |
| | | 6900 | | | 7240 | 6730 | 6210 | 7260 | 6560 | 5940 |
| | | | 8320Y/4800 | | 8730Y/5040 | 8110Y/4680 | | 8800Y/5080 | 7900Y/4560 | |
| | | | **12000Y/6930** | | 12600Y/7270 | 11700Y/6760 | | 12700Y/7330 | 11400Y/6580 | (Note f) |
| | | | **12470Y/7200** | | **13090Y/7560** | **12160Y/7020** | (Note f) | **13200Y/7620** | **11850Y/6840** | |
| | | | 13200Y/7620 | | **13860Y/8000** | **12870Y/7430** | | **13970Y/8070** | **12504Y/7240** | |
| | | | 13800/7970 | | 14490Y/8370 | 13460Y/7770 | | 14520Y/8380 | 13110Y/7570 | |
| | | **13800** | | | **14490** | **13460** | **12420** | **14520** | **13110** | **11880** |
| | | | 20780Y/12000 | | 21820Y/12600 | 20260Y/11700 | | 22000Y/12700 | 19740Y/11400 | |
| | | | 22860Y/13200 | | 24000Y/13860 | 22290Y/12870 | | 24200Y/13970 | 21720Y/12540 | (Note f) |
| | | 23000 | | | 24150 | 22430 | (Note f) | 24340 | 21850 | |
| | | | **24940Y/14400** | | **26190Y/15120** | **24320Y/14040** | | **26400Y/15240** | **23690Y/13680** | |
| | | | **34500Y/19920** | | **36230Y/20920** | **33640Y/19420** | | **36510Y/21080** | **32780Y/18930** | |
| | | 34500 | | | 36230 | 33640 | | 36510 | 32780 | |
| | | | | | Maximum Voltage | | | | | |
| | | 46000 | | | (Note g) 48300 | | | | | |
| | | **69000** | | | **72500** | | | | | |
| High Voltage | | **115000** | | | **121000** | | | | | |
| | | **138000** | | | **145000** | | | | | |
| | | 161000 | | | 169000 | | | | | |
| | | **230000** | | | **242000** | | | | | |
| | | | (Note h) | | | | | | | |
| Extra-High Voltage | | **345000** | | | **362000** | | | | | |
| | | **500000** | | | **550000** | | | | | |
| | | **765000** | | | **800000** | | | | | |
| Ultra-High Voltage | | **1100000** | | | **1200000** | | | | | |

Notes: (1) Minimum utilization voltages for 120-600 volt circuits not supplying lighting loads are as follows:

| | Nominal System Voltage | Range A | Range B |
|---|---|---|---|
| | 120 | 108 | 104 |
| | 120/240 | 108/216 | 104/208 |
| (Note 2) | 208Y/120 | 187Y/108 | 180Y/104 |
| | 240/120 | 216/108 | 208/104 |
| | 240 | 216 | 208 |
| | 480Y/277 | 432Y/249 | 416Y/240 |
| | 480 | 432 | 416 |
| | 600 | 540 | 520 |

(2) Many 220 volt motors were applied on existing 208 volt systems on the assumption that the utilization voltage would not be less than 187 volts. Caution should be exercised in applying the Range B minimum voltages of table 1 and note (1) to existing 208 volt systems supplying such motors

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NOTES

(a) Three-phase three-wire systems are systems in which only the three-phase conductors are carried out from the source for connection of loads. The source may be derived from any type of three-phase transformer connection, grounded or ungrounded. Three-phase four-wire systems are systems in which a grounded neutral conductor is also carried out from the source for connection of loads. Four-wire systems in table 1 are designated by the phase-to-phase voltage, followed by the letter Y (except for the 240/120-volt delta system), a slant line, and the phase-to-neutral voltage. Single-phase services and loads may be supplied from either single-phase or three-phase systems. The principal transformer connections that are used to supply single-phase and three-phase systems are illustrated in Annex A.

(b) The voltage ranges in this table are illustrated in Annex B.

