2595512 0078630 25T

NEMA-ST1

ADOPTION NOTICE

NEMA-ST1, "Specialty Transformers (Except General-Purpose Type)," was adopted on October 3, 1994, for use by the Department of Defense (DoD). Proposed changes by DoD activities must be submitted to the DoD Adopting Activity: Commander, Defense Electronic Supply Center, Attn: DESC-ELVI, 1507 Wilmington Pike, Dayton, OH 45444. DoD activities may obtain copies of this standard from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094. The private sector and other Government agencies may purchase copies from the National Electrical Manufacturers Association, 2101 L Street, NW, Suite 300, Washington, DC 20037.

Custodians:
Army - ER
Navy - YD1
Air Force - 85

Adopting Activity
DLA - ES

FSC 5950

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

NEMA Standards Publication No. ST 1-1988 (R1994, R1997)

Specialty Transformers (Except General Purpose Type)

Published by:

National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209

© Copyright 2001 by the National Electrical Manufacturers Association. All rights including translation into other languages reserved under the Universal Copyright Convention, the Berne Convention for the Protection of Literary and Artistic Works, and the International and Pan American Copyright Conventions.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

TABLE OF CONTENTS

		PAGE
	FOREWORD	i
	SCOPE	ii
Section 1	REFERENCED STANDARDS & DEFINITIONS	1
Section 2	GENERAL	
	Service Conditions	6
	Frequency	6
	Effect of Altitude on Temperature Rise	6
	Insulation Systems	6
	Designation of Voltage Ratings of Windings	7
	Low Frequency Dielectric Requirement	8
	Losses and Impedance	8
	Basis of Ratings	8
	Tests	8
	Marking	12
Section 3	CONTROL TRANSFORMERS	
	Output and Voltage Ratings	15
	Dielectric Tests	15
	Voltage Ratio	16
	Limits of Temperature Rise	16
	Construction	16
Section 4	INDUSTRIAL CONTROL TRANSFORMERS	
	Types	18
	Output and Voltage Rating(s)	18
	Dielectric Tests	18
	Tolerances for Regulation	19
	Limits of Temperature Rise	19
	Construction	19
	Standard Application Data	19
Section 5	CLASS 2 TRANSFORMERS	
	Types	22
	Output and Voltage Ratings	22
	Dielectric Tests	22
	Temperature Rise	23
	Construction	23
	Output Limitations	25
Section 6	SIGNALLING TRANSFORMERS	
	Output and Voltage Ratings	26
	Dielectric Tests	26
	No-load Losses (Excitation Losses)	26
	Voltage Ratio	26
	Limits of Temperature Rise	27
	Construction	27
Section 7	IGNITION TRANSFORMERS	
	Ratings	29
	Dielectric Tests	29

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Tolerances for Voltage Ratio 29
Limits of Temperature Rise 30
Construction 30
Secondary Spark-gap and Short-circuit Current 31
Air Delivery and Electrode Spacing 31

Section 8 LUMINOUS-TUBE TRANSFORMERS

Ratings 32
Dielectric Tests 32
Tolerances for Voltage Ratio 32
Limits of Temperature Rise 34
Construction 34
Application Guide 35

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

FOREWORD

This Standards Publication is a revision of NEMA Standard Publication ST 1-1978.

In the preparation of this Standards Publication, input of users and other interested parties has been sought and evaluated. Inquiries, comments, and proposed or recommended revisions should be submitted to:

Manager, Engineering Department
National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, DC 20037

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SCOPE

This Standards Publication covers control transformers, industrial control transformers, Class 2 transformers, signalling transformers, ignition transformers, and luminous-tube transformers. The publication contains service conditions, tests, classifications, performance characteristics, and construction data for the transformers.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SPECIALTY TRANSFORMERS (EXCEPT GENERAL-PURPOSE TYPE)

Section 1
REFERENCED STANDARDS AND DEFINITIONS

1.1 REFERENCED STANDARDS

The following publications are adopted, whole or in part as indicated, by reference in this Standards Publication.

Underwriters Laboratories, Inc.
333 Pfingsten Road
Northbrook, IL 60062

UL 506-1984 — *Specialty Transformers*

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

ANSI/NFPA 70-1987 — *National Electrical Code*

1.2 DEFINITIONS

1.2.1 Crest

1.2.1.1 Crest Factor of a Function

The crest factor of a function is the ratio of its crest (peak, maximum) value to its root-mean-square (rms) value.

1.2.1.2 Crest Value (Peak Value)

Crest value is the maximum absolute value of a function when such a maximum exists.

NEMA Standard 9-20-1972.

1.2.2 Current

1.2.2.1 Eddy Currents

Eddy currents are those currents which are induced in the body of a conducting mass by a variation of magnetic flux due to the result of a varying magnetic field or of a relative motion of the mass with respect to the magnetic field.

1.2.2.2 Excitation Current of a Transformer

The excitation current of a transformer is the current which maintains the excitation of the transformer and is expressed in per unit, or in percent, of the rated current of the winding in which it is measured.

NEMA Standard 9-26-1988.

1.2.3 Diagram, Connection

A connection diagram is a diagram that shows the connections of an installation or its component devices or parts. It covers internal or external connections, or both, and contains such detail as is needed to make or trace connections that are involved.

NEMA Standard 9-26-1988.

1.2.4 Dielectric Tests

Dielectric tests are tests which consist of the application of a voltage higher than the rated voltage, for a specified time, for the purpose of determining the adequacy against the breakdown of insulation materials and spacing.

1.2.4.1 Applied Dielectric Test

An applied dielectric test is one which is intended to test the insulation between windings and between windings and ground.

1.2.4.2 Impulse Test

Impulse tests are dielectric tests that consist of the application of a high-frequency voltage wave of a specified shape applied between windings and between windings and ground.

1.2.4.3 Induced Dielectric Test

An induced dielectric test is one which is intended to test turn-to-turn insulation and layer-to-layer insulation.

NEMA Standard 9-20-1972.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

1.2.5 Impedance

1.2.5.1 Impedance kVA

Impedance kVA is the kVA measured in the excited winding with the other winding short-circuited and with sufficient voltage applied to the excited winding to cause rated current to flow in the winding.

1.2.5.2 Impedance Voltage of a Transformer

The impedance voltage of a transformer is the voltage required to circulate rated current through one winding of the transformer when another winding is short-circuited, with the respective windings connected as for rated-voltage operation. It is expressed in per unit, or in percent, of the rated voltage of the winding in which the voltage is measured.

NEMA Standard 9-26-1988.

1.2.6 Insulation

1.2.6.1 Insulating Materials

Insulating materials are processed compositions of recognized individual raw materials and simple combinations thereof before they are fabricated, processed, and placed in position in dry-type transformer coils or other structures identified with specific parts of the transformer.

1.2.6.2 Insulation System

An insulation system is an assembly of fabricated, processed, and in-place combinations of component insulating materials with related structural parts as used in dry-type transformers and/or in a form representative of such use through simulation of operational conditions while portraying the effectiveness of the physical support for the insulation and the severity of forces (including environmental) tending to disrupt it.

NEMA Standard 9-20-1972.

1.2.7 Losses

1.2.7.1 Load Losses

The load losses of a transformer are those losses which are incident to the carrying of the load. Load losses are I2R loss in the winding due to load current; stray loss due to stray fluxes in the windings, core clamps, and such; and the loss due to circulating currents, if any, in parallel windings.

1.2.7.2 No-load (Excitation) Losses

No-load losses are those losses which are incident to the excitation of the transformer. No-load (excitation) losses are core loss, dielectric loss, conductor loss in the winding due to the exciting current, and conductor loss due to circulating current in parallel windings.

1.2.7.3 Total Losses

The total losses of a transformer shall be the sum of the excitation losses and the load losses, excluding losses due to accessories.

NEMA Standard 9-20-1972.

1.2.8 Marking, Relative Lead Polarity of a Transformer

The relative lead polarity of a transformer is a designation of the relative instantaneous directions of current in its leads.

Primary and secondary leads are said to have the same polarity when, at a given instant during most of each half cycle, the current enters an identified, or marked, primary lead and leaves the similarly identified, or marked, secondary in the same direction, as though the two leads formed a continuous circuit.

This relative lead polarity of a single-phase transformer shall be either additive or subtractive. If one pair of adjacent leads from the two windings is connected together and voltage is applied to one of the windings, then:

1. The relative lead is additive if the voltage across the other two leads of the windings is greater than that of the higher voltage winding alone.
2. The relative lead polarity is subtractive if the voltage across the other two leads of the windings is less than that of the higher voltage winding alone.

The relative lead polarity shall be indicated by identification marks on primary and secondary of leads of like polarity, or by other appropriate identification.

NEMA Standard 9-26-1988.

1.2.9 Ratings

1.2.9.1 Continuous Rating

The continuous rating of a transformer defines the maximum constant load which can be carried continuously without exceeding established temperature-rise limitations under prescribed conditions of test and within the limitations of established standards.

1.2.9.2 kVA or Voltampere Short-circuit Primary Rating of a High-reactance Transformer

The short-circuit primary rating of a high-reactance transformer at secondary short-circuit designates the primary kVA or voltamperes at rated primary voltage with the secondary terminals short-circuited.

1.2.9.3 kVA Rating of a Transformer

The kVA rating of a transformer is the output which can be delivered for the time specified at secondary voltage and rated frequency without exceeding the specified temperature rise limitations under prescribed

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

conditions of test and within the limitations of established standards.

1.2.9.4 Load (Output)

The load of a transformer is the power in kilo-voltamperes, or voltamperes, supplied by the transformer.

1.2.9.5 Primary Voltage Rating

The primary voltage rating of a transformer designates the input-circuit voltage for which the primary winding is designed.

1.2.9.6 Rated Current of Equipment (or of a Winding)

The rated current of equipment, or of a winding, is the current for which the equipment, or winding, is designed, and to which certain operating and performance characteristics are referred.

1.2.9.7 Rating of Transformer Equipment

The rating of transformer equipment consists of a voltampere output, together with any other characteristics, such as voltage, frequency, and power factor, assigned to it by the manufacturer.

The rating of a transformer is regarded as a test rating which defines an output which can be taken from the transformer under prescribed conditions of test and within the limitations of established standards.

1.2.9.8 Secondary Short-circuit Current Rating of a High-reactance Transformer

The secondary short-circuit current rating of a high-reactance transformer designates the current in the secondary winding when the primary winding is connected to a circuit of rated primary voltage and frequency, and when the secondary terminals are short-circuited.

1.2.9.9 Secondary Voltage Rating

The secondary voltage rating of a transformer designates the load-circuit voltage for which the secondary winding is designated.

1.2.9.10 Winding Voltage Rating

The winding voltage of a transformer designates the voltage for which the winding is designed.

NEMA Standard 9-20-1972.

1.2.10 Ratio

1.2.10.1 Turn Ratio of a Transformer

The turn ratio of a transformer is the ratio of the number of turns in the high-voltage winding to that in the low-voltage winding. For a transformer having taps for changing its voltage ratio, the turn ratio is based on the number of turns, corresponding to the normal rated voltage of the respective windings to which operating and performance characteristics are referred.

NEMA Standard 9-26-1988.

1.2.10.2 Voltage Ratio of a Transformer

The voltage ratio of a transformer is the ratio of the rms primary terminal voltage to the rms secondary terminal voltage under specified conditions of load.

NEMA Standard 9-26-1988.

1.2.11 Reactor

A reactor is a device used for introducing impedance into an electric circuit, the principal element of which is inductive reactance.

1.2.11.1 Current-limiting Reactor

A current-limiting reactor is a reactor intended for limiting the current that can flow in a circuit under short-circuit conditions, or under operating conditions such as starting, synchronizing, and so forth.

NEMA Standard 9-20-1972.

1.2.12 Regulation Of A Transformer

The regulation of a transformer is the change in output (secondary) voltage which occurs when the load is reduced from rated value to zero, with the applied (primary) voltage maintained constant. For a multi-winding transformer, the loads on all windings, at specified power factors, are reduced from kVA to zero simultaneously. The regulation is expressed in per unit, or in percent, on the base of the rated output (secondary voltage at full load).

NEMA Standard 9-26-1988.

1.2.13 Taps

1.2.13.1 Rated kVA Tap (in a Transformer)

A rated kVA tap in a transformer is a tap through which the transformer can deliver its rated kVA output without exceeding the specified temperature rise.

1.2.13.2 Reduced kVA Tap (in a Transformer)

A reduced kVA tap in a transformer is a tap through which the transformer can deliver only an output less than rated kVA without exceeding the specified temperature rise.

1.2.13.3 Tap (in a Transformer)

A tap in a transformer is a connection brought out of a winding, at some point between its extremities, to permit changing the voltage or current ratio.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

1.2.13.4 ENERGY-LIMITING TRANSFORMER

An energy-limiting transformer is a transformer that is intended for use on an approximately constant-voltage supply circuit and that has sufficient inherent impedance to limit the output current to a thermally safe maximum value.

1.2.13.5 HIGH-POWER-FACTOR TRANSFORMER

A high-power-factor transformer is a high-reactance transformer which has a power-factor correcting device such as a capacitor, so that the input current is a power factor of not less than 90 percent when the transformer delivers rated current to its intended load device.

1.2.13.6 HIGH-REACTANCE TRANSFORMER

A high reactance transformer is an energy-limiting transformer which has sufficient inherent reactance to limit the output current to a maximum value.

1.2.13.7 INDOOR TRANSFORMER

An indoor transformer is a transformer which, because of its construction, must be protected from the weather if used outdoors.

1.2.13.8 INSULATING TRANSFORMER

An insulating transformer is a transformer used to insulate one circuit from another.

1.2.13.9 LIQUID-IMMERSED TRANSFORMER

A liquid-immersed transformer is a transformer in which the core and coils are immersed in liquid.

1.2.13.10 LOW-POWER-FACTOR TRANSFORMER

A low-power-factor transformer is a high-reactance transformer which does not have means for power-factor correction.

1.2.13.11 NON-ENERGY-LIMITING TRANSFORMER

A non-energy-limiting transformer is a constant-potential transformer which does not have sufficient inherent impedance to limit the output current to a thermally safe maximum value.

1.2.13.12 OUTDOOR TRANSFORMER

An outdoor transformer is a transformer which is so constructed that exposure to the weather will not interfere with its successful operation.

1.2.13.13 SPECIALTY TRANSFORMER

Specialty transformer is a transformer which is generally intended to supply electric power control, machine tool, Class 2, signalling, ignition, luminous-tube, cold-cathode, lighting, series street-lighting, low-voltage general purpose, and similar applications.

