XR 12-88 6470247 0005766 7
F-87-03

NEMA STANDARDS PUBLICATION/NO. XR 12-1988

nema

Electrical and Thermal Characteristics for X-Ray Tubes and X-Ray Tube Housings Used in Medical Diagnosis

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ■ 2101 L STREET, N.W., WASHINGTON, D.C. 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

XR 12-88

6470247 0005767 9

POSTAGE
BEFORE
MAILING

Standards Publications Editor
National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, D.C. 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

XR 12-1988

XR 12

Electrical and Thermal Characteristics for X-Ray Tubes and X-Ray Tube Housings Used in Medical Diagnosis

Published by
National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, D.C. 20037

© by National Electrical Manufacturers Association 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

TABLE OF CONTENTS

		Page
	PURPOSE	i
	SCOPE	ii
Section 1	DEFINITIONS	1
Section 2	GENERAL REQUIREMENTS	
	Required Data for User Information	3
	Operational Characteristics	3
	Maximum Potential Difference	3
	Filament Voltage and Current	3
	Emission Characteristics	3
	Input Power	3
	Thermal Characteristics	3
	Load Ratings	3
	Mechanical Requirements	3
	Thermal Overload Sensing Provisions	3
Section 3	VERIFICATION METHODS	
	General	4
	Anode Heat Storage Capacity	4
	Housing Heat Storage Capacity	4
	Heat Dissipation	4
	Heat Dissipation, Maximum, Anode	4
	Heat Dissipation, Maximum Continuous, X-ray Tube Housing	4
	Heat Dissipation, Maximum Continuous, X-ray Tube Housing Assembly, Verification	4
	Load Ratings, X-ray Tube	4
	Single Load Rating, Verification	5
	Serial Load Rating, Verification	5

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

Purpose

The purpose of this Standards Publication is to provide a common basis for the presentation of data, based on specified conditions related to the electrical and thermal characteristics of diagnostic x-ray tubes and x-ray tube housings.

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 document outlines the electrical and thermal ratings information, covering x-ray tubes and x-ray tube housing assemblies, that must be provided to properly facilitate the use for which they were designed. Procedures are provided to allow verification of single load and serial load ratings of x-ray tubes.

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

ELECTRICAL AND THERMAL CHARACTERISTICS FOR X-RAY TUBES AND X-RAY TUBE HOUSINGS USED IN MEDICAL DIAGNOSIS

Section 1
DEFINITIONS

ANODE

The target electrode in an x-ray tube from which x-rays are emitted.

NEMA Standard 5-25-1988.

COOLING CURVE, ANODE

A curve showing anode heat content (ordinate) as a function of time (abscissa) with zero input power, beginning when the anode heat content is equal to the anode heat storage capacity.

NEMA Standard 5-25-1988.

COOLING CURVE, X-RAY TUBE HOUSING

A curve showing total heat content (ordinate) as a function of time (abscissa), under specified conditions beginning when the total heat content is equal to the heat storage capacity.

NEMA Standard 5-25-1988.

CURRENT, X-RAY TUBE

The average electric current flowing in the electron beam that produces x-rays. The current measurement technique must be specified by the manufacturer.

NEMA Standard 5-25-1988.

EMISSION CHARACTERISTICS

The dependence of the x-ray tube current on filament heating current and x-ray tube potential difference.

NEMA Standard 5-25-1988.

HEAT CONTENT, ANODE

The energy expressed in joules or other appropriate units accumulated in the anode of an x-ray tube during loading.

NEMA Standard 5-25-1988.

HEAT CONTENT, X-RAY TUBE HOUSING

The energy expressed in joules or other appropriate units accumulated in the x-ray tube housing during or retained after loading.

NEMA Standard 5-25-1988.

HEAT DISSIPATION, MAXIMUM, ANODE

The highest value of the input power expressed in watts which can be applied to the target anode of an x-ray tube, under specified conditions, without exceeding its maximum permissible operating temperature with an ambient temperature of 20°C to 25°C or from a specified temperature. Maximum anode heat dissipation is not to be confused with the maximum average ratings the manufacturer can specify to protect the tube bearings or other internal structures.

NEMA Standard 5-25-1988.

HEAT DISSIPATION, MAXIMUM CONTINUOUS, X-RAY TUBE HOUSING

The highest value of total input power expressed in watts which can be applied to an x-ray tube housing continuously, under specified conditions, without exceeding its maximum permissible operating temperature with an ambient temperature of 20°C to 25°C or from a specified temperature.

NEMA Standard 5-25-1988.