(c) For 120-600-volt nominal systems, voltages in this column are maximum service voltages. Maximum utilization voltages would not be expected to exceed 125 volts for the nominal system voltage of 120, nor appropriate multiples thereof for other nominal system voltages through 600 volts.

(d) A modification of this three-phase, four-wire system is available as a 120/208Y-volt service for single-phase, three-wire, open-wye applications.

(e) Certain kinds of control and protective equipment presently available have a maximum voltage limit of 600 volts; the manufacturer or power supplier or both should be consulted to assure proper application.

(f) Utilization equipment does not generally operate directly at these voltages. For equipment supplied through transformers, refer to limits for nominal system voltage of transformer output.

(g) For these systems Range A and Range B limits are not shown because, where they are used as service voltages, the operating voltage level on the user's system is normally adjusted by means of voltage regulations to suit their requirements.

(h) Standard voltages are reprinted from American National Standard C92.2-1987 for convenience only.

(i) Nominal utilization voltages are for low-voltage motors and control. See Annex C for other equipment nominal utilization voltages (or equipment nameplate voltage ratings.)



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## Annex A
(informative)
## Principal transformer connections to supply the system voltages of table 1
## (See figure A1)

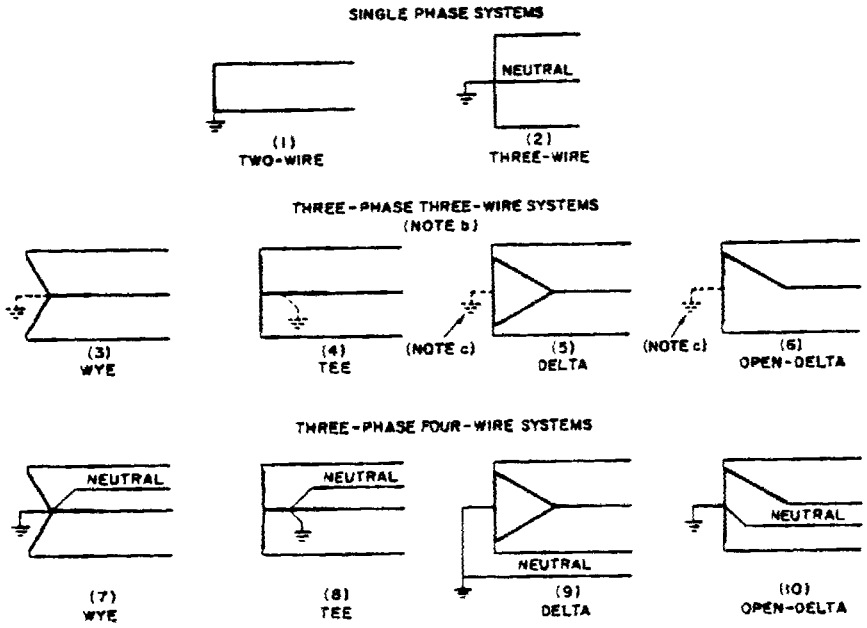


**Figure A1**

NOTES
(a) The above diagrams show connections of transformer secondary windings to supply the nominal system voltages of table 1. Systems of more than 600 volts are normally three-phase and supplied by connections (3), (5) ungrounded, or (7). Systems of 120-600 volts may be either single-phase or three phase, and all of the connections shown are used to some extent for some systems in this voltage range.
(b) Three-phase, three-wire systems may be solidly grounded, impedance grounded, or ungrounded but are not intended to supply loads connected phase to-neutral (as the four-wire systems are).
(c) In connections (5) and (6) the ground may be connected to the midpoint of one winding as shown (if available), to one phase conductor ("corner" grounded), or omitted entirely (ungrounded).
(d) Single-phase services and single-phase loads may be supplied from single-phase systems or from three-phase systems. They are connected phase-to-phase when supplied from three-phase, three-wire systems and either phase-to-phase or phase-to-neutral from three-phase, four-wire systems.