1.2.13.14 STEP-DOWN TRANSFORMER

A step-down transformer is a transformer in which the energy transfer is from a high-voltage circuit to a low-voltage circuit.

1.2.13.15 STEP-UP TRANSFORMER

A step-up transformer is a transformer in which the energy transfer is from a low-voltage circuit to a high-voltage circuit.

1.2.13.16 SUBMERSIBLE TRANSFORMER

A submersible transformer is a transformer which is so constructed that it will operate when submerged in water under specified conditions of time and external pressure.

NEMA Standard 9-20-1972.

1.2.14 Temperature, Ambient

Ambient temperature is the average temperature of the air in the immediate neighborhood of the transformer.

NEMA Standard 9-20-1972.

1.2.15 Transformer

A transformer is an electric device, without continuously moving parts, which by electromagnetic induction transfers electric energy from one or more circuits to one or more other circuits at the same frequency, usually with changed value(s) of voltage and current. The term "transformer," as used in these standards, includes both transformers and reactors.

NEMA Standard 9-20-1972.

1.2.15.1 AUTOTRANSFORMER

An autotransformer is a transformer in which part of one winding is common to both the primary and secondary circuits associated with that winding.

1.2.15.2 CONSTANT-POTENTIAL TRANSFORMER

A constant-potential transformer is a transformer that maintains an approximately constant voltage ratio over the range from zero to rated output.

NEMA Standard 9-20-1972.

1.2.15.3 DRY-TYPE TRANSFORMER

A dry-type transformer is a transformer in which the windings are immersed in air or some other dry gas which remains in the gaseous state throughout the range of transformer operating temperatures. The windings shall be permitted to be coated or enclosed with compounds.

NEMA Standard 9-26-1988.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

1.2.16 Windings

1.2.16.1 HIGH-VOLTAGE AND LOW-VOLTAGE WINDINGS

The terms "high voltage" and "low voltage" are used to distinguish the winding having the greater, from that having the lesser voltage rating.

1.2.16.2 PRIMARY WINDING

The primary winding is the winding on the energy input side.

1.2.16.3 SECONDARY WINDING

The secondary winding is the winding on the energy output side.

NEMA Standard 9-20-1972.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Section 2
GENERAL

Section 2 is applicable to specialty transformers and applies to several, though not all, of the types of specialty transformers covered in Sections 3 through 9.

Authorized Engineering Information 9-26-1988.

2.1 SERVICE CONDITIONS

2.1.1 Ambient Temperature

Transformers conforming to this standard shall be suitable for operation at their standard ratings, provided that the ambient temperature does not exceed 40°C.

If the maximum ambient temperature exceeds 40°C and the conditions of operation produce the permissible temperature rise, the maximum total temperature will be exceeded, and deterioration of the insulation may result.

Authorized Engineering Information 9-26-1988.

2.1.2 Service Conditions

The following are service conditions affecting construction of protective features:

1. Exposure to damaging fumes or vapors;
2. Exposure to excessive dirt or abrasive dust;
3. Exposure to steam, salt spray, excessive moisture, or drifting water;
4. Exposure to explosive mixtures of dust or gases; and
5. Exposure to abnormal vibration, shock, or tilting.

Authorized Engineering Information 9-20-1972.

2.2 FREQUENCY

The standard frequency shall be 60 hertz, except as otherwise specified in Sections 3 through 9, inclusive.

NEMA Standard 9-20-1972.

2.3 EFFECT OF ALTITUDE ON TEMPERATURE RISE

The decrease in air density due to high altitudes increases the temperature rise of transformers that are dependent upon air for the dissipation of heat losses. The temperature rise specifications in Sections 3 through 9 inclusive, apply to transformers that are intended for service at altitudes not exceeding 3300 feet above sea level. To determine that the standard temperature rise will not be exceeded when transformers are operated in accordance with their ratings at higher altitudes, the observed temperature rises, as tested at low altitudes, shall be less than those specified in this standard by the following percentages for each 330 feet or altitude in excess of 3300 feet above sea level:

1. Dry-type transformers—0.5 percent
2. Liquid immersed transformers—0.4 percent.

NEMA Standard 9-20-1972.

2.4 INSULATION SYSTEMS

2.4.1 System Limiting Temperature

The limiting temperatures of 150°C, 185°C, and 220°C shall be used for 80°C rise, 115°C rise, and 150°C rise materials, respectively, only when used in the insulation systems of apparatus within the scope of this publication. These temperatures shall not be confused with the values used for identification and classification of the materials themselves.

NEMA Standards 9-26-1988.

2.4.2 105°C Insulation System for 55°C Rise Transformers

Component insulating materials found suitable, from experience or test, for 55°C rise transformers are: (1) cotton, silk, paper, and similar organic materials when impregnated; (2) molded and laminated materials with cellulose, filler, phenolic resins, and other resins of similar properties; (3) films and sheets of cellulose acetate and other cellulose derivatives of similar properties; and (4) varnishes (enamel) as applied to conductors.

Other materials or combinations of materials may be included in this insulation system if by experience or accepted test they can be shown to be capable of operation at 105°C.

An insulation is considered to be "impregnated" when a suitable substance replaces the air between its fibers, even if this substance does not completely fill the spaces between the insulated conductors. The impregnated substances, in order to be considered suitable, should have good insulating properties, should entirely cover the fibers and render them adherent to each other and to the conductor, should not produce interstices within itself as a consequence of evaporation of the solvent or through any other cause, should not flow during the operation of the apparatus at full working load or at the temperature limit specified, and should not unduly deteriorate under prolonged exposure to operating temperature.

The electrical and mechanical properties of the insulated winding should not be impaired by the application

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

of the hottest-spot temperature permitted for the specific insulation system. The word "impaired" is here used in the sense of causing any change that could disqualify the insulating material from continuously performing its intended function, whether it is creepage spacing, mechanical support, or dielectric barrier action.

Authorized Engineering Information 9-20-1972.

2.4.3 150°C Insulation System for 80°C Rise Transformers

Component insulating materials found suitable, from experience or test, for 80°C rise transformers are mica, asbestos, glass fiber, and similar inorganic materials in built-up form with organic binding substances. A small proportion of 55°C rise materials may be used for structural purpose only. Glass fiber or asbestos magnetic-wire insulations are included in this insulation system. These may include supplementary organic materials, such as poly-vinylacetal or polyamide films.

Other materials or combinations of materials may be included in this insulation system if by experience or accepted test they can be shown to be capable of operation at 150°C.

Authorized Engineering Information 9-20-1972.

2.4.4 185°C Insulation System for 115°C Rise Transformers

Component insulating materials found suitable, from experience or test, for 115°C rise transformers are materials or combinations of materials such as mica, glass fiber, asbestos, and such, with suitable bonding substances. Other materials or combinations of materials necessarily inorganic, may be included in this insulation system if by experience or accepted tests, they can be shown to be capable of operation at 185°C.

Authorized Engineering Information 9-20-1972.

2.4.5 220°C Insulation System for 150°C Rise Transformers

Component insulating materials found suitable, from experience or test, for 150°C rise transformers are materials or combinations of materials such as silicone elastomer, mica, glass fiber, asbestos, and such, with suitable bonding substances such as appropriate silicone resins. Other materials or combinations of materials may be included in this insulation system if by experience or accepted tests, they can be shown to be capable of operation at 220°C.

Authorized Engineering Information 9-26-1988.

2.4.6 Over 220°C Insulation System for Over 150°C Rise Transformers

Component insulating materials found suitable, from experience or test, for over 150°C rise transformers are mica, glass, quartz, and similar inorganic materials. Other materials or combinations of materials may be included in this insulation system if by experience or accepted tests, they can be shown to have the required thermal life at temperatures over 220°C.

Authorized Engineering Information 9-20-1972.

2.5 DESIGNATION OF VOLTAGE RATINGS OF WINDINGS

2.5.1 General

A long dash (–) shall be used to separate the voltage ratings of separate windings. A slant (/) or x shall be used to separate voltages obtained by the use of taps, or by series-parallel connection in the same winding, in accordance with 2.4.2 through 2.4.5.

NEMA Standard 9-20-1972.

2.5.2 Delta-Y

A single-phase winding designed for either delta or Y system shall be designated by the delta-voltage rating, followed by a slant and the Y-voltage rating.

NEMA Standard 9-20-1972.

Example – 120/208Y signifies that the windings may be connected for either 120 volts delta or 208 volts Y.

Authorized Engineering Information 9-20-1972.

2.5.3 Series-Parallel or Three-wire

A single-phase winding designed for series-parallel or three-wire connection shall be designated by the parallel voltage rating followed by a slant and the series voltage rating.

NEMA Standard 9-20-1972.

Example – 120/240 signifies a winding suitable for 120-parallel connection or 240-volt series connection or 240/120-volt three-wire connection.

Authorized Engineering Information 9-26-1988.

2.5.4 Series-parallel Only

A single-phase winding designed for both series and parallel connection shall be designated by the parallel voltage rating followed by an x and the series voltage rating.

NEMA Standard 9-20-1972.

Example – 240 x 480 signifies a winding suitable for 240-volt parallel connection or 480-volt series connection, but not for 480/240-volt three-wire connection.

Authorized Engineering Information 9-26-1988.

2.5.5 Three-wire Single Phase

A winding having a midtap and designed for one-half rated kVA (kilovoltamperes) at one half the voltage across the full winding shall be designated by the full winding voltage followed by a slant and the voltage from the line to midpoint.

NEMA Standard 9-20-1979.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Example—240/120 signifies a 240-volt full winding with midtap for one-half rated kVA at 120 volts; 240/120/480 signifies a winding suitable for connection for either 240 or 480 volts, the 240-volt connection having a midtap for one-half rated kVA at 120 volts.

Authorized Engineering Information 9-26-1988.

2.6 LOW-FREQUENCY DIELECTRIC REQUIREMENT

Transformers, while still hot from the temperature test, shall be capable of withstanding the low-frequency dielectric tests described in Sections 3 through 9, inclusive.

Since deterioration of insulations results from repeated dielectric stress, test voltages used in field tests shall not exceed the following percentages of rms (root-mean -square) voltages specified for factory tests:

1. For acceptance field tests, or tests on old apparatus rebuilt in the field, 75 percent.
2. For periodic field insulation tests, 65 percent.

Specialty transformers shall not be required to withstand impulse tests.

NEMA Standard 9-20-1979.

2.7 LOSSES AND IMPEDANCE

2.7.1 Reference Temperature

The reference temperature, for the purpose of determining total losses, voltage regulation, and full-load voltage ratio, shall be as follows:

Winding Temperature Rise by Resistance, Degrees C	Reference Temperature, Degrees C
55	75
80	100
115	135
150	170

2.7.2 No-load (Excitation) Losses

No-load losses shall be determined for rated voltage and frequency on the basis of a true sine wave.

NEMA Standard 9-20-1972.

2.7.3 Total Losses

Total losses shall be determined for rated voltage, current, and frequency with the load-loss component corrected to the proper reference temperature (see 2.7.1).

NEMA Standard 9-20-1972.

2.8 BASIS OF RATING

The rating of transformers is based upon temperature rise (rather than the total temperature). However, the life of insulating materials commonly used in transformers depends very largely upon the total temperatures to which they are subjected and the duration of such temperatures.

Authorized Engineering Information 9-26-1988.

The insulation systems for each temperature rise shall consist of combinations of materials that have been shown by experience or test to be capable of operation at the hottest spot temperature permitted for the specific temperature rise.

NEMA Standard 9-26-1988.

Since the total temperature is the sum of the ambient temperature and the hottest spot temperature rise, it is apparent that the ambient temperature very largely determines the load that can reasonably be carried in service.

Other factors upon which the life of insulating materials depends are:

1. Electric stress and associated effects;
2. Vibration or varying mechanical stress;
3. Repeated expansion and contraction; and
4. Exposure to air, moisture, and such.

Authorized Engineering Information 9-26-1988.

2.9 TESTS

2.9.1 General

Unless otherwise specified, conformance to these standards shall be determined by tests made at the factory.

For test purposes the ambient temperature shall be between 10°C and 40°C.

NEMA Standard 9-20-1972.

2.9.2 Dielectric Tests

1. *Applied-potential Test*—See Sections 3 through 9, inclusive.
2. *Induced-potential Test*—The induced-potential test for transformers which receive the full standard applied-potential test shall be made by applying between the terminals of one winding a voltage of twice the normal voltage developed in winding. The induced-potential test shall be applied for 7200 cycles. The duration shall not exceed 60 seconds.

NEMA Standard 9-26-1988.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Examples of equivalent tests are as follows:

Frequency, Hertz	Duration of Test, Seconds
120 or less	60
180	40
240	30
360	20
400	18

The test voltage may be started at one quarter or less of the full value and brought up gradually to full value in not more than 15 seconds. After being held for the time specified in the preceding paragraph, the voltage may be reduced slowly in not more than 5 seconds to one quarter of the maximum value or less, and the circuit may be opened.

Authorized Engineering Information 9-20-1972.

2.9.3 Measurement of High Rms and Crest Voltages

Although other methods may be used, the measurement of secondary rms and crest voltages of ignition, luminous-tube, and cold-cathode lighting transformers is best accomplished by the use of an instrument such as described in Figure 2-1 and in the following paragraphs.

Authorized Engineering Information 9-20-1972.

1. *Constant-potential Transformer*—The transformer is of the two-winding type and has a ratio of 100:1. The primary coils are wound in not less than 4 sections. The transformer is so designed that, with a 20 kV (kilovolt) sinusoidal wave applied to the primary, the ratio of the crest voltage to the rms voltage does not vary more than 1 percent from 1.414. The magnetizing current of the transformer at 15 kV does not exceed 0.0002 ampere. The rms voltage measurement between 1 kV and 2 kV is not reliable.
2. *Alternating-current Voltmeter*—The alternating-current voltmeter has a 100- and 200-volt scale with not less than 100 divisions and is satisfactory for use on frequencies up to 200 hertz. The scale is not less than 3.2 inches long.
3. *Crest Voltmeter*—The crest voltmeter does not draw more than 100 microamperes at full-scale deflection, 300 volts, and has a scale that is not less than 5 inches long.
4. *Rectifier*—A Westinghouse #DRO-586 rectifier tube, or its equivalent, is used.