HEAT STORAGE CAPACITY, ANODE

The maximum energy expressed in joules or other appropriate units which can be permitted to accumulate in the anode of an x-ray tube above a base temperature of 20°C to 25°C or from a temperature specified by the manufacturer.

NEMA Standard 5-25-1988.

HEAT STORAGE CAPACITY, TOTAL X-RAY TUBE HOUSING

The maximum energy expressed in joules or other appropriate units which can be permitted to accumulate in an x-ray tube housing, above an ambient temperature of 20°C to 25°C or from a specified temperature.

NEMA Standard 5-25-1988.

HEATING CURVE, ANODE

A curve or series of curves showing anode heat content (ordinate) as a function of loading time (abscissa) for various specified values of constant anode input power which is not focal spot temperature limited. The curves start at a value of anode heat content corresponding to a temperature of 20°C to 25°C, or from a specified temperature.

NEMA Standard 5-25-1988.

INPUT POWER, ANODE

The power expressed in watts or kilowatts applied to the anode of an x-ray tube to produce x radiation.

NEMA Standard 5-25-1988.

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

INPUT POWER, EQUIVALENT, ANODE

The value of a continuous constant anode input power, expressed in watts, which would result in a desired steady thermal state of the anode of an x-ray tube.

NEMA Standard 5-25-1988.

INPUT POWER, NOMINAL ANODE

The maximum value of permitted anode input power expressed in kilowatts, which can be applied for a single load during the specific loading time of 0.1 second using a 3-phase generator or a generator as specified by the manufacturer. The anode rotation speed is specified as part of this parameter.

NEMA Standard 5-25-1988.

LOAD, X-RAY TUBE

The power applied to an x-ray tube expressed in appropriate units for the loading factors.

NEMA Standard 5-25-1988.

LOADING

The act of applying input power to an x-ray tube.

NEMA Standard 5-25-1988.

LOADING FACTOR

Each factor influencing the x-ray tube load, e.g., value and waveform of an x-ray tube potential difference, x-ray tube current, and loading time.

NEMA Standard 5-25-1988.

LOADING TIME

The time during which the input power is applied to the x-ray tube.

NEMA Standard 5-25-1988.

POTENTIAL DIFFERENCE, X-RAY TUBE

The potential difference between the anode and cathode of an x-ray tube expressed in kilovolts peak.

NEMA Standard 5-25-1988.

POTENTIAL DIFFERENCE, MAXIMUM, X-RAY TUBE

The maximum permitted x-ray tube potential difference for specific operating conditions.

NEMA Standard 5-25-1988.

SERIAL LOAD RATING

The maximum permitted x-ray tube load which is given by the relationship between anode input power and loading time for the total of a specified series of individual x-ray tube loads with specified factors.

NEMA Standard 5-25-1988.

SINGLE LOAD RATING

The maximum permitted x-ray tube load given by a relationship between constant anode input power and loading time for a single load under specified conditions.

NEMA Standard 5-25-1988.

X-RAY TUBE

A high vacuum tube used for medical diagnostic purposes which produces x-rays by bombarding an anode with a beam of electrons accelerated through a potential difference.

NEMA Standard 5-25-1988.

X-RAY TUBE HOUSING

An enclosure into which an x-ray tube is mounted for use, providing protection against electrical shock and limiting the radiation to a specified value. Some x-ray tube housings include cooling systems.

NEMA Standard 5-25-1988.

X-RAY TUBE HOUSING ASSEMBLY

The x-ray tube housing with the x-ray tube installed. Some x-ray tube housing assemblies will include the high voltage and filament transformers, cooling systems and other appropriate elements.

NEMA Standard 5-25-1988.

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

Not for Resale

Section 2
GENERAL REQUIREMENTS

2.1 REQUIRED DATA FOR USER INFORMATION

The manufacturer shall provide sufficient electrical and thermal ratings information covering x-ray tubes and x-ray tube housing assemblies to properly facilitate the use for which they were designed.

The following data shall be provided as a minimum:

NEMA Standard 5-25-1988.

2.2 OPERATIONAL CHARACTERISTICS

2.2.1 Maximum Potential Difference

Values shall be given for the maximum permitted potential difference between the following elements:

a. Anode and cathode;
b. Anode and ground;
c. Cathode and ground;
d. Grid and cathode (if applicable).

NEMA Standard 5-25-1988.

2.2.2 Filament Voltage and Current

The maximum values of filament voltage and current for the operating range of the x-ray tube shall be given.