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## Annex B
(informative)
## Illustration of voltage ranges of table 1

Figure B1 shows the basis of the Range A and Range B limits of table 1. The limits in table 1 were determined by multiplying the limits shown in this chart by the ratio of each nominal system voltage to the 120-volt base. [For exceptions, see note (d) to figure B1.]

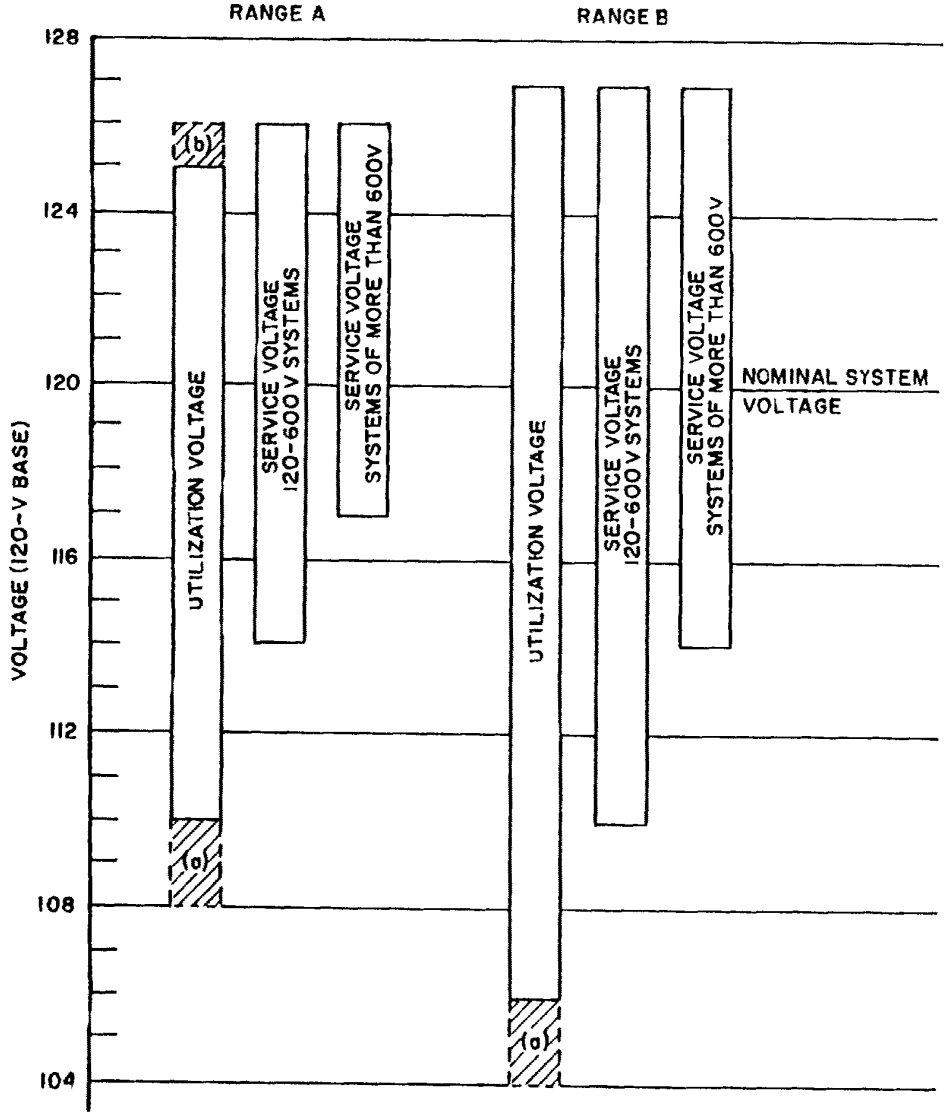


**Figure B1**

NOTES
(a) These shaded portions of the ranges do not apply to circuits supplying lighting loads. See note 1 to table 1.
(b) This shaded portion of the range does not apply to 120-600-volt systems. See note (c) to table 1.
(c) The difference between minimum service and minimum utilization voltages is intended to allow for voltage drop in the customer's wiring system. This difference is greater for service at more than 600 volts to allow for additional voltage drop in transformations between service voltage and utilization equipment.
(d) The Range B utilization voltage limits in table 1 for 6900-volt and 13800-volt systems are 90% and 110% of the voltage ratings of the standard motors used in these systems and deviate slightly from this figure.