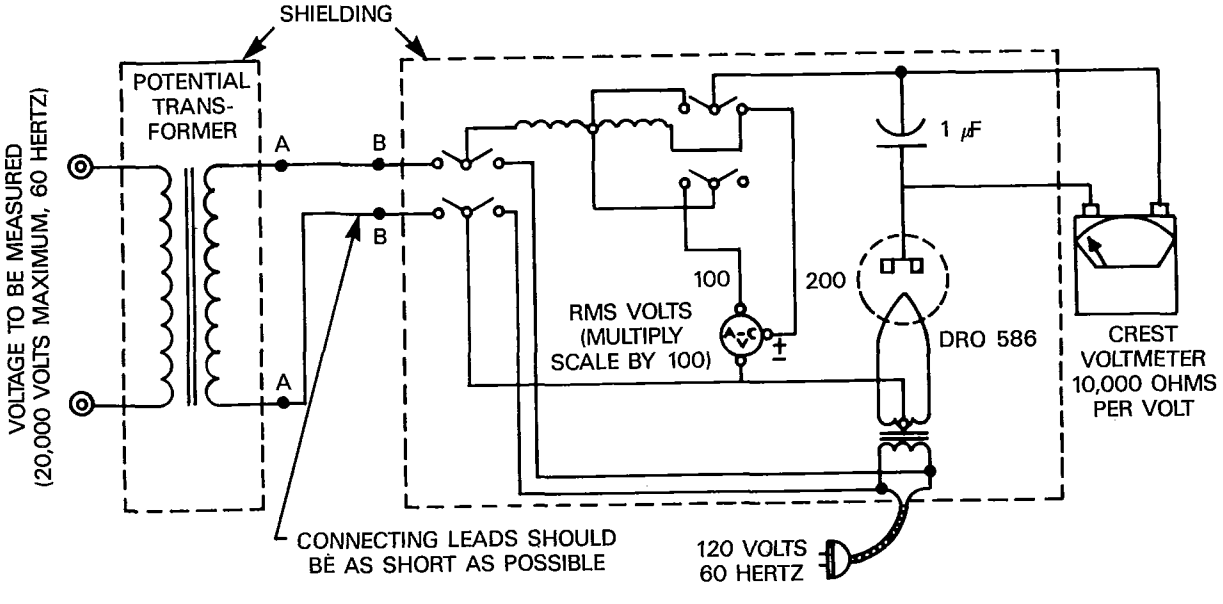


Figure 2-1
INSTRUMENT FOR MEASUREMENT OF SECONDARY ROOT-MEAN-SQUARE AND CREST VOLTAGES OF IGNITION, LUMINOUS-TUBE AND COLD-CATHODE LIGHTING TRANSFORMERS

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

5. *Capacitor* – A capacitor of not less than 1 microfarad and with not less than 500 megohms resistance is used.
6. *Resistor* – Only wire-wound resistors are used.
7. *Input to Instrument* – The complete instrument does not draw more than 4.5 VA (volt-amperes) at 15 kV, and at lower voltages, the input is less.

Authorized Engineering Information 9-26-1988.

2.9.4 Computation of Voltage Regulation

The voltage regulation of constant-potential transformers for any specified loss and power factor may be computed from the measured impedance loss, impedance voltage, and current, as follows:

1. Exact Formulas for the Calculation of Regulation are:
   a. When the load is lagging, regulation =

$$\sqrt{(p+r)^2+(x+q)^2}\ -1$$

(Equation 2-1)

   b. When the load is leading, regulation =

$$\sqrt{(p+r)^2+(x-q)^2}\ -1$$

(Equation 2-2)

where –

p = power factor of load

$q = \sqrt{1-p^2}$

r = resistance factor of transformer at reference temperature (see 2.7.1) = $\frac{\text{impedance loss in watts}}{\text{rated VA of transformers}}$

x = reactance factor of transformer = $\sqrt{z^2-r^2}$

z = impedance factor of transformer = $\frac{\text{impedance VA}}{\text{rated VA of transformer}}$

The quantities p, q, x, and r are on a per-unit basis, so the result is to be multiplied by 100 to get the regulation in percent.

For convenience, some of the corresponding values of p and q are given in the following table:

p	q	p	q
1.00	0.00	0.65	0.760
0.95	0.312	0.60	0.800
0.90	0.436	0.50	0.866
0.85	0.527	0.40	0.916
0.80	0.600	0.30	0.954
0.75	0.661	0.20	0.980
0.70	0.714	0.10	0.995

2. Approximate Formulas Generally Used for the Calculation of Regulation are:
   a. When the load is lagging, regulation =

$$pr + qx + \frac{(px-qr)^2}{2}$$

(Equation 2-3)

   b. When the load is leading, regulation =

$$pr - qx + \frac{(px+qr)^2}{2}$$

(Equation 2-4)

The approximate formulas give results very close to those of the exact formula.

Authorized Engineering Information 9-26-1988.

2.9.5 Temperature-rise Test

2.9.5.1. Methods of Temperature Determination

The temperature shall be measured by the resistance method or by the thermometer or thermocouple method.

1. *Thermometer or Thermocouple Method.* Temperatures shall be determined applying alcohol or resistance thermometers or thermocouples to the hottest accessible part.
2. *Resistance Method.* Temperatures shall be determined by comparing the resistance of a winding at the temperature to be determined with the resistance at a known temperature.

NEMA Standard 9-20-1972.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

2.9.5.2. METHODS OF LOADING

Transformers should be tested whenever practicable under conditions that will yield total losses approximating, as closely as possible, those obtained under specified load conditions.

Transformers may be tested under actual load conditions by loading them on a rheostat, bank of lamps, water box, and such.

Single-phase transformers of the same design and rating may be tested in banks of two by connecting both the high- and low-voltage windings design in parallel and by applying rated voltage at rated frequency to one set of paralleled windings, as shown in Figure 2-2. The connections of the other pair of windings may be opened at one point, and a voltage from an auxiliary source may be impressed across the break. This voltage should be just sufficient to circulate rated current through the windings. The circulated current should preferably be at rated frequency. If at other than rated frequency, it should be adjusted to yield the true impedance losses of the transformers.

Authorized Engineering Information 9-26-1988.

2.9.5.3. TEST PROCEDURE

Transformers under test shall be completely assembled, shall have their final exterior finish, and shall be mounted essentially as they would be in service.

The test shall be made in a room as free from drafts as practicable. The enclosure or core of the transformer, or both, shall be grounded during the test.

The ambient temperature shall be determined by several thermometers placed at different points around the room. The thermometers shall be located approximately at the same elevation as the transformer and at a distance of approximately 3 feet (1 meter) from the transformer and shall be protected from drafts and abnormal heating.

NEMA Standard 9-26-1988.

All reasonable precaution should be taken to avoid errors due to the time lag between the temperature of the transformer and the variations in the ambient temperature. For example, mercury thermometers immersed approximately 2 inches in a suitable heavy metal cup containing oil may be used.

Authorized Engineering Information 9-26-1988.

Where applicable, provision shall also be made to measure the surface temperature of iron or alloy parts surrounding, or adjacent to, the outlet leads or terminals

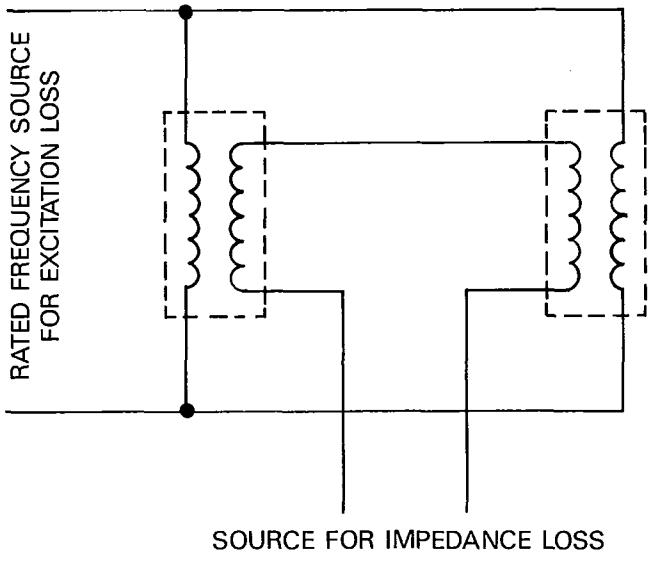


Figure 2-2
TWO SINGLE-PHASE TRANSFORMERS IN OPPOSITION

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

carrying large currents. Readings shall be taken at intervals or immediately after shutdown.

The temperature rise shall be determined after the temperature of the transformer has become constant. The temperature shall be considered constant when 3 successive readings of thermometers or thermocouples, placed at the hottest accessible part of the transformer, taken at minimum intervals of 10 minutes, indicate a change no greater than 2½ percent or 1°C, whichever is greater.

The bulbs of thermometers, or the junctions of thermocouples used for taking temperatures of other than oil-immersed transformers, shall be covered by glazier's putty or by pads cemented or taped to the transformer, except that grooved sticks may be used when putty or pads interfere with ventilation, as in ventilation ducts between coils.

NEMA Standard 9-26-1988.

The time required to bring the transformer to constant temperature may be shortened by the use of initial overloads, restricted cooling, or any other suitable method. Care should be taken to avoid overheating and consequent damage to insulation.

Authorized Engineering Information 9-26-1988.

All hot-resistance readings shall be completed, if possible, within 4 minutes after shutdown. If this cannot be accomplished, the temperature test shall be resumed until constant temperatures are again obtained, after which the remainder of the readings shall be taken. The elapsed time between the instant of shutdown and each resistance measurement shall be recorded and shall not in any case exceed 4 minutes. When transferring the measuring leads from one winding to another, the same relative polarity shall be maintained between the measuring leads and the transformer terminals.

The relation between the average temperature of a copper winding and its resistance shall be determined from the following formula:

$$\theta_1 = \frac{R_1}{R_0} (K + \theta_0) - K$$

(Equation 2-5)

where –

θ_1 = temperature in degrees C corresponding to hot resistance, R_1

θ_0 = temperature in degrees C corresponding to cold resistance, R_0

K = 234.5 for copper and 226 for aluminum.

The observed temperature rise at a measured time from shutdown shall be corrected back to the actual time of shutdown. This correction shall be permitted to be determined by making a series of resistance measurements and, from these, calculating and plotting a time-temperature curve which is extrapolated back to the instant of shutdown.

NEMA Standard 9-26-1988.

For 65°C rise or less, approximate results may be obtained by using an arbitrary correction of 1°C per minute, provided the time between the instant of shutdown and the measurement of the hot resistance does not exceed 4 minutes and provided the winding loss as measured by a wattmeter does not exceed 7 watts per pound for copper or 14 watts per pound for aluminum.

In determining the winding loss in watts per pound, the total loss in both windings, measured by a watthour, may be apportioned between the high- and low-voltage windings in the ratio of their respective calculated I^2R loss, if the conductor I^2R and eddy loss cannot be determined conveniently.

Authorized Engineering Information 9-26-1988.

2.10 MARKING

These standards cover the marking of winding terminals brought out of the case and of external terminals of a core-and-coil transformer. They do not apply to the winding terminals inside the case or to the internal coil connections of a core-and-coil transformer.

2.10.1. Polarity of Single-phase Transformers

When terminals are marked in accordance with Figures 2-3 through 2-7, the polarity will be additive.

2.10.2 Identification of Windings and Marking of Terminals

In a two-winding transformer, the high-voltage winding shall be designated as the H winding and the low-voltage windings as the X winding. If both windings have the same voltage rating and if one is compensated, the winding that is compensated shall be designated as the X winding.

The terminals of a winding shall be distinguished from one another by marking each terminal with the capital letter designating the winding, followed by a number, e.g., H1, H2, X1, X2.

When a transformer has a two-terminal secondary winding with one terminal grounded and the other ungrounded, the grounded terminal shall be marked X2.

NEMA Standard 9-20-1972.

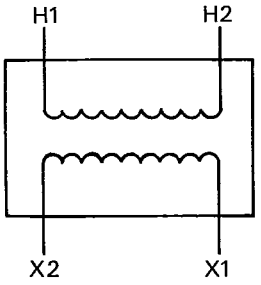
2.10.3. Numbering Terminals

2.10.3.1 Order of Terminals of Any Winding

1. The terminals of any winding brought out of the case shall be numbered 1, 2, 3, 4, 5, etc., the lowest (and the) highest numbers marking the full winding and the intermediate numbers marking fractions of windings or

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale



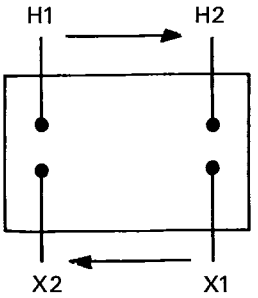


Figure 2-3
SIMPLE H AND X WINDINGS WITHOUT TAPS

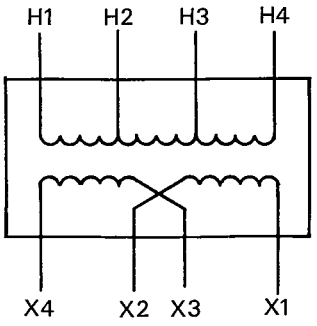


Figure 2-4
SIMPLE H WINDING WITH TAPS
SERIES-PARALLEL X WINDING

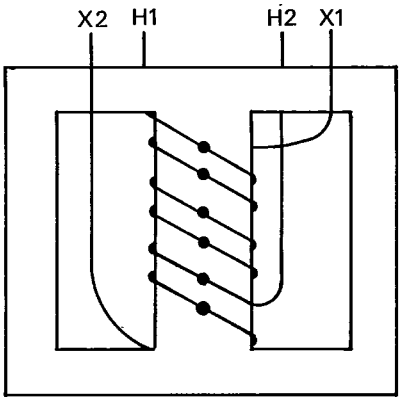


Figure 2-6
ADDITIVE POLARITY—
SINGLE-PHASE TRANSFORMER

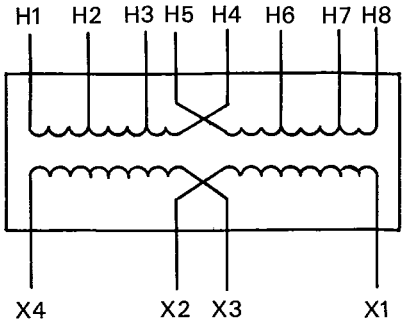


Figure 2-5
SERIES-PARALLEL H WINDING WITH TAPS
SERIES-PARALLEL X WINDING

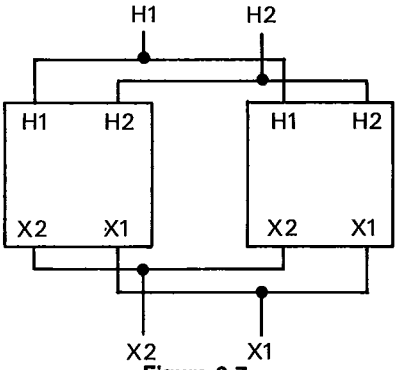


Figure 2-7
CONNECTIONS FOR SINGLE-PHASE TRANSFORMERS
IN PARALLEL—ADDITIVE POLARITY

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

taps. All numbers shall be so applied that the potential difference from any terminal having a lower number toward any terminal having a higher number shall have the same sign at any instant. (See Figures 2-3 through 2-5)

NEMA Standard 9-20-1972.

