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STANDARDS PUBLICATION NO. XR 14

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Recommended Practices for Load-Bearing Mechanical Assemblies Used in Diagnostic Imaging

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ■ 2101 L STREET, N.W., WASHINGTON, D.C. 20037

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XR 14

RECOMMENDED PRACTICES FOR LOAD-BEARING MECHANICAL ASSEMBLIES USED IN DIAGNOSTIC IMAGING

Published by

National Electrical Manufacturers Association
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Foreword

This Standard Publication defines practices for the design and construction of mechanical assemblies that provide mechanical integrity to avoid potential injury.

In the preparation of this standards publication, the input of users and other interested parties has been sought and evaluated. Inquiries, comments, and proposed or recommended revisions should be submitted by contacting the:

Vice President, Engineering Department
National Electrical Manufacturers Association
2101 L Street, N.W., Suite 300
Washington, D.C. 20037

Scope

This document outlines practices for the design, construction and use of load-bearing castings, weldments and threaded fasteners.

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Section 1
REFERENCED STANDARDS

In this publication, reference is made to the standards listed below.

American National Standards Institute
11 West 42nd Street
New York, NY 10036

ANSI/AWS D1.1-1988	*Structural Welding Code - Steel*
ANSI/AWS D1.2-1983	*Structural Welding Code - Aluminum*
ANSI/UL 187 1985	*Safety Standard for X-ray Equipment*
IEC Publication 601-1, 2nd Edition, 1988	*Safety of Medical Electrical Equipment*

Refer to ANSI Standards Index for standards covering appropriate fasteners such as: bolts, nuts, pins, rivets, machine screws, etc.

Department of Defense
Washington, DC 20301

MIL-STD-2175	*Castings, Classification & Inspection of*
MIL-W-8604	*Welding, Fusion, Aluminum Alloys, Process and Performance of*
MIL-W-8611	*Welding, Metal Arc & Gas, Steel*
MIL-W-18326	*Welding of Magnesium Alloys, Gas and Arc Manual and Machine Processes for*
MIL-STD-453	*Inspection, Radiographic*
MIL-STD-6866	*Inspection, Penetrant Method of*
MIL-STD-1595	*Qualification of Aircraft, Missile and Aerospace Fusion Welders*
MIL-A-21180	*High Strength Aluminum Alloy Castings*

The Aluminum Association
818 Connecticut Avenue, N.W.
Washington, DC 20006

AA-CS-M5-71	*Aluminum Sand Castings*

American Society of Mechanical Engineers
345 East 47th Street
New York, NY 10017

Boiler and Pressure Vessel Code Section IX-1989	*Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators*

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Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

1989 SAE Handbook Volume I Materials

American Society for Testing and Materials
1916 Race Street
Philadelphia, PA 19103

ASTM B0618-1985 *Standard Specification for Aluminum Alloy Investment Castings*

ASTM B26/B26M-1988 *Standard Specifications for Aluminum Alloy Sand Castings*

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Section 2
RECOMMENDED PRACTICES

2.1 DESIGN CONSIDERATIONS

Load-bearing assemblies shall be analyzed to determine whether loss of mechanical integrity could be hazardous. If so, they shall be designed with adequate safety factors as described in:

IEC 601-1, *Medical Electrical Equipment*, Part 1, *General Requirements For Safety* (2nd Edition 1988): Clause 21-Mechanical Strength and Clause 28-Suspended Masses and; ANSI/UL 187-1985 *Standards For X-Ray Equipment*, Section 34.

Furthermore, they shall be designed according to accepted design practices following published standards, design handbooks and directions furnished by the suppliers of mechanical components used in such assemblies.

NEMA Standard 9-5-1990

2.1.1 Castings

Castings used in these assemblies shall be cast of ductile material with a 5% or greater elongation property under tensile load. Consideration shall be given to notch sensitivity and fatigue strength, impact loads and stress reversals as well. Subsequent production shall conform to a proven quality control test and evaluation method such as metallurgical testing, non-destructive testing or similar testing for purpose of detecting weaknesses which could lead to failure; for example, improper material, unacceptable porosity and non-uniformities in critical areas.

NEMA Standard 9-5-1990

2.1.2 Weldments

Welds used in these assemblies should be designed to carry loads only in compression.

Authorized Engineering Information 9-5-1990

If welds are used in tension or shear, they shall be backed up by rabbitted, pinned, threaded or other similar joint construction or alternatively they shall meet all of the following:

a. Be made by certified welders using certified material
b. Conform to a proven quality control test and evaluation method such as metallurgical testing, non-destructive testing or similar testing for purposes of detecting adequate penetration and filler material
c. Be shaped (ground flush with surface) so as not to promote stress concentrations if the structure is subject to repeated loads
d. Have defect limits for unacceptable welds clearly defined on drawings or by reference to applicable specifications.