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## Annex C
## Voltage ratings for 60-hertz electric utilization equipment

(Refer to Annex E for a partial list of applicable standards.)

In tables C1 and C2 only representative categories of equipment are listed because the sheer number of present and prospective equipment makes it impractical to cover all of them.

### Table C1 – Lamps, ballasts, and miscellaneous appliances

| Equipment | Applicable to All Nominal System Voltages Containing This Voltage(s) | Equipment Nameplate Voltage Rating |
|---|---|---|
| Lighting devices | | |
| Incandescent lamps | 120 | 120 |
| Fixtures and ballasts for fluorescent and high-pressure vapor lamps [Notes (a) and (b)] | 120 | 120 |
| | 208 | 208 |
| | 240 | 240 |
| | 277 | 277 |
| | 480 | 480 |
| Motor-operated appliances [Note (c)] | | |
| Hair dryers | | |
| Clocks | 120 | 120 |
| Dryers – clothes | 120 | 120 |
| Fans | 120/240, 240/120, 208Y120 | 120/240 |
| Food mixers | | 120 |
| Food waste disposers | | 120 |
| Timers | | 115 |
| Vacuum cleaners | 120 | 120 |
| Washers | | 120 |
| Clothes | | |
| Dishes | | 115 |
| | | 115 |
| Communication appliances | | |
| Projectors, silent and sound | 120 | 120 |
| Small | 120/240, 240/120 | 120/240 |
| Large | 208Y/120 | 120/208 |
| Phonographs | | |
| Radios | | |
| Tape recorders | 120 | 120 |
| Television | | |
| Heating and cooking appliances | | |
| Blankets | | |
| Cooking appliances, table and counter | 120 | 120 |
| Household – small | | |
| Household – large | 120 | 120 |
| Commercial – small | | |
| Commercial – large | 240 | 240 |
| | 208 | 208 |
| | 480 | 480 |
| Heaters, portable air | | 120 |
| Heating pads | | 120 |
| Irons | 120 | |
| Hand | | 120 |
| Soldering | | 120 |
| Rangers – household type | 120/240, 240/120 | 120/240 |
| | 208Y/120 | 120/208 |
| Water heaters | 120 | 120/240 |
| Tank – small | 240 | |
| Tank – large | 240 | 240 |
| | 280 | 280 |

NOTES

(a) Lighting systems incorporating two ungrounded wires for service may require special ballasts and auxiliaries.

(b) Some ballasts are rated for use on more than one system voltage by use of taps or multiple primary windings.

(c) Attention is called to the fact that under emergency conditions on electric systems, voltages below Range B of table 1 may be encountered. This should be taken into account particularly in the design of motor-operated appliances for automatic starting and in the application of motors and control.



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**Table C2 – Heating, refrigeration, and air-conditioning equipment**

| Equipment | Phase | Applicable to All Nominal System Voltages Containing This Voltage(s) | Equipment Nameplate Voltage Rating |
|---|---|---|---|
| Gas and oil furnaces and fractional hp coil units | 1 | 120 | 115 |
| | | 240 | 230 |
| Stokers | 1 | 120 | 115 |
| Refrigerators and freezers | 1 | 120 | 115 |
| Room air conditioners | 1 | 120 | 115 |
| | | 208 | 208, (200)* |
| | | 240 | 230 |
| | | 208, 240 | 208/230℗, (200/230)*℗ |
| Unitary air conditioners and heat pumps | | | |
| Motor compressors | | | |
| Condensing units | 1 and 3 | 208 | 208, (200)* |
| Water-chilling packages | 1 and 3 | 240 | 230 |
| Integral hp fan coil units, etc. | 1 and 3 | 208,240 | 208/230℗, (200/230)*℗ |
| Duct and auxiliary electric heaters for air-conditioning units and heat pumps | 1 | 277 | 265 |
| | 3 | 480 | 460 |
| | 3 | 600 | 575 |
| Electric furnaces | 1 and 3 | 240 | 230 |
| | 3 | 208 | 208, (200)* |
| | | 120 | 120 |
| Comfort heating | 1 | 208 | 208 |
| | | 240 | 240 |
| | | 277 | 277 |
| Refrigerated drinking-water coolers | 1 | 120 | 115 |
| Dehumidifiers | 1 | 120 | 115 |

* Parenthetical values are under consideration for future design.
℗ Slant between voltage values denotes 'either-or.'