2. If the winding is divided into two or more parts for series-parallel connections and the terminals of these parts are brought out of the case, 2.10.3.1.a shall apply for the series connection with the addition that the terminals of each portion of the winding shall be given consecutive numbers. (See Figures 2-4 and 2-5)

NEMA Standard 9-20-1972.

2.10.3.2 Order of Terminals of Different Windings

1. The terminals of the H winding and the terminals of the X winding of a single-phase transformer shall be located and numbered so that when H1 and X1 are connected together and voltage applied to the transformer, the voltage between the highest numbered H terminal and the highest numbered X terminal shall be less than the voltage of the H winding. When more than two windings are used, the same relationship shall apply between each pair of windings.

NEMA Standard 9-20-1972.

2. Single-phase autotransformer terminals shall, as far as practical, be marked in accordance with Figure 2-8.

NEMA Standard 9-26-1988.

2.10.3.3 Location of External Terminals of Single-Phase Transformers

1. To simplify the work of connecting transformers, the H1 terminal shall be brought out on the right-hand side of the case, facing the higher voltage side of the case, and other H terminals shall be brought out in numerical order from right to left.

NEMA Standard 9-20-1972.

2. When the high-voltage winding has only one terminal brought out through a rated-voltage bushing and the other terminal is grounded, the rated-voltage terminal shall be designated as H1. For polarity marking and testing, the H1 terminal shall be regarded as located on the right, regardless of its actual location.

NEMA Standard 9-20-1972.

Exception – If two alternate positions are provided for the single rated-voltage bushing, the two positions shall be identified by terminal markings in accordance with 2.10.3.3.1.

NEMA Standard 9-26-1988.

2.10.3.4 Parallel Operation

Single-phase transformers having terminals marked in accordance with this standard may be operated in parallel by connecting similarly marked terminals together, provided their ratios, voltages, resistances, reactances, and ground connections are such as to permit parallel operation.

NOTE – In some cases, designs may be such as to permit parallel operation although, due to a difference in the number of tap terminals, the terminals to be connected are not similarly marked.

Authorized Engineering Information 9-26-1988

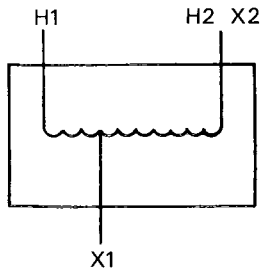


Figure 2-8
AUTOTRANSFORMER

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Section 3
CONTROL TRANSFORMERS

Section 3 applies to a type of specialty transformer commonly known as a control transformer. These transformers are dry-type, constant-potential, step-down, insulating transformers, which are generally used with their primary windings connected to secondary distribution circuits of 600 volts or less to supply lighting and control loads up to 250 volt-amperes. These standards, except for ratings, may be applicable to transformers having other than standard rating. Portions of the general standards given in Section 2 also apply to control transformers.

Authorized Engineering Information 9-20-1972.

3.1. OUTPUT AND VOLTAGE RATINGS

Output and voltage ratings of control transformers shall be in accordance with Table 3-1.

These output voltampere ratings are based on the highest rated secondary voltage and are proportionately reduced at the lower secondary voltage.

NEMA Standard 9-20-1972.

3.2 DIELECTRIC TESTS

3.2.1 Applied-potential Test

Control transformers shall be capable of withstanding for 1 minute, between windings and between each winding and ground, successive applications of a low-frequency voltage from an external source in accordance with Table 3-2.

All other circuits and metal parts shall be grounded during the test.

NEMA Standard 9-20-1972.

Table 3-1
Ratings of Control Transformers

Primary Voltage Rating, Volts	Secondary Voltage Rating, Volts	Output Rating, Voltamperes								
		7.5	10	15	25	35	50	75	150	200
120 or 240	6	X	X	X	X	X	X	X	X	X
	12	X	X	X	X	X	X	X	X	X
	24	X	X	X	X	X	X	X	X	X
	32	X	X	X	X	X	X	X	X	X
	8-16-12	X	X	X	X	X	X	X	X	X
	6-12	...	X	X	X	X	X	X	X	X
480 or 600	12	X	X	X	X	X	X	X	X	X
	24	X	X	X	X	X	X	X	X	X
	120	...	...	...	X	...	X	X	X	X
	240	...	...	X	...	X	X	X	X	X

Table 3-2
Low Frequency Voltage Test

Rated Voltage of Winding or Circuit, Volts*	Test Potential	
	Rms	Volts
25 or less	1	500
26-250	1	500
251-600	2	500

* If it is known that a winding will operate in a circuit having a higher voltage than the rated voltage of the winding, the test voltage shall be in accordance with the rated voltage of the circuit.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

3.2.2 Induced-potential Test

Control transformers shall be capable of withstanding between the terminals of one winding, at a suitable frequency, the application of a voltage that is twice the rated voltage of that winding. For the duration of this test, see 2.9.2.2.

NEMA Standard 9-20-1972.

3.3 VOLTAGE RATIO

A control transformer shall be so designed that, when rated voltage is applied to the primary winding, the secondary winding will deliver rated voltamperes at approximately rated voltage. For control transformers, this will necessitate an alteration in the turns ratio to compensate for regulation. Transformers shall be compensated at the proper reference temperature (see 2.7.1) to deliver rated voltamperes at 100-percent power factor, at approximate rated voltage, from one winding when rated voltage is applied to the other winding.

NEMA Standard 9-20-1972.

3.4 LIMITS OF TEMPERATURE RISE

The temperature rise of a control transformer above the ambient temperature, when measured by the resistance method and tested in accordance with the applicable provisions of 2.9.5, shall not exceed the following:

Winding Temperature Rise by Resistance, Degrees C	Hottest-spot Winding Temperature Rise,Degrees C
55	65
80	110

For the test, the transformer shall be operated continuously at rated output and highest rated secondary voltage from a rated primary voltage.

See 2.3 for correction factors to be applied for transformers intended for service at altitudes higher than 3300 feet (1000 meters).

NEMA Standard 9-20-1972.

3.5 CONSTRUCTION

3.5.1 Approval

Authorities having jurisdiction over electrical installations generally require control transformers to conform to the appropriate standards of nationally recognized safety testing organizations, such as Underwriters Laboratories, Inc.

Authorized Engineering Information 9-26-1988.

3.5.2 Insulating Bushings

Bushings of control transformers shall be of porcelain, cold-molded, or phenolic composition or of other insulating material suitable for the purpose. Rubber, wood, hot-molded, shellac, and tar compositions shall not be used.

NEMA Standard 9-26-1988.

3.5.3 Terminals

Control transformers shall be provided with wire leads for the connection of primary and secondary circuit conductors.

In the case of transformers having output ratings exceeding 100 voltamperes and having secondary voltage ratings not exceeding 150 volts, wire leads shall consist of stranded wire no smaller than No.18 AWG and shall have an insulation at least equal to Type RF-2 rubber-covered fixture wire (for explanation of these designations, see the *National Electrical Code)* or its approved equivalent.

In the case of transformers having output ratings exceeding 100 voltamperes and having secondary voltage ratings exceeding 150 volts, wire leads shall consist of stranded wire no smaller than No. 14 AWG and shall have an insulation at least equal to Type R rubber-covered or Type V varnished-cambric-covered wire (for explanation of these designations, see the *National Electrical Code*) or their approved equivalent.

Leads shall extend not less than 6 inches and, if of wire smaller than No. 14 AWG, no more than 12 inches outside of the enclosure.

Leads shall be securely soldered, brazed, or connected by other equivalent means to the windings within the enclosure. Unless they enter the enclosure through a nipple or other means for the attachment of conduit, leads shall enter the enclosure (if of conducting material) through insulating bushings that will separate the wires and provide a spacing of not less than ½ inch between the wires and the plane of support of the transformer. Strain relief shall be provided so that a mechanical strain on leads will not be transmitted to the soldered joints at the connections to the windings.

Leads shall not enter the enclosure through a removable cover if connections are to be made in the field.

NEMA Standard 9-20-1972.

3.5.4 Mechanical Construction

3.5.4.1. ENCLOSURE

Control transformers shall be provided with enclosures of non-combustible moisture resistant material protected against corrosion. The enclosures shall contain all uninsulated live metal parts, except that primary or secondary leads may extend outside of enclosures.

The enclosure of an indoor transformer, if of sheet steel, shall be formed from stock not less than 0.027 inch (No. 22 Manufacturer's Standard Gage) in thickness.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

An enclosure of material other than sheet steel shall provide equivalent mechanical strength and rigidity.

The enclosure of an outdoor transformer, if of sheet steel, shall be formed from stock not less than 0.054 inch (No. 16 Manufacturer's Standard Gage) in thickness. An enclosure of material other than sheet steel shall provide equivalent strength and rigidity. Holes for conduits shall be threaded when located above any live metal part. Threaded holes for conduits shall be reinforced to provide metal at least 1/4 inch in thickness. Bushed holes for open wiring shall not be located in the top or back of the enclosure, except when special hood fittings are provided. When bushed holes are located in the sides above live metal parts, provision shall be made for wires to leave the enclosure in a downward direction.

NEMA Standard 9-20-1972.

3.5.4.2. MOUNTING

The enclosure of a control transformer shall be so designed that it can be mounted on a plane surface and shall make contact only at the points of support. The mounting shall be such as to maintain an air space of not less than 1/4 inch between the enclosure and the supporting surface.

NEMA Standard 9-20-1972.

3.5.5 Marking

3.5.5.1. TRANSFORMER MARKING

Control transformers shall be plainly marked with the following minimum information in such a manner that the markings will be readily visible after the transformers are installed as intended:

1. Manufacturer's name or trademark;
2. Catalog or distinguishing number;
3. Frequency;
4. Voltages; and,
5. Voltampere output (continuous rating).

3.5.5.2. TERMINAL MARKING

The terminals of control transformers shall be marked in accordance with 2.10.

NEMA Standard 9-20-1972.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SECTION 4
INDUSTRIAL CONTROL TRANSFORMERS

Section 4 applies to a type of specialty transformer commonly known as an industrial control transformer. These transformers are dry-type, constant-potential, step-down, insulating transformers, which are generally used with primary windings connected to secondary distribution circuits of 600 volts or less to supply localized lighting and to operate electromagnetic devices, including solenoids, contactors, and relays for the control of motors in both portable and stationary tools. These standards, except for ratings, may be applicable to transformers having other than standard ratings. Portions of the general standards given in Section 2 also apply to industrial control transformers.

Authorized Engineering Information 9-20-1972.

4.1 TYPES

An industrial control transformer shall be one of the following types:

Type I – Without integral overcurrent protection.

Type II – With integral overcurrent protection.

NEMA Standard 9-20-1972.

4.2 OUTPUT AND VOLTAGE RATINGS

Ratings of industrial control transformers shall be in accordance with Table 4-1.

NEMA Standard 9-20-1972.

These standards, except for standards rating, may be applicable to transformers other than standard ratings.

Authorized Engineering Information 9-26-1988.

4.3 DIELECTRIC TESTS

4.3.1 Applied-potential Test

1. Industrial Control transformers shall be capable of withstanding for 1 minute, between windings and between each winding and ground, successive applications of a low-frequency voltage from an external source, in accordance with the following:

Rated Voltage of Winding	Test Voltage	
Volts	Rms	Volts
250 or less	1	050
251-600	2	500
2400	10	000
4160	12	000
4800	12	000

All other circuits and metal parts shall be grounded during the test.

NEMA Standard 9-20-1972.

2. As an alternative to the 1 minute test, production/routine may be for 1 second with a voltage 20 percent higher than the 1 minute test voltage where the specified test voltage is 2500 volts or less.

Authorized Engineering Information 9-26-1988.

Table 4-1
Ratings of Industrial Control Transformers

Primary Voltage Rating, Volts	Secondary Voltage Rating, Volts	Frequency, Hertz	Output Rating, Voltamperes								
			75	150	300	500	750	1000	1500	3000	5000
240/480	120	60	X	X	X	X	X	X	X	X	X
208/230/380/416/460	115/95*	50†	...	X	X	...	X	X	X	...	...
230/460/575	115	25	...	X	X	X	...	...	...	...	...
2400	120	60	...	...	...	...	...	...	X	X	X
4160	120	60	...	...	...	...	...	X	X	X	X
4800	120	60	...	...	...	...	...	X	X	X	X

*The 95-volt tap is intended to operate electromagnetic devices at 50 Hz at the rated current obtained at 115 volts, 60 Hz.

†These transformers may be operated at 60 Hz. In such cases, the output voltages may be slightly lower than that shown in Figures 4-1 and 4-2.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

4.3.2 Induced-potential Test

Industrial control transformers shall be capable of withstanding between the terminals of one winding, at a suitable frequency, the application of a voltage that is twice the rated voltage of that winding. For the duration of this test, see 2.9.1.

NEMA Standard 9-20-1972.

4.4 TOLERANCES FOR REGULATION

An industrial control transformer shall be so designed that, when rated voltage and frequency are applied to the primary winding, the secondary voltage shall be within the limits shown by the curves of Figures 4-1 and 4-2.

Secondary voltages at various loads shall be obtained by actual measurement when the temperature of the windings is 75°C or shall be calculated by the methods set forth in 2.9.4.

NEMA Standard 9-20-1972.

4.5 LIMITS OF TEMPERATURE RISE

The temperature rise of an industrial control transformer above the ambient temperature, when measured by the resistance method and tested in accordance with applicable provisions of 2.9.5, shall not exceed the following:

Winding Temperature Rise by Resistance, Degrees C	Hottest-spot Winding Temperature Rise, Degrees C
55	65
80	110
115	145
150	180

For this test, the transformer shall be operated from a circuit of rated primary voltage and shall deliver rated kVA output at:

1. Rated secondary voltage; and,
2. Higher secondary-voltage rating when the transformer has a secondary tap.

If provided with taps in the primary winding, the transformer shall deliver rated kVA output at the secondary voltages specified above when excited on the rated kVA tap of the lowest voltage.