NEMA Standard 9-5-1990

2.1.3 Threaded Fasteners

Threaded fasteners used in these assemblies:

a. Should have shear loads transmitted by adequately sized dowel pins, shoulder bolts, rabbitted joints or similar construction.

Authorized Engineering Information 9-5-1990

If ordinary threaded fasteners are used in shear, they shall be adequately torqued to support the shear forces through friction between the mating surfaces. If multiple supports are used in shear, the worst case loading shall be assumed, i.e. - that only one or two of the supports, depending on their orientation to the shear force, will support the load.

b. Shall have torque specifications for tightening the fasteners included in the manufacturing and/or accompanying documents.
c. Shall incorporate appropriate means of restraint such as castellated nuts and cotter pins, safety wire, frictional elements integral to the fastener itself or equivalent means if the fastener may be repeatedly assembled or disassembled as part of routine maintenance. Where recommended by the manufacturer, new fasteners shall be used for each reassembly.
d. Shall be secured as in (c.) above or with split ring lock washers or locking solutions if the fastener is not subjected to repeated assembly and disassembly in the field, but may experience cyclically varying loads or vibration.
e. Shall be accompanied by instructions concerning the proper reassembly of the threaded fasteners and by any required replacement threaded fasteners and/or locking means if replacement parts require the disassembly of the fasteners.

NEMA Standard 9-5-1990

2.2 TESTS

Load bearing assemblies designed in accordance with 2.1 shall be load tested and life tested as follows.

2.2.1 Load Test

Representative models or prototypes shall be load tested with the loads specified in 2.1. The ultimate test load shall be no less than the safety factor times the loads specified in 2.1.

NEMA Standard 9-5-1990

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2.2.2 Life Test

Representative models or prototypes of assemblies subject to cyclic loading shall be life tested with at least the maximum load specified in 2.1 for at least the maximum number of operations expected during the product's lifetime. The test should be conducted until a hazardous condition results. (This sentence approved as Authorized Engineering Information 9-5-1990.)

NEMA Standard 9-5-1990

2.3 INSTALLATION INTEGRITY

Load-bearing assemblies intended for field assembly as part of installation and maintenance activities shall have, in accompanying documents, specifications and checkout procedures for proper fasteners, methods of assembly, torquing instructions, locking methods and instructions for fastening to the structure of the building or other housing structure.

NEMA Standard 9-5-1990

2.4 USEFUL LIFE

If the useful life of a load bearing assembly is limited, this life shall be defined in the user document along with instructions for the disposition of the assembly at the end of its useful life. The useful life is to be based on worst case loading. Components requiring periodic replacement shall be identified and the replacement period shall be specified in the user directions.

NEMA Standard 9-5-1990

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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 their particular needs. 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. 8)

Categories of Standards

National Electrical Manufacturers Association Standards are of three classes:

1. NEMA Standard, which relates to a product, process or procedure 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.
3. Adoptive Standard, which is adopted in whole or in part from the standards of another organization, either domestic, regional, or international.

(Standardization Policies and Procedures, pp 7 & 16)

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. 7 & 16)

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 7 & 16)*

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.

July 17, 1990

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

MEMBER COMPANIES

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Milpitas, CA 95035-7443

Advanced Instrument
Development, Inc.
Melrose Park, IL 60160

Belmont Equipment Corporation
Somerset, NJ 08873

Bennett X-Ray Corporation
Copiague, NY 11726

Camtronics Ltd. Medical Systems
Hartland, WI 53029

Capintec, Inc.
Pittsburgh, PA 15238

Comet North America
Norwalk, CT 06850

Continental X-Ray Corporation
Broadview, IL 60153

Dornier Medical Systems, Inc.
Marietta, GA 30144

Eastman Kodak Company
Rochester, NY 14653-9105

Eigen
Nevada City, CA 95959

Varian Power Grid & X-Ray
Tube Products
Salt Lake City, UT 84104

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

Elscint, Inc.
Hackensack, NJ 07601

Eureka X-Ray Tube, Inc.
Arlington Heights, IL 60004-1818

Fischer Imaging Corporation
Denver, CO 80241

Gammex, Inc.
Milwaukee, WI 53226-0708

GE Medical Systems
Milwaukee, WI 53201

Hewlett-Packard Company
McMinnville, OR 97128

Instrumentarium Imaging, Inc.
Milwaukee, WI 53207

Liebel-Flarsheim Company
Cincinnati, OH 45215-6305

J. Morita Corporation
Torrance, CA 90505

Nuclear Associates
Carle Place, NY 11514

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Fairfax, VA 22031

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New Milford, CT 06776

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3M Imaging Systems Division
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Toshiba America Medical
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