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For the purposes of this Annex, the term 'motor control equipment' is used in a general sense and includes some types of equipment classified as 'switchgear.' For applicable standards, see Annex E.

The single-phase and three-phase motor and control voltage ratings shown in table C3 are well suited to the nominal system voltages indicated. It should be generally understood that motors with these ratings are to be considered as suitable for ordinary use on their corresponding system; for example, a 230-volt motor is suited for use on a nominal 240-volt system. Operation of 230-volt motors on 208-volt systems is not recommended because the utilization voltage encountered will commonly be below the -10% tolerance on the voltage rating for which the motor is designed.

APPENDIX

Suitable measures should be taken by manufacturers and power suppliers to indicate to the purchaser that equipment is intended to be used on the system whose nominal voltage is associated with, but may both be numerically equal to, the equipment nameplate voltage rating; for example, a motor and its control rated 230 volts is intended for use on a nominal 240-volt system.

It should be noted that successful operation of a motor under given running conditions does not necessarily mean that it will be able to start and accelerate all loads to which it may be applied under these same operating conditions.

It should be recognized that synchronous motors, especially those rated 0.8 power factor, are reactive power sources and consequently may increase the voltage at their terminals to higher values than those experienced for induction motors under similar conditions.

**Table C3 – Motor and motor control equipment**

| Applicable to All Nominal System Voltages Containing This Voltage | All Motor and Motor Control Equipment Nameplate Voltage Ratings Containing This Voltage | | | |
|---|---|---|---|---|
| | Integral Horsepower | | Fractional Horsepower | |
| | Three-Phase | Single-Phase | Three-Phase | Single-Phase |
| 120 | – | 115 | – | 115 |
| 208 | 200 | – | 200 | – |
| 240 | 230 | 230 | 230 | 230 |
| 480 | 460 | – | 460 | – |
| 600* | 575 | – | 575 | – |
| 2400 | 2300 | – | – | – |
| 4160 | 4000 | – | – | – |
| 4800 | 4600 | – | – | – |
| 6900 | 6600 | – | – | – |
| 13800 | 13200 | – | – | – |

* Certain kinds of control and protective equipment presently available have a maximum voltage limit of 600 volts; the manufacturer or power supplier, or both, should be consulted to ensure proper application.



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## Annex D
## Polyphase voltage unbalance

### D.1 Introduction

Studies on the subject of three-phase voltage unbalance indicate that: (1) all utility-related costs required to reduce voltage unbalance and all manufacturing-related costs required to expand a motor's unbalanced voltage operating range are ultimately borne directly by the customer, (2) utilities' incremental improvement costs are maximum as the voltage unbalance approaches zero and decline as the range increases, and (3) manufacturers' incremental motor-related costs are minimum at zero voltage unbalance and increase rapidly as the range increases.

When these costs, which exclude motor-related energy losses, are combined, curves can be developed that indicate the annual incremental cost to the customer for various selected percent voltage unbalance limits.

The optimal range of voltage unbalance occurs when the costs are minimum.

Field surveys and statistics indicate that:

(1) Each motor rating is associated with a unique optimal range of voltage unbalance
(2) These ranges vary from 0–2.5 percent to 0–4.0 percent voltage unbalance with the average at approximately 0–3.0 percent
(3) Approximately 98 percent of the electric supply systems surveyed are within the 0–3.0 percent voltage-unbalance range, with 66 percent at 0–1.0 percent or lass

### D.2 Recommendation

Electric supply systems should be designed and operated to limit the maximum voltage unbalance to 3 percent when measured at the electric-utility revenue meter under no-load conditions.