See 2.3 for correction factors to be applied for transformers intended for service at altitudes higher than 3300 feet (1000 meters).

NEMA Standard 9-20-1972.

4.6 CONSTRUCTION

4.6.1 Overcurrent Protective Device

Type II industrial control transformers shall be provided with a cartridge or plug-type fuse or with some other type of overcurrent protective device placed in series with the X1 terminal of the secondary circuit and mounted on the terminal panel or in a readily accessible position at or near the top of the transformer.

NEMA Standard 9-20-1972.

4.6.2 Terminals

Industrial control transformers shall be provided with leads, screw or stud-type, or quick connect terminals, which shall be mounted on the coil or on a panel(s) or equivalent, readily accessible from the top of the transformer, opposite the mounting brackets or plate.

NEMA Standard 9-26-1988.

4.6.3 Mechanical Construction

Industrial control transformers shall be of the unenclosed core and coil type and shall be provided with mounting brackets or a mounting plate.

NEMA Standard 9-26-1988.

Exception: Encapsulated or similar construction may be used; however, the terminals should not be enclosed.

Authorized Engineering Information 9-26-1988.

4.6.4 Marking

4.6.4.1. TRANSFORMER MARKING

Marking shall be permanent in nature and shall be so located that it will be readily visible after the transformers are installed as intended. It shall consist of the following minimum information:

1. Manufacturer's name or trademark;
2. Catalog or distinguishing number;
3. Frequency;
4. Voltages; and,
5. Voltampere output (continuous ratings).

A connection diagram shall be furnished with each transformer, preferably on the nameplate.

4.6.4.2. TERMINAL MARKINGS

The terminal's industrial control transformers shall be marked in accordance with 2.10.

NEMA Standard 9-20-1972.

4.7 STANDARD APPLICATION DATA

These standards are intended for general guidance in the design and application of industrial control transformers. To ensure the selection of the proper transformer particular for the load or loads involved, it is recommended that the transformer manufacturer be consulted.

Authorized Engineering Information 9-20-1972.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS Not for Resale

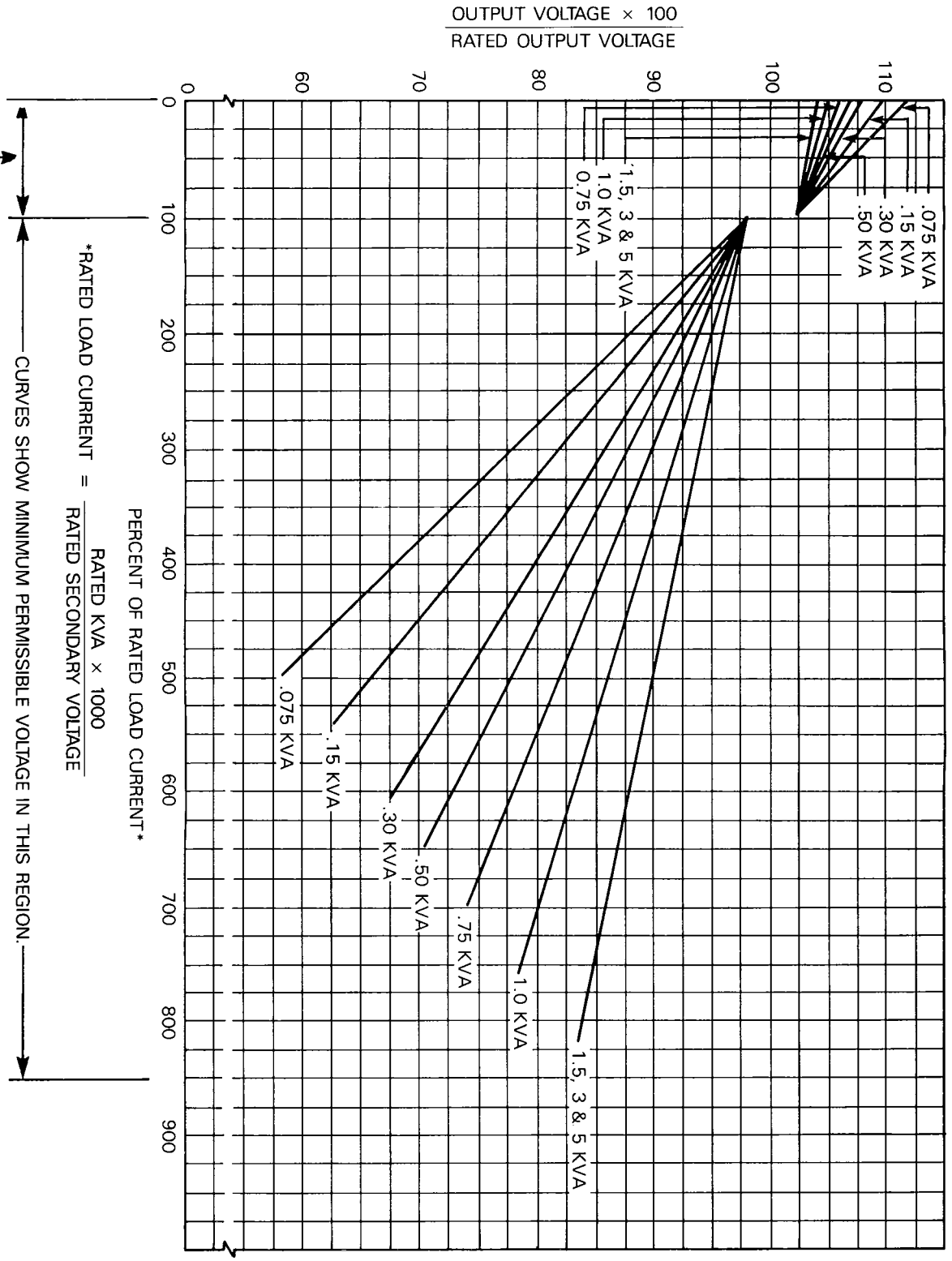


Figure 4-1
CURVES FOR OUTPUT VOLTAGE VERSUS LOAD CURRENT—100 PERCENT POWER-FACTOR LOAD

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

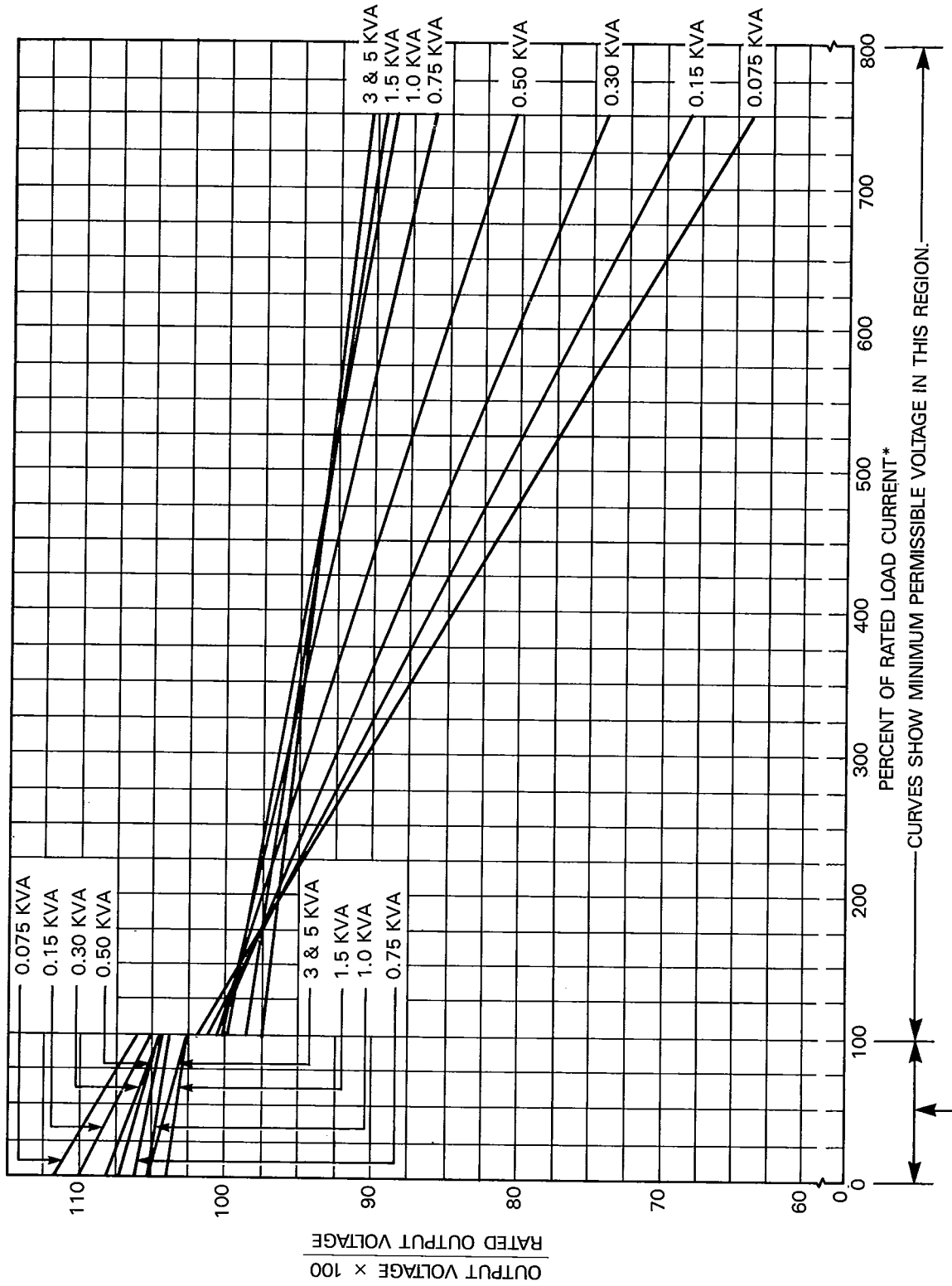


Figure 4-2
CURVES FOR OUTPUT VOLTAGE VERSUS LOAD CURRENT—20 PERCENT LAGGING POWER-FACTOR LOAD

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

SECTION 5
CLASS 2 TRANSFORMERS

Section 5 applies to a type of specialty transformer commonly known as a Class 2 transformer. These transformers are dry-type, step-down, insulating transformers suitable for use in *National Electrical Code* Class 2 circuits. They are generally used in remote-control, low-energy-power, and signal circuits for the operation of bells, chimes, furnace controls, valves, relays, solenoids, and the like. These standards, except for ratings, may be applicable to transformers having other than standard ratings. Portions of the general standards given in Section 2 also apply to Class 2 transformers.

Authorized Engineering 9-20-1972.

5.1 TYPES

A Class 2 transformer shall be permitted to be either an energy-limiting or a non-energy-limiting transformer. (See 1.2.13.4 and 1.2.13.11.)

NEMA Standard 9-26-1988.

An energy-limiting Class 2 transformer may or may not be provided with a thermostat or other temperature-sensitive devices to limit maximum temperature.

Authorized Engineering Information 9-26-1988.

A non-energy-limiting Class 2 transformer shall be provided with an overcurrent protective device limiting the output current to a thermally safe maximum value.

NEMA Standard 9-20-1972.

5.2 OUTPUT AND VOLTAGE RATINGS

The primary voltage rating of Class 2 transformers shall be 120 volts. Output ratings shall be in accordance with Table 5-1.

NEMA Standard 9-20-1972.

5.3 DIELECTRIC TESTS

5.3.1 Applied-potential Test

Class 2 transformers shall be capable of withstanding for 1 minute, between windings and between each winding and ground, successive applications of a low-frequency voltage from an external source, in accordance with the following:

Winding	Test Potential, Rms Volts
Primary	1500
Secondary	500

All other circuits and metal parts shall be grounded during the test.

NEMA Standard 9-20-1972.

5.3.2 Induced-potential Test

Between the terminals of one winding and at a suitable frequency, Class 2 transformers shall be capable of withstanding the application of a voltage

Table 5-1
Ratings of Class 2 Transformers

	Secondary Voltage Rating, Volts	Output Rating, Voltamperes							
		5	10	20	25	35	45	50	75
	Maximum Open-circuit Voltage								
Energy-limiting Transformer	10*	X	...	...	...	...	...	...	...
	16*	...	X	...	...	...	...	...	...
	30	...	X	X	X	X	X	...	...
	Load Voltage								
Non-energy-limiting Transformer	24	...	...	X	X	X	...	X	X

*Bell and chime transformers.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

that is twice the rated voltage of that winding. For the duration of this test, see 2.9.2.

NEMA Standard 9-20-1972.

5.4 TEMPERATURE RISE

5.4.1 Energy-limiting Class 2 Transformer

The temperature rise above the ambient temperature, when measured by thermocouple at any point on the enclosure, shall not exceed 60°C when the transformer is operated continuously on a circuit of rated primary voltage and frequency with all secondary terminals short-circuited; except that the temperature rise shall be permitted to exceed 60°C but shall not exceed 125°C, if the transformer is designed to burn out, without the emission of flame or molten material and without other evidence of hazard, in less than 1 hour after the primary is energized. The transformer shall be tested in accordance with the applicable provisions of 2.9.5.

NEMA Standard 9-20-1972.

5.4.2 Non-energy-limiting Class 2 Transformer

The temperature rise above the ambient temperature, when measured by a thermocouple at any point on the enclosure, shall not exceed 60°C when the transformer is deliveringcontinuously its rated voltampere output to a resistance load, with the primary terminals connected to a circuit of rated primary voltage and frequency. The transformer shall be tested in accordance with the applicable provisions of 2.9.5. The overcurrent protective device shall not be shunted out and shall not break the circuit during the test.

See 2.3 for correction factors to be applied for transformers intended for service at altitudes higher than 3300 feet (1000 meters).

NEMA Standard 9-20-1972.

5.5 CONSTRUCTION

5.5.1 Approval

Authorities having jurisdiction over electrical installations generally require Class 2 transformers to conform to the standards of nationally-recognized safety testing organizations.

Authorized Engineering Information 9-26-1988.

5.5.2 Protective Devices

5.5.2.1. GENERAL

1. Mounting—All parts of a protective device (other than the reset button or handle of a manually reset device), provided as part of a Class 2 transformer, shall be reliably secured inside the transformer enclosure in such a manner that they will be inaccessible to tampering; except that renewable devices shall be accessible for replacement purposes. A renewable device shall not be interchangeable with one of a different current rating.

   NEMA Standard 9-20-1972.