NEMA Standard 5-25-1988

2.2.3 Emission Characteristics

Data shall be provided relating typical x-ray tube current, filament heating current and x-ray tube potential difference with its associated waveform.

NEMA Standard 5-25-1988

2.2.4 Input Power

The nominal anode input power shall be provided.

NEMA Standard 5-25-1988.

2.2.5 Thermal Characteristics

The following thermal characteristics shall be provided:

a. The anode heat storage capacity;
b. Anode cooling curve;
c. Total heat storage capacity of the x-ray tube housing;
d. X-ray tube housing cooling curves;
e. Maximum continuous heat dissipation of an x-ray tube housing.

NEMA Standard 5-25-1988

2.2.6 Load Ratings

Applicable load ratings shall be provided as follows:

a. *Single load rating.* Data shall be given as a curve or a table of numerical values, showing maximum constant anode input power as a function of loading time for specified values of equivalent anode input power or anode heat content. Appropriate loading factors, e.g., focal spot size, target anode rotational speed, value and waveform of x-ray tube potential difference shall be specified.

b. *Serial load rating.* Serial load ratings shall be given with values of the appropriate loading factors. For example:

—initial anode heat content;
—anode input power for an individual x-ray tube load;
—total number of loadings or the duration of a series of loadings;
—number of individual x-ray exposures per second.

NEMA Standard 5-25-1988

2.3 MECHANICAL REQUIREMENTS

The nominal dimensions, weight and mounting provisions of the x-ray tube housing assembly shall be provided.

NEMA Standard 5-25-1988

2.4 THERMAL OVERLOAD SENSING PROVISIONS

X-ray tube assemblies that are provided with thermal overload sensing provisions shall, when properly connected within the system, terminate anode input power. Data supplied with such assemblies shall specify the wiring connections for these provisions.

NEMA Standard 5-25-1988.

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

Section 3
VERIFICATION METHODS

3.1 GENERAL

A commonly accepted definition of heat capacity is that quanitity of heat required to increase the temperature of a system or substance by one degree of temperature. The quantitative determination of heat capacity is based on the physical constants of the specific heat and mass of the constituent materials.

Heat storage capacity of a system or substance is defined as the capacity times the maximum temperature differential permitted.

NEMA Standard 5-25-1988.

3.2 ANODE HEAT STORAGE CAPACITY

The anode heat storage capacity is comprised of the sum of the heat storage capacities of the component materials of the anode. Anode heat storage capacity measurements are verified under controlled laboratory conditions by isolating the anode from the x-ray tube. The specific value has been determined by the manufacturer and attempts to duplicate these measurements may damage the device and are therefore not recommended.

Authorized Engineering Information 5-25-1988.

3.3 HOUSING HEAT STORAGE CAPACITY

The housing heat storage capacity is comprised of the sum of the heat storage capacities of the component materials of the housing. Housing heat storage capacity measurements are verified under controlled laboratory conditions by isolating the housing from the x-ray tube. The specific value has been determined by the manufacturer and attempts to duplicate these measurements may damage the device and are therefore not recommended.

Authorized Engineering Information 5-25-1988.

3.4 HEAT DISSIPATION

The quantitative determination of heat dissipation is based on the physical constants (emissivity, thermal conductivity, etc.), surface area and temperature differentials of the constituent materials. The maximum heat dissipation occurs at maximum heat storage.

NEMA Standard 5-25-1988.

3.4.1 Heat Dissipation, Maximum, Anode

The maximum anode heat dissipation measurements are verified under controlled laboratory conditions by isolating the anode from the x-ray tube. The specific value has been determined by the manufacturer and attempts to duplicate these measurements may damage the device and are therefore not recommended.

Authorized Engineering Information 5-25-1988.

3.4.2 Heat Dissipation, Maximum Continuous, X-Ray Tube Housing

The maximum continuous x-ray tube housing heat dissipation measurements are verified under controlled laboratory conditions by isolating the housing from the x-ray tube. The specific value has been determined by the manufacturer and attempts to duplicate these measurements may damage the device and are therefore not recommended.

Authorized Engineering Information 5-25-1988.

3.4.3 Heat Dissipation, Maximum Continuous, X-Ray Tube Housing Assembly, Verification

Heat dissipated by the x-ray tube housing assembly includes stator power, filament power and anode power. Maximum continous heat dissipation rates are limited to the smaller of the maximum dissipation rates of either the housing or the x-ray tube. Normal operation of the x-ray tube housing assembly within the ratings and duty cycle supplied by the manufacturer are evidence of verification.