This recommendation should not be construed as expanding the voltage ranges prescribed in 2.4. If the unbalanced voltages of a polyphase system are near the upper or lower limits specified in table 1, Range A or Range B, each individual phase voltage should be within the limits in table 1.



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## D.3 Definitions

Voltage unbalance of a polyphase system is expressed as a percentage value and calculated as follows:

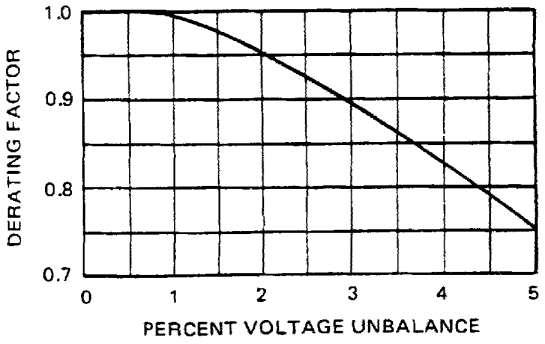


**Figure D1 – Derating factor**

NOTE—See 14.35 of NEMA MG 1-1993 for more complete information about the derating factor.

$$\text{Percent voltage unbalance} = 100 \times \frac{(\text{max. deviation from average v})}{(\text{Average Voltage})}$$

Example: with phase-to-phase voltages of 230, 232, and 225, the average is 229; the maximum deviation from average is 4; and the percent unbalance is (100 X 4)/229 = 1.75 percent.

## D.4 Derating for unbalance

The rated load capability of polyphase equipment is normally reduced by voltage unbalance. A common example is the derating factor, from figure D1, used in the application of polyphase induction motors.

## D.5 Protection from severe voltage unbalance

User systems should be designed and operated to maintain a reasonably balanced load.

In severe cases of voltage unbalance, consideration should be given to equipment protection by applying unbalance limit controls.



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## Annex E
## Applicable standards

### E.1 List of standards

The following is a partial list of standards (by general number) for equipment from which voltage ratings and other characteristics can be obtained.

| Equipment | Standard* |
|---|---|
| Air-conditioning and refrigerating equipment nameplate voltages | ARI 110 |
| Air filter equipment | ARI 680 |
| Ammonia compressors and compressor units | ARI 510 |
| Application, installation, and servicing of unitary systems | ARI 260 |
| Automatic commercial ice makers | ARI 810 |
| Cable terminating devices (power) | IEEE 48 |
| Central forced-air electric heating equipment | ARI 280 |
| Central-station air-handling units | ARI 430 |
| Connectors for electric utility applications | ANSI C119. 1 |
| Definite purpose magnetic contactors | ARI 780 |
| Dehumidifiers | ANSI/AHAM DH-1 |
| Electrical measuring instruments | ANSI C39 Series |
| Electrical power insulators | ANSI C29 Series |
| Electricity metering | ANSI C12 Series |
| Forced circulation, free-delivery air coolers for refrigeration | ARI 420 |
| Gas-fired furnaces | ANSI Z21 Series |
| Industrial control apparatus | ANSI/NEMA ICS Series |
| Insulated conductors | ANSI/NFPA 70<br>AEIC Series<br>ICEA Series |
| Lamps | |
| Bactericidal lamps | |
| Electrical discharge lamp | ANSI C78 Series |
| Incandescent lamps | |
| Lamp ballasts | |
| Low-voltage fuses | ANSI C82 Series |
| Low-voltage molded-case circuit breakers | ANSI/NEMA FU 1 |
| Mechanical transport refrigeration units | NEMA AB 1 |
| Oil-fired furnaces | ARI 1110 |
| Packaged terminal air conditioners | CS 195 |
| Positive displacement refrigerant compressor and condensing units | ARI 310 |
| Power switchgear | ANSI/ARI 520 |
| Automatic circuit reclosers | |
| Automatic line sectionalizers | |
| Capacitor switches | |
| Distribution current-limiting fuses | |
| Distribution cutout and fuse links | |
| Distribution enclosed single-pole air switches | |
| Distribution oil cutouts and fuse links | |
| Fused disconnecting switches | |
| High-voltage air switches | ANSI C37 Series |
| Manual and automatic station control | |
| Power circuit breakers | |
| Power fuses | |
| Relays and relay systems | |
| Secondary fuses | |
| Supervisory and associated telemetering equipment | |
| Switchgear assemblies including metal enclosed bus | |
| Reciprocating water-chilling packages | ANSI/ARI 590 |
| Recreational vehicle air-conditioning equipment | ARI 250 |
| Remote mechanical draft air-cooled refrigerant condensers | ARI 460 |
| Room air conditioners | ANSI/AHAM RAC-1 |

| Equipment | Standard* |
|---|---|
| Room fan-coil air conditioners | ARI 441 |
| Rotating electrical machinery | |
| AC induction motors | |

*See list of organizations in Section E2.

table continued on next page



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| | |
|---|---|
| Cylindrical rotor synchronous generators | ANSI C50 Series and |
| Salient pole synchronous generator and condensers | NEMA MG 1 |
| Synchronous motors | |
| Universal motors | ANSI/ARI 620 |
| Self-contained humidifiers | ANSI/ARI 1010 |
| Self-contained mechanically refrigerated drinking-water coolers | ANSI/IEEE 18 |
| Shunt power capacitors | |
| Solenoid valves for liquid and gaseous flow | ARI 760 |
| Static power conversion equipment | ANSI C34 |
| Surge arresters | ANSI C62.61 & NEMA LA 1 |
| Transformers, regulators, and reactors | |
| Arc furnace transformers | |
| Constant-current transformers | |
| Current-limiting reactors | |
| Distribution transformers, conventional subway-type | |
| Dry type | ANSI C57 Series |
| Instrument transformers | ANSI/NEMA ST 20 |
| Power transformers | |
| Rectifier transformers | |
| Secondary network transformers | |
| Specialty | |
| Step-voltage and induction-voltage regulators | |
| Three-phase load-tap-changing transformers | |
| Unit ventilators | ARI 330 |
| Unitary air-conditioning equipment | ARI 210 |
| Commercial and industrial unitary air-conditioning equipment | ANSI/ARI 360 |
| Unitary heat-pump equipment | ARI 240 |
| Wiring devices | ANSI C73 Series |

*See list of organizations in Section E2.



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## E.2 Organizations Referred to in Section E.1

| | |
|---|---|
| AEIC | Association of Edison Illuminating Companies<br>P.O. Box 2641<br>Birmingham, AL 35291-0992 |
| AHAM | Association of Home Appliance Manufacturers<br>20 North Wacker Drive<br>Chicago, IL 60606 |
| AMCA | Air Movement and Control Association<br>30 West University Drive<br>Arlington Heights, IL.60004 |
| ANSI | American National Standards Institute, Inc<br>11 West 42nd Street, 13th Floor<br>New York, N.Y. 10036 |
| ARI | Air Conditioning and Refrigeration Institute<br>4301 N. Fairfax Drive; Suite 425<br>Arlington, VA 22203 |
| CS | Commercial Standards<br>Office of Commodity Standards<br>National Institute of Standards and Technology,<br>U.S. Department of Commerce<br>Gaithersburg, MD 20899-0001 |
| IBR* | Hydronics Institute<br>35 Russo Place,<br>P.O. Box 218<br>Berkeley Heights, NJ 07922 |
| IEEE | The Institute of Electrical and Electronics Engineers, Inc.<br>445 Hoes Lane<br>Piscataway, NJ 08855 |
| ICEA | Insulated Cable Engineers Association<br>Box P<br>South Yarmouth, MA 02664 |
| NEMA | National Electrical Manufacturers Association<br>1300 North 17th Street; Suite 1847<br>Rosslyn, VA 22209 |

*Institute of Boiler and Radiator Manufacturers.



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