2. Overload Test on Manually Reset Devices—A manually reset temperature-sensitive or overcurrent device shall be capable of withstanding an overload test for 50 opening-and-closing cycles with a maximum of 1 minute between opening and closing. The transformer shall be connected to a circuit of rated voltage and frequency, and maximum current shall be drawn from the secondary winding. There shall be no emission of flame or molten material from the transformer enclosure and no other evidence or hazard, and, at the conclusion of the test, the device shall be operable.

   NEMA Standard 9-20-1972.

5.5.2.2. TEMPERATURE-SENSITIVE DEVICES FOR ENERGY-LIMITING CLASS 2 TRANSFORMERS

A manually reset temperature-sensitive device shall be trip-free.

An automatically temperature-sensitive device shall not open when the transformer is delivering its rated voltampere load.

A transformer provided with an automatically reset temperature-sensitive device shall be capable of operating for 15 days with the primary terminals connected to a circuit of rated voltage and frequency and with maximum current drawn from the secondary winding. There shall be no emission of flame or molten material from the transformer enclosure and no other evidence of hazard, and, at the conclusion of the test, the device shall be operable.

NEMA Standard 9-20-1972.

5.5.2.3. OVERCURRENT PROTECTIVE DEVICES FOR NON-ENERGY-LIMITING CLASS 2 TRANSFORMERS

An overcurrent protective device shall not be of the automatic-reclosing type and shall be trip-free.

A fuse, when used as an overcurrent protective device, shall be rated at not more than 5 amperes if the open-circuit secondary voltage is 15 volts or less, and 3.2 amperes if the voltage is more than 15 volts.

An overcurrent protective device, other than a fuse, shall open the circuit within the time indicated, when the transformer is delivering the secondary current indicated in the following table:

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Rated Open-circuit Second Voltage, Volts	Secondary Test Current, Amperes	Maximum Time for Overcurrent Protective Device to Open, Minutes
15 or less	10	2
15 or less	6.75	60
16-30	6.4	2
16-30	4.32	60

NEMA Standard 9-20-1972.

5.5.3 Terminals

5.5.3.1. Primary Circuit Leads

Wire leads shall be provided as a part of a Class 2 transformer for the connection of the primary circuit conductors, unless the transformer is designed to be mounted on an outlet box.

Such leads shall be of Type RF-2 stranded fixture wire or approved equivalent, and shall not be smaller than No. 18 AWG. They shall extend not less than 6 inches and, if of wire smaller than No. 14 AWG, not more than 12 inches outside of the enclosure.

They shall enter the enclosure (if of conducting material) through insulating bushings, which will separate the wires and provide a spacing of not less than ½ inch between the wires and plane of support of the transformer; except that, where a transformer is mounted on an outlet box cover in such a manner that the leads enter the outlet box without being exposed, the insulating bushings may be omitted if a smoothly rounded opening is provided. Strain relief shall be provided so that a mechanical strain on the leads will not be transmitted to the points at the connections to the primary winding.

NEMA Standard 9-20-1972.

5.5.3.2. Secondary Circuit Connections

Either binding screw terminals or insulated wire leads shall be provided for the connection of secondary circuit conductors. Secondary terminal plates and wire-binding screws, studs, and nuts shall be constructed as specified for primary terminals, except that they may be of plated steel; and cupped washers, upturned lugs, or the equivalent are not required.

NEMA Standard 9-20-1972.

5.5.3.3. Connections for Outlet-box-mounted Transformers

Primary binding screw terminals for the connection of circuit conductors shall be permitted for use on Class 2 transformers designed to be mounted on an outlet box. The terminal lugs in such a case shall be of nonferrous metal, shall be made of stock not less than 0.030 inch in thickness, and shall have not less than two full threads in the metal for the binding screws.

Primary wiring terminals shall be provided with cupped washers, upturned lugs, or equivalent means to retain the wires under the heads of screws or nuts, and shall be No. 6-32 or larger machine screws. They shall be so located or protected that they will not be forced against the wiring in the outlet box when the transformer is installed and shall be so designed that a spacing of not less than ½ inch will be maintained between live parts of opposite polarity and between live parts and metal that may be grounded.

NEMA Standard 9-20-1972.

5.5.4 Mechanical Construction

5.5.4.1. Enclosure

Class 2 transformers shall be provided with enclosures of non-combustible, moisture-resistant material protected against corrosion. The enclosures shall contain all uninsulated live metal parts except secondary terminals. However, if the transformer is intended for mounting on an outlet box, primary terminals that will be inside the outlet box when the transformer is installed need not be additionally enclosed.

NEMA Standard 9-20-1972.

The enclosure, if of sheet steel, shall be formed from stock not less than 0.027 inch (No. 22 Manufacturer's Standard Gage) in thickness. An enclosure of material other than sheet steel shall provide equivalent mechanical strength and rigidity. The design of the enclosure shall be such that it will be unnecessary to have access to the interior in mounting the device or connecting wires. All covers, bases, and such, shall be securely fastened in place.

NEMA Standard 9-20-1972.

5.5.4.2. Mounting

The enclosure of a Class 2 transformer shall be designed for mounting either on a plane surface or on an outlet box.

For mounting on a plane surface, the enclosure shall be so designed that it will make contact only at the points of support. An air space of not less than 1/4 inch shall be maintained between the enclosure and the supporting surface.

For mounting on an outlet box in place of a cover, the transformer shall include an outlet box cover or the equivalent which, if of sheet steel, shall have an average thickness of not less than 0.067 inch (No. 14 Manufacturer's Standard Gage).

NEMA Standard 9-20-1972.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

5.5.5 Marking

5.5.5.1. TRANSFORMER MARKING

Class 2 transformers shall be plainly marked with the following minimum information in such a manner that the markings will be readily visible after the transformers are installed as intended:

1. Manufacturer's name or trademark;
2. Catalog or distinguishing number;
3. Frequency;
4. Voltages;
5. Voltampere output; and,
6. The words "Class 2."

NEMA Standard 9-20-1972.

5.5.5.2. TERMINAL MARKING

The primary terminals or leads shall be marked "Line." The secondary terminals or leads shall be marked "Load," except that they shall be permitted to be marked "Bell" or "Chime" if intended for such applications.

NEMA Standard 9-20-1972.

5.6 OUTPUT LIMITATIONS

5.6.1 Open-circuit Secondary Voltage Limitation

The open-circuit voltage between any two secondary terminals of a Class 2 transformer shall not exceed 30 volts when the transformer is operated with rated primary voltage and frequency applied to the primary terminals; in the case of a non-energy-limiting transformer having an open-circuit rating of 15 volts or less, the open-circuit secondary voltage shall not exceed 15 volts.

NEMA Standard 9-20-1972.

5.6.2 Current Output Limitation (Energy-limiting Transformer)

The secondary output current of an energy-limiting-Class 2 transformer shall not exceed 8 amperes.

NEMA Standard 9-20-1972.

5.6.3 Voltampere Capacity Limitation (Non-energy-limiting Transformer)

The voltampere capacity of a non-energy-limiting transformer shall not exceed 100 volt-amperes.

NEMA Standard 9-20-1972.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SECTION 6
SIGNALLING TRANSFORMERS

Section 6 applies to a type of specialty transformer commonly known as a signalling transformer. These transformers are dry-type, constant-potential, step-down, insulating transformers, which are generally used with primary windings connected to secondary distribution circuits to supply signalling systems not subject to Class 2 circuit limitations. These standards except for ratings, may be applicable to transformers having other than standard ratings. Portions of the general standards given in Section 2 also apply to signalling transformers.

Authorized Engineering Information 9-20-1972.

6.1 OUTPUT AND VOLTAGE RATINGS

Output and voltage ratings of signalling transformers shall be as given in the following:

Primary Voltage Rating, Volts	Secondary Voltage Rating, Volts*	Operating Rating, Voltamperes†
120 or 240	4-8-12-16-20-24	50, 100, 250, 500, 750, 1000

*The secondary voltages shall be obtained with four leads or terminals, as follows:

< --4 volts-- > < ------12 volts------ > < ----8 volts---- >

< --------16 volts-------- >

< ----------20 volts---------- >

< ------------24 volts------------ >

†These output voltampere ratings are based on the highest rated secondary voltage and are proportionately reduced at the lower secondary voltages.

NEMA Standard 9-20-1972.

6.2 DIELECTRIC TESTS

6.2.1 Applied-potential Test

Signalling transformers shall be capable of withstanding for 1 minute, between windings and between each winding and ground, successive applications of a low-frequency voltage from an external source, in accordance with the following:

Rated Voltage of Winding, Volts	Test Potential, Rms Volts
25 or less	1050
26-250	1500

All other circuits and metal parts shall be grounded during the test.

NEMA Standard 9-20-1972.

6.2.2 Induced-potential Test

Signalling transformers shall be capable of withstanding between the terminals of one winding, at a suitable frequency, the application of a voltage that is twice the rated voltage of that winding. For the duration of this test, see 2.9.2.

NEMA Standard 9-20-1972.

6.3 NO-LOAD LOSSES (EXCITATION LOSSES)

The no-load losses (excitation losses) of a signalling transformer shall not exceed the following when the primary winding is connected to a circuit of rated voltage and the secondary winding is open-circuited:

Transformer Rating, Voltamperes	No-load Loss, Watts
50	5
100	8
250	15
500	25
750	35
1000	50

NEMA Standard 9-20-1972.

6.4 VOLTAGE RATIO

A signalling transformer shall be so designed that, when rated voltage is applied to the primary winding, the secondary winding will deliver rated volt-amperes at approximately rated voltage. For signalling transformers, this will necessitate an alteration in the turns ratio to compensate for regulation. Transformers shall be compensated at the proper reference temperature (see 2.7.1) to deliver rated volt-amperes at 100 percent power factor, at approximately rated voltage, from one winding when rated voltage is applied to the other winding.

The open-circuit secondary voltages shall not exceed standard ratings by more than 10 percent.

NEMA Standard 9-20-1972.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

6.5 LIMITS OF TEMPERATURE RISE

The temperature rise of a signalling transformer above the ambient temperature, when measured by the resistance method and tested in accordance with the applicable provisions of 2.9.5, shall not exceed the following:

Winding Temperature Rise by Resistance, Degrees C	Hottest-spot Winding Temperature Rise, Degrees C
55	65
80	110

The transformer shall be operated continuously at rated output and highest rated secondary voltage from a circuit of rated primary voltage.

See 2.3 for correction factors to be applied for transformers intended for service at altitudes higher than 3300 feet (1000 meters).

NEMA Standard 9-20-1972.

6.6 CONSTRUCTION

6.6.1 Approval

Authorities having jurisdiction over electrical installations generally require signalling transformers to conform to the appropriate standards of nationally recognized safety testing organizations.

Authorized Engineering Information 9-26-1988 .

6.6.2 Insulating Bushings

Bushings of signalling transformers shall be of porcelain, cold-molded, or phenolic composition, or of other insulating material suitable for the purpose. Rubber, wood, hot-molded shellac, and tar compositions shall not be used.

NEMA Standard 9-20-1972.

6.6.3 Terminals

If wire leads are provided for transformers having output ratings not exceeding 100 voltamperes, they shall consist of Type RF-2 stranded fixture wire or approved equivalent, and shall be not smaller than No. 18 AWG.

In the case of transformers having output ratings exceeding 100 volt-amperes, wire leads shall consist of stranded wire not smaller than No. 14 AWG, Type V varnished-cloth-covered wire, or their approved equivalent.

Leads shall extend not less than 6 inches and, if of wire smaller than No. 14 AWG, not more than 12 inches outside of the enclosure.

Leads shall be securely soldered, brazed, or connected by other equivalent means to the windings within the enclosure. Unless they enter the enclosure through a nipple or other means for the attachment of conduit, leads shall enter the enclosure (if of conducting material) through insulating bushings that will separate the wires and provide a spacing of not less than ½ inch between the wires and the plane of support of the transformer. Strain relief shall be provided so that a mechanical strain on the leads will not be transmitted to the soldered joints at the connections to the windings. The insulating bushings shall be permitted to be omitted if a smoothly rounded opening is provided, such as a machine rolled edge or equivalent.

Leads shall not enter the enclosure through a removable cover if connections are to be made in the field.

Signalling transformers shall be provided with either binding screw terminals or insulated wire leads for the connection of primary and secondary circuit conductors. The set-screw form of wiring terminal shall be used.

If binding screw terminals are provided, the terminal lugs shall be of nonferrous metal, shall be made of stock not less than 0.030 inch in thickness, and shall have not less than 2 full threads in the metal for the binding screws. Terminals shall be provided with cupped washers, up-turned lugs, or equivalent means to retain the wires under the heads of screws or nuts. Binding screws shall be No. 6-32 or larger machine screws. Terminals shall be so designed that a spacing of not less than ½ inch will be maintained between live parts of opposite polarity and between live parts and metal that may be grounded. Terminals shall be enclosed.

NEMA Standard 9-26-1988.

6.6.4 Mechanical Construction

6.6.4.1. ENCLOSURE

Signalling transformers shall be provided with enclosures of non-combustible, moisture-resistant material protected against corrosion. The enclosures shall contain all uninsulated live metal parts except that primary or secondary leads may extend outside of the enclosure.

The enclosure, if of sheet metal, shall be formed from stock not less than 0.027 inch (No. 22 Manufacturer's Standard Gage) in thickness. An enclosure of material other than sheet steel shall provide equivalent mechanical strength and rigidity.

NEMA Standard 9-20-1972.

6.6.4.2. MOUNTING

The enclosure of a signalling transformer shall be so designed that it can be mounted on a plane surface and shall make contact only at the points of support and maintain an air space of not less than ¼ inch between the enclosure and the supporting surface.

NEMA Standard 9-20-1972.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

6.6.5 Transformer Marking

Signalling transformers shall be plainly marked with the following minimum information in such a manner that the markings will be readily visible after the transformers are installed as intended:

1. Manufacturer's name or trademark;
2. Catalog or distinguishing number;
3. Frequency; and,
4. Volt-ampere output (continuous rating).

NEMA Standard 9-20-1972.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

SECTION 7
IGNITION TRANSFORMERS

Section 7 applies to a type of specialty transformer commonly known as an ignition transformer. These transformers are dry-type, high-voltage, high-reactance, step-up, insulating transformers, designed to provide ignition for gas or oil burners. These transformers deliver high voltage to spark electrodes in such a manner that the spark will ignite a mixture of fuel and air which passed through its path. These standards, except for ratings, may be applicable to transformers having other than standard ratings. Portions of the general standards given in Section 2 also apply to ignition transformers.

Authorized Engineering Information 9-20-1972.