NEMA Standard 5-25-1988

3.5 LOAD RATINGS, X-RAY TUBE

CAUTION—It is extremely important to make certain that parameters affecting the x-ray tube load be accurately known and applied in accordance with the manufacturer's specifications. These factors include, but are not limited to, tube potential difference, peak current, waveforms, pulse duration, and anode rotation speed. Improper calibration of any of these parameters can result in tube damage.

NEMA Standard 5-25-1988.

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

Not for Resale

3.5.1 Single Load Rating, Verification

a. Single load ratings shall be determined at the highest constant anode input power allowable for a specified loading time. These ratings can be repeated at intervals of time where, at the beginning of each loading, the anode heat content has returned to the equivalent anode input power or a specified anode heat content.
b. Supply energy for ten successive loadings according to the x-ray tube single load ratings at each of the loading times, 0.01 second, 0.1 second and 1.0 second.
c. The time interval between successive loadings shall be determined from the anode cooling curve or from the x-ray tube housing cooling curve, as appropriate, so that the anode heat content at the beginning of each successive loading is equal to that corresponding to the specified equivalent anode input power.
d. The x-ray tube shall withstand the test without significant damage.

NEMA Standard 5-25-1988

3.5.2 Serial Load Rating, Verification

The serial load performance ratings are found on the tube manufacturer's product data information sheets for various serial load procedures. These ratings show maximum operating techniques and duty factors that must not be exceeded. These ratings shall be verified by using the following procedure.

a. Begin the test with an x-ray tube housing assembly that has not been operated for at least one hour.
b. Perform the x-ray tube warm-up procedure per the manufacturer's instructions, if required.
c. Select a serial load procedure sequence from those specified by the x-ray tube manufacturer and perform the sequence.
d. Allow the x-ray tube housing to cool for the applicable time interval specified by the manufacturer and then repeat the serial load procedure specified in step c. Repeat this procedure three times.
e. The x-ray tube housing assembly shall withstand the test without significant damage.

NEMA Standard 5-25-1988.

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

X-RAY IMAGING PRODUCTS SECTION OF THE NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

MEMBER COMPANIES

ADAC Laboratories
Milpitas, CA 95035

Advanced Instrument Development, Inc.
Melrose Park, IL 60160

Belmont Equipment Corp.
Somerset, NJ 08873

Bennett X-Ray Corp.
Copiague, NY 11726

Canon U.S.A., Inc.
Jericho, NY 11753-1679

Capintec, Inc.
Pittsburgh, PA 15238

Continental X-Ray Corp.
Broadview, IL 60153

Dornier Medical Systems, Inc.
Marietta, GA 30067

Eastman Kodak Co.
Rochester, NY 14650

Eigen
Nevada City, CA 95959

EIMAC
Division of Varian
Salt Lake City, UT 84104

Elema-Schonander, Inc.
Schaumburg, IL 60173-3887

Elscint, Inc.
Boston, MA 02215-7602

Eureka X-Ray Tube Co.
Chicago, IL 60641

Fischer Imaging Corp.
Denver, CO 80241

Gammex, Inc.
Milwaukee, WI 53226

GE Medical Systems
Milwaukee, WI 53201

Hewlett-Packard Co.
Medical Products Group
McMinnville, OR 97128

Keystone X-Ray, Inc.
Neptune Township, NJ 07753

Liebel Flarsheim Co.
Cincinnati, OH 45215-6305

Lixi, Inc.
Downers Grove, IL 60515

The Machlett Laboratories, Inc.
Stamford, CT 06907

Medicor USA Ltd.
Columbus, OH 43212

MEICOR
Pleasanton, CA 94566

J. Morita USA., Inc.
Tustin, CA 92680

Nuclear Associates
Div. of Victoreen, Inc.
Carle Place, NY 11514

Oldelft Corp. of America
Fairfax, VA 22031

Philips Medical Systems
North America, Inc.
Shelton, CT 06484

Picker International, Inc.
Highland Heights, OH 44143

Dunlee, Inc.
Bellwood, IL 60104

Siemens Medical Systems, Inc.
Iselin, NJ 08830

Thomson-CSF Electron Tubes
Dover, NJ 07801

3 M
Imaging Systems Div.
St. Paul, MN 55144

Toshiba Medical Systems
Tustin, CA 92680

Transworld X-Ray Corp.
Charlotte, NC 28224

Universal/Allied Imaging, Inc.
Chicago, IL 60651

Xerox Medical Systems
Pasadena, CA 91107

XRE Corp.
Littleton, MA 01460

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 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