7.1 RATINGS

Standard ratings of ignition transformers shall be in accordance with Table 7-1.

NEMA Standard 9-20-1972.

Transformers of 6,000 volts are intended for the ignition of fuel gas.

Transformers of 10,000 and 12,000 volts are intended for the ignition of fuel oil.

Transformers of 14,000 volts are intended for the ignition of fuel oil or gas.

Authorized Engineering Information 9-26-1988.

7.2 DIELECTRIC TESTS

7.2.1 Applied-potential Test

Ignition transformers shall be capable of withstanding for 1 minute, between the primary winding and the core and case, the application of a low-frequency voltage of 1,500 volts.

Transformers having their secondary windings fully insulated shall be capable of withstanding for 1 minute, between the secondary winding and the primary winding, core and case, the application of a low-frequency voltage that is 125 percent of rated secondary voltage.

All other circuits and metal parts shall be grounded during these tests.

NEMA Standard 9-20-1972.

7.2.2 Induced-potential Test

Ignition transformers shall be capable of withstanding the application of 150 percent of rated primary voltage to the primary winding at a suitable frequency. For the duration of this test, see 2.9.2. One end of the primary winding shall be solidly connected to the enclosure for this test.

Transformers having their secondary windings fully insulated shall be capable of withstanding this test with first one end of the secondary winding and then the other connected to the common connection of the primary and enclosure.

NEMA Standard 9-20-1972.

7.3 TOLERANCES FOR VOLTAGE RATIO

Secondary open-circuit voltages of ignition transformers at rated primary voltages shall be within the following limits:

Secondary Voltage Rating, Volts	Minimum Open-circuit Voltage, Rms Volts	Maximum Open-circuit Voltage, Rms Volts
6,000	5,700	6,600
10,000	9,200	11,000
12,000	11,000	13,200
14,000	14,000	15,400

The secondary crest voltage for a given rms rating shall not exceed the maximum rms voltage multiplied by 1.414. The measured crest voltage shall be corrected for the form or crest factor of the supply circuit by applying the following formula:

$$\text{(Corrected secondary crest voltage)} = \frac{\text{(Measured crest voltage)} \div \text{(Crest factor of supply circuit)} \times \text{(Crest factor of testing transformer)}}{2}$$

(Equation 7-1)

Table 7-1
Ratings of Ignition Transformers

Primary Voltage Rating, Volts	Secondary Open-circuit Voltage Rating, Volts	Secondary Short-circuit Current Rating, Milliamperes	Primary Rating at Secondary Short Circuit, Voltamperes
120 or 240	6,000	20	140
	10,000	23	250
	12,000	20	275
	14,000	28	430

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Apparatus for measuring the rms and crest voltages is described in 2.9.3.

NEMA Standard 9-20-1972.

7.4 LIMITS OF TEMPERATURE RISE

The temperature rise of an ignition transformer above the ambient temperature, when measured by thermocouples at any point on the enclosure and tested in accordance with the applicable provisions of 2.9.5, shall not exceed 65°C.

The transformers shall be tested with the primary winding at rated frequency, and at 120 volts or 240 volts, and with the secondary winding delivering current to a spark gap having a spacing of 1/8 inch, if the secondary winding is rated less than 12,000 volts, and 3/16 inch, if the secondary winding is rated 12, 000 volts or above. If the secondary winding is rated 10,000 volts or above, the temperature test shall be made with an air velocity of 50 feet per second across the spark gap.

See 2.3 for correction factors to be applied for transformers intended for service at altitudes higher than 3300 feet (1000 meters)

NEMA Standard 9-20-1972.

7.5 CONSTRUCTION

7.5.1 Approval

Authorities having jurisdiction over electrical installations generally require ignition transformers to conform to the appropriate standards of nationally recognized safety testing organizations.

7.5.2 Terminals

Ignition transformers shall be provided with insulated binding posts, male receptacles, or wire leads for the connection of primary circuit conductors.

If wire leads are provided, they shall consist of stranded wire not smaller than No. 18 AWG and shall be brought out by the enclosure through beaded, eyeleted, or insulated holes, unless they are brought through nipples or other means for the attachment of conduit. A two-conductor rubber-jacketed cord, Type SJ or equivalent, shall be used.

Leads shall extend not less than 6 inches nor more than 48 inches outside of the enclosure. Leads shall be permitted to be brought out into a built-in or externally attached junction box.

Leads shall be securely soldered, brazed, or connected by other equivalent means to the windings within the enclosure. Strain relief shall be provided so that a mechanical strain on the leads will not be transmitted to the soldered joints at the connections to the windings.

Secondary terminals shall be of the screw, slip-on, or plunger types (male and female) and shall be brought out through insulated bushings of suitable configuration. The bushings shall be of ceramic or equivalent materials.

NEMA Standard 9-20-1972.

7.5.3 Radio Influence

Ignition transformers shall be provided with suitable means to suppress radiated and conducted radio noise from the primary circuit. The means shall not cause switching surges that may be detrimental to other electrical equipment and shall not consist of external radio-noise-suppression capacitors across the primary winding.

NEMA Standard 9-20-1972.

7.5.4 Mechanical Construction

7.5.4.1. ENCLOSURE

Ignition transformers shall be provided with enclosures of non-combustible, moisture-resistant material protected against corrosion. The enclosures shall contain all uninsulated live metal parts, except that primary or secondary leads or terminals may extend outside of the enclosure.

NEMA Standard 9-20-1972.

The enclosure, if of sheet steel, shall be formed from stock not less than 0.027 inch (No. 22 Manufacturer's Standard Gage) in thickness. An enclosure of material other than sheet steel shall provide equivalent mechanical strength and rigidity.

NEMA Standard 9-20-1972.

7.5.4.2. MOUNTING

The following types of mounting shall be standard:

1. Flat rectangular plate with one or more holes or slots on each end;
2. Flat plate, nonrectangular, with one hole or slot on each end;
3. Base with mounting studs; and,
4. Flange-type base.

7.5.5 Transformer Marking

Ignition transformers shall be plainly marked with the following minimum information in such a manner that the markings will be readily visible after the transformers are installed as intended.

1. Manufacturer's name or trademark;
2. Catalog or distinguishing number;
3. Frequency;
4. Voltages;
5. Short-circuit current;
6. Primary current or volt-amperes;
7. Type of secondary grounding (midpoint or one end); and,
8. Twin-spark-gap operation (if applicable).

NEMA Standard 9-20-1972.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

7.6 SECONDARY SPARK-GAP AND SHORT-CIRCUIT CURRENT

Secondary spark-gap current shall be measured by connecting the secondary winding of the transformer to a set of electrodes mounted horizontally at diametrically opposite points in an air tube consisting of a 10-foot length of 4-inch conduit, with a gap spacing as given in Table 7-2. The electrodes shall be steel rods 1/16 inch in diameter. They shall have blunt points and shall be porcelain insulated and adjustable. The electrodes shall be mounted near one end of the air tube. A power blower at the other end shall establish an air velocity of 50 feet per second in the tube, as measured by a differential Pitot tube so mounted that its orifice is spaced 3 inches from the arc gap, or by other equivalent measuring means. The orifice shall be placed between the spark gap and the open end of the tube.

The measured secondary spark-gap and short-circuit current of ignition transformers shall be not less than that given in Table 7-2.

Ignition transformers of the twin-terminal, single-spark-gap midpoint-grounded secondary type shall be designed in such a way that, with the primary connected to a circuit of rated voltage and frequency and with one of the secondary terminals connected to ground or short-circuited, the voltage between the other side and ground will be reduced to such a value that no spark will occur between blunt-nosed electrodes spaced 1/32 inch apart.

NEMA Standard 9-20-1972.

7.7 AIR DELIVERY AND ELECTRODE SPACING

Ignition transformers shall be used with air delivery not exceeding 50 feet per second and with electrode spacings not greater than those shown in the following:

Secondary Voltage Rating, Volts	Electrode Spacing, inches	Number of Gaps
6,000	1/16	1
10,000	1/8	1
12,000	3/16	1
14,000	3/16	2

NEMA Standard 9-20-1972.

Table 7-2
Secondary Spark-gap and Short-circuit Current of Ignition Transformers

	Secondary Voltage Rating, Volts			
	6,000	10,000	12,000	14,000
1. With rated primary voltage applied: Secondary short-circuit current, milliamperes	18.7	19.5	18.0	17.5
2. With 70% rated primary voltage applied:				
Electrode spacing, inches	...	1/8	3/16	3/16
Air velocity, feet per second	...	50	50	50
Secondary spark-gap current, milliamperes	*	11.6	9.4	8.7

*No minimum secondary spark-gap current limit has been established for this rating.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SECTION 8
LUMINOUS-TUBE TRANSFORMERS

Section 8 applies to a type of specialty transformer commonly known as a luminous-tube transformer. These transformers are dry-type, high-voltage, high-reactance, step-up, insulating transformers, designed to supply low current to electrodes of luminous-tube signs. These standards, except for ratings, may be applicable to transformers having other than standard ratings. Portions of the general standards given in Section 2 also apply to luminous-tube transformers.

Authorized Engineering Information 9-20-1972.

8.1 RATINGS

8.1.1 Primary Voltage Rating

The primary voltage rating of luminous-tube transformers shall be 120 or 240 volts.

NEMA Standard 9-20-1972.

8.1.2 Short-circuit Characteristics

Short-circuit volt-ampere primary ratings and the corresponding secondary open-circuit voltage and secondary short-circuit current ratings shall be in accordance with Table 8-1.

NEMA Standard 9-20-1972.

8.2 DIELECTRIC TESTS

8.2.1 Applied-potential Test

Luminous-tube transformers shall be capable of withstanding for 1 minute, between the primary winding and the core and case, the application of a low-frequency voltage of 1,500 volts.

Transformers having their secondary windings fully insulated shall be capable of withstanding for 1 minute, between the secondary winding and the primary winding, core and case, the application of a low-frequency voltage which is 125 percent of the rated secondary voltage.

All other circuits and metal parts shall be grounded during these tests.

NEMA Standard 9-20-1972.

8.2.2 Induced-potential Test

Luminous-tube transformers shall be capable of withstanding the application of 150 percent of rated primary voltage to the primary winding at a suitable frequency for the duration of this test; see 2.9.2. One end of the primary winding shall be solidly connected to the enclosure for this test.

Transformers having their secondary windings fully insulated shall be capable of withstanding this test with first one end of the secondary winding and then the other connected to the common connection of the primary and enclosure.

NEMA Standard 9-20-1972.

8.3 TOLERANCES FOR VOLTAGE RATIO

8.3.1 Fully Insulated or Midpoint-Grounded Type

The secondary open-circuit rms voltage of luminous-tube transformers of the fully insulated or midpoint-grounded types shall be within +10 percent and –3 percent of the rated secondary open-circuit voltage and shall in no case be more than 16,000 volts. The secondary crest voltage shall be not greater than that indicated in the following table:

Secondary Open-circuit-Voltage Rating, Volts	Maximum Secondary Crest Voltage, Volts
5,000 or less	7,800
5,001 - 10,000	15,600
10,001 - 15,000	22,600

NEMA Standard 9-20-1972.

8.3.2 One-end Grounded Type

The secondary open-circuit rms voltage of luminous-tube transformers of the one-end-grounded type shall be within +10 percent or –3 percent of the rated secondary open-circuit voltage and shall in no case be more than 8,000 volts. The secondary crest voltage shall be not greater than that indicated in the following table:

Secondary Open-circuit Voltage Rating, Volts	Maximum Secondary Crest Voltage, Volts
2,500 or less	3,900
2,501 - 5,000	7,800
5,001 - 7,500	11,300

NEMA Standard 9-20-1972.

8.3.3 Measurement

In measuring the voltage ratio, the primary winding shall be connected to a circuit of rated voltage and frequency which shall have a crest factor within 1 percent of 1.414. The measured crest voltage shall be

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Table 8-1
Open-circuit Voltage and Short-circuit Voltage and Current Ratings

Secondary Open-circuit Voltage Rating, Volts	Secondary Short-circuit Current Ratings,* Milliamperes	Primary Rating at Secondary Short Circuit, Voltamperes		Type of Construction‡
		Low Power Factor†	High Power Factor†	
2,000	18	50	...	CC-O
3,000	18	75	45	CC-O
	30	100	55	O
	60	180	100	O
4,000	18	90	50	CC-O
	30	140	75	O
	60	240	130	O
5,000	18	100	55	CC-O-I
	30	160	90	O
	60	300	170	O
	120	600	330	O
6,000	18	130	75	O-I
	30	180	100	O
	60	360	200	O
	120	720	400	O
7,500	18	150	85	O-I
	30	225	125	O-I
	60	450	250	O
	120	900	500	O
9,000	18	180	100	O-I
	30	270	150	O-I
	60	540	300	O
	120	1,080	600	O
12,000	18	225	125	O
	30	360	200	O-I
	60	720	400	O
15,000	18	270	150	O
	30	450	250	O-I
	60	900	500	O

* Secondary operating currents of approximately 80 percent of short-circuit current are satisfactory.

† See 1.2.13.5 and 1.2.13.10.

‡ CC - Core and coil, open; O - Outdoor, encased for protection application; I - Indoor, encased.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

corrected for the form or crest factor of the supply circuit by applying the formula in 7.3.

Apparatus for measuring the rms and crest voltages is described in 2.9.3

NEMA Standard 9-20-1972.

8.4 LIMITS OF TEMPERATURE RISE

The temperature rise of a luminous-tube transformer above the ambient temperature, when measured by the resistance method and tested in accordance with the applicable provisions of 2.9.5, shall not exceed 65°C. The transformer shall be connected to a tube load and shall deliver 80 percent ± 2 ½ percent of the measured short-circuit secondary current with the primary winding at rated voltage and frequency.

See 2.3 for correction factors to be applied for transformers intended for service at altitudes higher than 3 3300 feet (1000 meters).

Liquid-filled power-factor-correcting capacitors, if used, shall be installed so that the temperature of the capacitor will not exceed 80°C during normal operation.

NEMA Standard 9-20-1972.

8.5 CONSTRUCTION

8.5.1 Approval

Authorities having jurisdiction over electrical installations generally require luminous-tube transformers to conform to the appropriate standards of nationally recognized safety testing organizations.

8.5.2 Terminals

Luminous-tube transformers shall be provided with wiring terminals (other than the set-screw form), wire leads, or a three-conductor flexible cord for the connection of primary circuit conductors.

Types, sizes, and spacings of primary and secondary terminals or leads shall be in accordance with the applicable requirements of UL 506.

Transformers rated higher than 225 volt-amperes shall have secondary high-voltage terminals at opposite ends.

Leads shall not enter the enclosure through a removable cover if connections are to be made in the field.

Provision shall be made for secondary connections by means of either Type GTO cable, wire leads, or wiring terminals mounted in or through bushings of porcelain, glass, steatite, or equivalent material; except that open core-and-coil transformers shall have wire leads which may be of other than Type GTO cable, provided such leads are not less than No. 20 AWG and not more than 6 inches in length.

NEMA Standard 9-20-1972.

8.5.3 Mechanical Construction

8.5.3.1. DIMENSIONS

Mounting centers and maximum overall dimensions of outdoor-type luminous-tube transformers shall be in accordance with Figure 8-1.

NEMA Standard 9-20-1972.

8.5.3.2. ENCLOSURE

Luminous-tube transformers shall be of either the unenclosed core- and-coil or the enclosed type. Enclosed transformers shall be provided with enclosures of noncombustible moisture-resistant material protected against corrosion. The enclosures shall contain all uninsulated live metal parts, except that primary or secondary leads or terminals may extend outside of the enclosure.

The enclosure of an indoor transformer, if of sheet steel, shall be formed from stock not less than 0.027 inch (No. 22 Manufacturer's Standard Gage) in thickness. An enclosure of material other than sheet steel shall provide equivalent mechanical strength and rigidity.

The enclosure of an outdoor transformer, if of sheet steel, shall be formed from stock not less than 0.054 inches (No. 16 Manufacture's Standard Gage) in thickness. An enclosure of material other than sheet steel shall provide equivalent strength and rigidity. Holes for conduits shall be threaded when located above any live metal part. Threaded holes for conduit shall be reinforced to provide metal at least ¼ inch in thickness. Bushed holes for open wiring shall not be located in the top or back of the enclosure, except when special hood fittings are provided. When bushed holes are located in the sides above live metal parts, provision shall be made for wires to leave the enclosure in a downward direction.

NEMA Standard 9-20-1972.

Some transformers are designed for application within the structure of outdoor signs. Such transformers are not suitable for application indoors unless ventilation is adequate to maintain an ambient temperature not greater than 40°C under maximum operating conditions.

Authorized Engineering Information 9-26-1988.

8.5.3.3. GROUNDING

Luminous-tube transformers shall have the enclosure bonded to the core. Transformers of the secondary-balanced or one-end-grounded type shall be provided with a ground terminal which shall be electrically bonded to the core and enclosure.

NEMA Standard 9-20-1972.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

8.5.4 Transformer Marking

Luminous-tube transformers shall be plainly marked with the following minimum information in such a manner that the marking will be readily visible after the transformers are installed as intended:

1. Manufacturer's name or trademark;
2. Catalog or distinguishing number;
3. Frequency;
4. Voltages;
5. Secondary short-circuit current;
6. Primary volt-amperes;
7. Type of secondary grounding (midpoint, one end, and such);
8. The words "Power-factor-corrected" (where applicable); and,
9. Application indication ("Outdoor" or "For indoor use only").

NEMA Standard 9-20-1972.

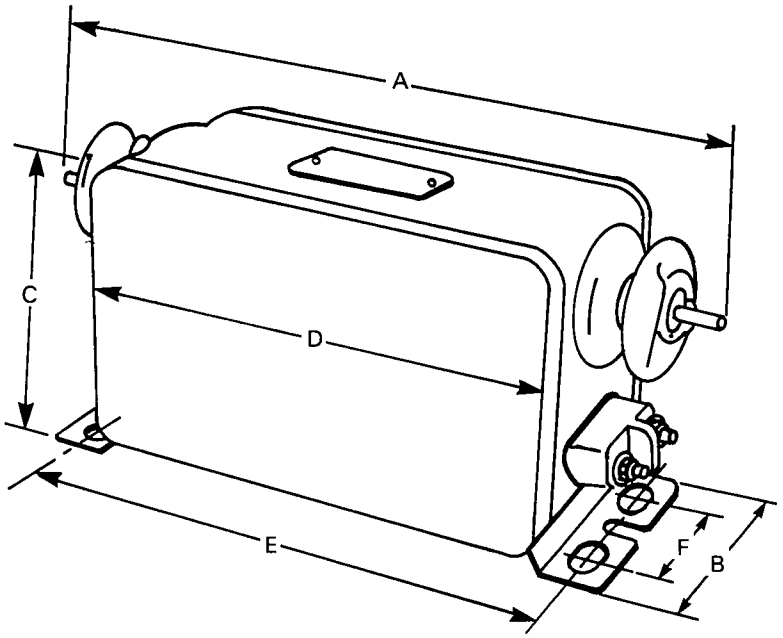
8.6 APPLICATION GUIDE

The luminous-tube footage chart, Table 8-2, indicates the normal maximum footage of average grade tubing that shall be operated with various ratings of luminous-tube transformers.

NEMA Standard 9-20-1972.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

6470247 0006496 9
ST 1-88



Ratings, Voltamperes		Maximum Overall Dimensions, Inches			Mounting Center, Inches						
					4 Hole				2 Hole		
Low Power Factor	High Power Factor	A	B	C	E	F	Slot or Hole	Bolt Size	E	Slot or Hole	Bolt Size
		Insulated Type									
50-150	50-100	10	4	5½	...	...	5/16	...	7½	5/16	¼
		Midpoint-grounded Type									
100-269	...	14	4¾	6	...	...	5/16	...	7½ to 10⅛	5/16	¼
...	50-149	14	4¾	7½	...	...	5/16	...	7½ to 10⅛	5/16	¼
270-360	150-200	15½	5	8	10	1¾	7/16	5/16	10¼	...	...
361-450	201-250	15½	5	8	10	3 3/16	7/16	5/16	10¼	7/16	3/8
451-900	251-500	15½	6½	8	10	3 3/16	7/16	5/16	10¼	7/16	3/8
901-1650	501-1000	16¼	7¾	10¾	10 to 13½	2½ to 5	...	5/16	...	...	...

Figure 8-1

Mounting Centers and Maximum Overall Dimensions of Outdoor-type Luminous Tube Transformers

Not for Resale
Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Table 8-2
Luminous-tube Footage Chart

Transformer Ratings				Normal Maximum Number of Feet of Tubing Operated (Based on Average Grade of Tubing)																														
				Clear or Fluorescent Red (Also Recommended for Neon Fluorescent Gold)												Clear or Fluorescent Mercury Filled Tubes, All Colors Indoor Applications*												Clear or Fluorescent Mercury Filled Tubes, All Colors Outdoor Applications†										
				Tube Size, Millimeters												Tube Size, Millimeters												Tube Size, Millimeters										
Secondary Voltage, Volts	Short-Circuit Current, Milliamperes	Primary Rating at Secondary Short Circuit, Volt-Amps	Approximate Watts Consumption at 115 Volts, 60-Hz	25	22	20	18	15	14	13	12	11	10	9	25	22	20	18	15	14	13	12	11	10	9	25	22	20	18	15	14	13	12	11	10	9
15,000	60	900	466	102	85	78	72	60	54	50	45	39	33	27	120	100	90	80	72	64	60	54	47	40	32	90	76	69	65	54	47	45	40	35	30	24
	30	450	234	102	85	78	72	60	54	50	45	39	33	27	120	100	90	80	72	64	60	54	47	40	32	90	76	69	65	54	47	45	40	35	30	24
	18	270	140					50	47	44	40	34	27	24					62	56	52	47	40	34	28					45	41	39	36	30	25	20
12,000	60	720	374	79	67	61	55	45	42	39	35	30	25	21	95	79	70	62	55	50	46	42	36	30	25	71	60	55	49	40	37	36	31	27	22	19
	30	360	187	79	67	61	55	45	42	39	35	30	25	21	95	79	70	62	55	50	46	42	36	30	25	71	60	55	49	40	37	36	31	27	22	19
	18	225	117					40	38	33	30	26	21	18					47	45	40	34	30	26	20					36	33	29	26	22	19	17
9,000	120	1,080	561	77	65	55	46	38	34	33	30	25	22	17	92	77	63	52	46	41	38	35	30	26	20	69	59	50	41	35	31	30	26	23	19	15
	60	540	281	67	57	48	40	33	30	29	26	22	19	15	80	67	55	45	40	36	33	31	26	23	18	60	51	43	36	30	27	26	23	20	17	13
	30	270	140	67	57	48	40	33	30	29	26	22	19	15	80	67	55	45	40	36	33	31	26	23	18	60	51	43	36	30	27	26	23	20	17	13
	18	180	94					28	26	24	22	18	15	13					34	31	29	26	22	18	16					25	23	22	20	18	13	11
7,500	120	900	466	59	47	39	32	28	26	25	23	18	15	13	70	55	45	36	32	31	31	27	22	18	14	52	42	35	29	24	23	23	21	17	14	11
	60	450	234	51	41	34	28	24	23	22	20	16	13	11	61	48	39	31	28	27	27	24	19	16	12	46	37	30	25	21	20	20	18	15	12	10
	30	225	117	51	41	34	28	24	23	22	20	16	13	11	61	48	39	31	28	27	27	24	19	16	12	46	37	30	25	21	20	20	18	15	12	10
	18	150	78					22	21	20	18	14	12	10					25	25	23	21	17	13	11					19	18	18	16	13	11	9
6,000	120	720	374	46	39	32	26	22	20	19	18	15	12	10	55	46	37	30	26	24	23	20	17	14	13	41	36	29	23	19	17	17	16	14	11	9
	60	360	187	40	34	28	23	19	18	17	16	13	11	9	48	40	32	26	23	21	20	18	15	12	11	36	31	25	20	17	15	15	14	12	10	8
	30	180	94	40	34	28	23	19	18	17	16	13	11	9	48	40	32	26	23	21	20	18	15	12	11	36	31	25	20	17	15	15	14	12	10	8
	18	130	68					17	16	15	14	10	9	7					20	19	17	16	12	11	8					15	14	14	12	9	8	6
5,000	120	600	312	38	32	26	22	19	18	17	14	11	10	8	46	38	31	25	22	22	18	16	14	12	9	34	29	23	19	17	16	16	14	10	9	7
	60	300	156	33	28	23	19	17	16	15	12	10	9	7	40	33	27	22	19	19	16	14	12	11	8	30	25	20	17	15	14	14	12	9	8	6
	30	160	83	33	28	23	19	17	16	15	12	10	9	7	40	33	27	22	19	19	16	14	12	11	8	30	25	20	17	15	14	14	12	9	8	6
	18	100	52					14	13	13	11	8	7	6					17	15	15	13	10	8	7					13	12	12	10	7	6	5
4,000	60	240	125	27	23	19	16	13	12	11	10	8	7	6	32	27	22	18	16	14	13	12	10	8	7	24	20	17	15	12	11	11	10	7	6	5
	30	140	73	27	23	19	16	13	12	11	10	8	7	6	32	27	22	18	16	14	13	12	10	8	7	24	20	17	15	12	11	11	10	7	6	5
	18	90	47					11	10	10	9	7	6	5					13	12	12	11	8	7	6					10	9	9	8	6	5	4
3,000	60	180	94	17	14	12	10	10	9	9	8	7	6	5	22	18	16	14	12	10	10	10	8	7	6	14	12	11	9	9	8	8	7	6	5	4
	30	100	52	17	14	12	10	10	9	9	8	7	6	5	22	18	16	14	12	10	10	10	8	7	6	14	12	11	9	9	8	8	7	6	5	4
	18	75	39					8	8	7	6	5	4	4					10	9	8	7	6	5	5					7	6	6	6	5	4	4
2,000	18	50	26					6	5	5	5	4	3	3					7	7	7	6	5	4	4					5	5	4	4	4	3	2
Recommended gas pressure, mm/Hg				6	7	7½	8	9	10	10	11	12	13	15	6	7	7½	8	9	10	10	11	12	13	15	6	7	7½	8	9	10	10	11	12	13	15

*No. B10, No. 50, or No. 1050 gas and fluorescent mercury. These footages are also recommended for OUTDOOR use where temperature does not fall below 40°F.
†No. B19 or No. 20 gas and fluorescent mercury.
NOTE: Deduct approximately 1 foot from the above figures for each pair of electrodes.

NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status, are set forth in certain clauses of the NEMA *Standardization Policies and Procedures* manual and are referenced below.

Purpose of Standards

National Electrical Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for its particular need. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard. *(Standardization Policies and Procedures, p. 1)*

Definition of a Standard

A standard of the National Electrical Manufacturers Association defines a product, process, or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Standardization Policies and Procedures, p. 2)

Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the standards publication may be capable of otherwise equivalent performance.

(Standardization Policies and Procedures, p. 9)

Classes of Standards

National Electrical Manufacturers Association Standards are of two classes:

1. NEMA Standard, which relates to a product commercially standardized and subject to repetitive manufacture, which standard has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon;
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote thereon.

(Standardization Policies and Procedures, pp. 8 & 17)

Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard or Suggested Standard for Future Design, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote on the standard.

(Standardization Policies and Procedures, pp. 8 & 17)

Official Standards Proposal

An Official Standards Proposal is an official draft of a proposed standard which is formally recommended to an outside organization(s) for consideration, comment, and/or approval, and which has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon.

(Standardization Policies and Procedures, pp. 8 & 17)

Identification of Status

Standards in NEMA Standards Publications are identified in the foreword or following each standard as "NEMA Standard" or "Suggested Standard for Future Design." These indicate the status of the standard. These words are followed by a date which indicates when the standard was adopted in its present form by the Association.

The material identified as "Authorized Engineering Information" and "Official Standards Proposal" is designated similarly.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SPECIALTY TRANSFORMER SECTION
OF THE
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

MEMBER COMPANIES

Acme Electric Corporation
Lumberton, NC 28358

American HV Test Systems, Inc.
Accident, MD 21520

Challenger Electrical Equipment Corporation
Jackson, MS 39225

GE
Hickory, NC 28501

Hevi-Duty Electric
Unit of General Signal Corporation
Goldsboro, NC 27530

International Transformer Corporation
Montebello, CA 90640

Matra Electric Corporation
Compton, , CA 90224

MGM Transformer Company
Commerce, CA 90040

National Industri Transformers, Inc.
Hampton, VA 23661

Neco Hammond, Inc.
Baraboo, WI 53913

Niagra Transformer Corporation
Buffalo, NY 14225

Southern Transformer Company
East Point, GA 30344

Square D Company
Palatine, Il 600676

R E Uptegraff Manufacturing Company
Scottdale, PA 15683

Westinghouse Electric Corporation
South Boston, VA 24592

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale