
Specification for Safety-Related Steel Structures for Nuclear Facilities

September 20, 2006

Supersedes the *Load and Resistance Factor Design Specification for Safety-Related Steel Structures for Nuclear Facilities* dated December 17, 2003, the *Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities* reaffirmed in 2004, including Supplements No. 1 and 2, and previous versions of this specification.

Approved by the
AISC Committee on Specifications
and issued by the AISC Board of Directors



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PREFACE

The AISC *Specification for Safety-Related Steel Structures for Nuclear Facilities*, hereafter referred to as the Nuclear Specification, addresses the design, fabrication, and erection of safety-related steel structures for nuclear facilities. This document uses the 2005 AISC *Specification for Structural Steel Buildings*, hereafter referred to as the Specification, as the baseline document and modifies the specific portions of the Specification to make it applicable to the design, fabrication, and erection of the safety-related steel structures for nuclear facilities.

Safety-related steel structures in nuclear facilities, which provide support and protective functions to equipment vital to the facility, are subjected to certain unique design forces and loads resulting from postulated accidents (such as turbine generated missiles and jet forces from high-energy line breaks) and from extreme natural phenomena (tornadoes and earthquakes). The relevant regulatory and jurisdictional authorities (for example, the Nuclear Regulatory Commission and the Department of Energy) dictate special quality assurance requirements and additional design requirements associated with these structures. As such, safety related nuclear structures require special design provisions. The provisions specified herein are to be used in conjunction with the 2005 AISC *Specification for Structural Steel Buildings*. The Nuclear Specification consists of modifications (additions, deletions, and replacements) to the Specification.

The Nuclear Specification has been developed as a consensus document to provide uniform practice in the design of steel-framed structures for nuclear facilities. This specification was approved by the AISC Committee on Specifications:

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The committee gratefully acknowledges the following task committee (TC 12—Nuclear Facilities Design) for their development of this document.

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A nonmandatory Commentary provides background for the Nuclear Specification provisions, and the user is encouraged to consult it.

The reader is cautioned that professional judgment must be exercised when data or recommendations in the Nuclear Specification are applied. The publication of the material contained herein is not intended as a representation or warranty on the part of the American Institute of Steel Construction, Inc., or any other person named herein that this information is suitable for general or particular use, or freedom from infringement of any patent or patents. Anyone making use of this information assumes all liability arising from such use. The design of safety related structures for Nuclear Facilities is within the scope of expertise of a competent licensed structural engineer, architect, or other licensed professional, for the application of principles to a particular structure.

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SYMBOLS

The symbols listed below shall be used in addition to or replacements for those in the AISC *Specification for Structural Steel Buildings*. Where there is a duplication of the use of a symbol between this Specification and the AISC *Specification for Structural Steel Buildings*, the symbol listed herein shall take precedence. The section or table number in the right-hand column refers to where the symbol is first used.

<u>Symbol</u>	<u>Definition</u>	<u>Section</u>
C	Rated capacity of crane	NB2.1
D	Dead loads due to the weight of the structural elements, fixed-position equipment, and other permanent appurtenant items; weight of crane trolley and bridge	NB2.1
E_o	Loads generated by the operating basis earthquake.	NB2.2
E_s	Loads generated by the safe shutdown or design basis earthquake	NB2.3
L	Live load due to occupancy and moveable equipment, including impact	NB2.1
L_r	Roof live load.	NB2.1
P_a	Maximum differential pressure load generated by the postulated accident.	NB2.4
P_a	Required compressive strength using ASD load combinations, kips (N)	Table NB3.2
R	Rain load	NB2.4
R_a	Pipe and equipment reactions generated by the postulated accident, including R_o	NB2.4
R_o	Pipe reactions during normal operating, start-up, or shutdown conditions, based on the most critical transient or steady-state condition	NB2.1
S	Snow load as stipulated in SEI/ASCE 7 for Category IV facilities	NB2.1
T_a	Thermal loads generated by the postulated accident, including T_o . . .	NB2.4
T_o	Thermal effects and loads during normal operating, start-up, or shutdown conditions, based on the most critical transient or steady-state condition	NB2.1
W	Wind load as stipulated in SEI/ASCE 7 for Category IV facilities . . .	NB2.2

<u>Symbol</u>	<u>Definition</u>	<u>Section</u>
W_t	Loads generated by the specified design tornado, including wind pressures, pressure differentials, and tornado-borne missiles	NB2.3
Y_j	Jet impingement load generated by the postulated accident	NB2.4
Y_r	Loads on the structure generated by the reaction of the broken high-energy pipe during the postulated accident	NB2.4
Y_m	Missile impact load, such as pipe whipping generated by or during the postulated accident.	NB2.4
ϵ_{st}	Strain corresponding to the onset of strain hardening	Table NB3.1
ϵ_u	Strain corresponding to elongation at failure (rupture)	Table NB3.1
ϵ_y	Strain corresponding to yield stress	Table NB3.1
μ	Ductility factor.	NB3.14

GLOSSARY

The terms listed herein shall be used in addition to or replacements for those in the AISC *Specification for Structural Steel Buildings*. Glossary terms are *italicized* where they first appear in a subsection of the Nuclear Specification.

Authority having jurisdiction (AHJ). Federal government agency (or agencies), such as the Nuclear Regulatory Commission or the Department of Energy, that is empowered to issue and enforce regulations affecting the design, construction, and operation of nuclear facilities.

Certificate of compliance. Document written specifically for the raw materials used. It must specifically identify the job order and component where these materials are to be used. In addition, this certification must be traceable to the applicable *certified material test report* for the raw materials used in fabrication.

Certified material test report (CMTR). Document identifying the chemical analysis, physical test data, and any other testing necessary to show compliance of the item for which the CMTR is supplied.

Design basis earthquake (DBE). See *safe shutdown earthquake (SSE)*. (Term used in connection with DOE facilities; also used interchangeably for older nuclear power facilities.)

Ductility factor. Ratio of permitted strain to the strain at yield or deformation to the deformation at yield.

Engineer. Individual or organization, designated by the *owner*, responsible for the preparation of the plans and specifications for the nuclear facility structures, or for the evaluation of the existing structure(s). The engineer of record as an individual or part of an organization shall be a licensed professional engineer, qualified to fulfill the assigned responsibility.

Impactive force. Time-dependent loads due to collision of masses that are associated with finite amounts of kinetic energy. The impactive load is determined by the inertia and stiffness properties of the impactor and the target structure. Impactive loads include the following examples/types: *tornado-borne missiles*, whipping pipes, aircraft missiles, and other internal and external missiles.

Impulsive force. Time-dependent loads that are not associated with collision of solid masses. The loads are not dependent on the target mass or stiffness properties. Impulsive loads include the following examples/types: *jet impingement load*, blast pressure, compartment pressurization, and *jet shield* reactions.

Jet impingement load. Force-time history depicting the forces resulting from the direct strike by a dense, high velocity jet of steam or water onto a structure, system, or component.

Jet shield. Device used to protect adjacent structures, systems, or components from the effects of a dense, high velocity jet of steam or water, resulting from the rupture of a high energy pipe line.



Missile impact. Collision of a projectile [for example, *tornado-borne missile* (see definition) or plant-generated missile] with a structure, system, or component.

Operating basis earthquake (OBE). Earthquake that could reasonably be expected to occur at the plant site during the operating life of the plant considering the regional and local geology and seismology and specific characteristics of local subsurface material. It is that earthquake that produces the vibratory ground motion for which the features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public are designed to remain functional. An earthquake greater than the OBE is associated with plant shutdown and inspection. See Appendix S of 10CFR50.

Owner. Organization responsible for the design, construction, operation, maintenance, and safety of the nuclear facility.

Pipe whip impact barrier. Energy-absorbing device used to protect *safety-related structures*, systems, or components from the potentially damaging forces of a whipping, high energy pipe.

Pipe whip restraint. Energy-absorbing device used to limit the potentially damaging motion of a whipping, high energy pipe, resulting from a pipe break/rupture, through the confining effects of the device.

Quality assurance. Program identifying the planned or systematic actions necessary to provide adequate confidence that an item or facility will be designed, fabricated, and constructed in accordance with the plans and specification.

Response spectrum. Plot of the maximum responses (acceleration, velocity, or displacement) of idealized single-degree-of-freedom oscillators as a function of the natural frequencies of the oscillators for a given damping value. The *response spectrum* is calculated for a specified vibratory motion input at the oscillators' supports.

Safe shutdown earthquake (SSE). Earthquake that produces the vibratory ground motion for which certain structures, systems, and components in the nuclear power plant must be designed to remain functional (see Appendix S of 10CFR50).

Safety-related. Classification that applies to structures, systems, or components used in a nuclear power plant that are relied upon during or following design basis events to ensure:

- (1) The integrity of the reactor coolant pressure boundary;
- (2) The capability to shut down the reactor and maintain it in a safe shut down condition;
or
- (3) The capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guideline exposures of 10CFR100.

Specified design (basis) tornado. Combination of translational speed, rotational speed, and prescribed pressure drop related to the environmental effects of a tornado (as defined by the licensing basis, design basis, and/or regulatory requirements; for example, USNRC Regulatory Guide 1.76).

Specified design (basis) wind. Combination of wind speed and exposure conditions, as defined by the facility specific document and/or other design basis documents, used to establish the forces acting on a structure from wind effects. The methodology of determining such forces should be in accordance with industry accepted practices (for example, SEI/ASCE 7).

Tornado-borne missiles. Missiles of specific weight and velocity that are assumed to impact structures after becoming airborne as a result of tornado winds and pressures. These missiles are defined by the AHJ at the facility site.



CHAPTER NA

GENERAL PROVISIONS

Modify Chapter A of the Specification as follows.

Replace the preamble with the following:

This chapter states the scope of the *Specification for Safety-Related Steel Structures in Nuclear Facilities*; summarizes referenced specification, code, and standard documents; and provides requirements for materials and design documents.

The chapter is organized as follows:

- NA1. Scope
- NA2. Referenced Specifications, Codes, and Standards
- NA3. Material
- NA4. Structural Design Drawings and Specifications
- NA5. Quality Assurance

NA1. SCOPE

Replace section with the following:

The *Specification for Safety-Related Steel Structures in Nuclear Facilities*, hereafter referred to as the Nuclear Specification, shall apply to the design of *safety-related* steel structures and steel elements in nuclear facilities.

The Chapter, Appendix, and Section designations within the Nuclear Specification are preceded by letter N to denote nuclear facility provisions.

The Nuclear Specification is compatible with the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360), hereafter referred to as the Specification. Provisions of the Specification are applicable unless stated otherwise. Only those sections that differ from the Specification provisions are indicated in the Nuclear Specification.

The Nuclear Specification includes the list of additional symbols, additional glossary terms, Chapters NA through NM, and Appendices N1 through N7. The commentary and user notes (interspersed throughout the specification) are not part of the specification.

User Note: User notes are intended to provide concise and practical guidance in the application of the provisions.

The steel elements shall be as defined in the AISC *Code of Standard Practice for Steel Buildings and Bridges*, Section 2.1.

Structures and structural elements subject to the Nuclear Specification are those steel structures that are part of a safety-related system or that support, house, or protect safety-related systems or components, the failure of which would impair the safety-related functions of these systems or components. Safety categorization for nuclear facility steel structures and structural elements shall be the responsibility of the *owner*.

Specifically excluded from the Nuclear Specification are the pressure-retaining components, for example, pressure vessels, valves, pumps, and piping.

In the design of members and connections of seismic load resisting systems, the *AISC Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341), in general, are not applicable. However, the detailing requirements of Sections 6 and 7 of the Seismic Provisions shall be appropriately considered when designing for inelastic behavior.

The sponsors of any structural system or construction within the scope of the Nuclear Specification, the adequacy of which has been shown by successful use or by analysis or test, but which does not conform to or is not covered by the Nuclear Specification, shall have the right to present the data on which their design is based to the *authority having jurisdiction* for review and approval.

User Note: For the design of structural members, other than hollow structural sections (HSS), that are cold-formed to shapes with elements not more than 1 in. (25 mm) in thickness, the use of provisions of the *AISI North American Specification for the Design of Cold-Formed Steel Structural Members* is recommended, incorporating the loads and load combinations delineated in Section NB2 of the Nuclear Specification.

NA2. REFERENCED SPECIFICATIONS, CODES, AND STANDARDS

Add the following:

ACI International (ACI)

ACI 349-01 *Standard Code Requirements for Nuclear Safety Related Concrete Structures*

American Institute of Steel Construction, Inc. (AISC)

ANSI/AISC 360-05 *Specification for Structural Steel Buildings*

Delete the following:

American Institute of Steel Construction, Inc. (AISC)

ANSI/AISC N690-1994(R2004) *Specification for the Design, Fabrication and Erection of Steel Safety-Related Structures for Nuclear Facilities*, including Supplement No. 2

ANSI/AISC N690L-03 Load and Resistance Factor Design Specification for Steel Safety-Related Structures for Nuclear Facilities

Add the following:

American Iron and Steel Institute (AISI)

North American Specification for the Design of Cold-Formed Steel Structural Members, 2001, including Supplement, 2004

American Society of Mechanical Engineers (ASME)

ASME NQA-1, Subpart 2.7 “Quality Assurance Requirements for Computer Software for Nuclear Facility Applications,” 2004

American Society of Civil Engineers (ASCE)

ANSI/ASCE 8-90 Specification for the Design of Cold-Formed Stainless Steel Structural Members

ASTM International (ASTM)

A20/A20M-04a Standard Specification for General Requirements for Steel Plates for Pressure Vessels

A27/A27M-03 Standard Specification for Steel Castings, Carbon, for General Application

A106/A106M-04 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

A148/A148M-03 Standard Specification for Steel Castings, High Strength, for Structural Purposes

A167-99 Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

A217/A217M-02 Standard Specification for Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High-Temperature Service

A240/A240M-04ae1 Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

A276-04 Standard Specification for Stainless Steel Bars and Shapes

A312/A312M-04a Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes

A320/A320M-03 Standard Specification for Alloy-Steel Bolting Materials for Low-Temperature Service

A435/A435M-90(2001) Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates

A479/A479M-04 Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels

A515/A515M-03 *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service*

A516/A516M-04 *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service*

A540/A540M-04 *Standard Specification for Alloy-Steel Bolting Materials for Special Applications*

A564/A564M-04 *Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes*

A666-03 *Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar*

A1008/A1008M-04a *Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability*

D3843-00 *Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities*

F606-06 *Standard Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets*

F606M-05 *Standard Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets [Metric]*

American Welding Society (AWS)

AWS A5.4-92 *Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding*

AWS A5.9-93 *Specification for Bare Stainless Steel Welding Electrodes and Rods*

AWS D1.6-1999 *Structural Welding Code Stainless Steel*

Crane Manufacturers Association of America

CMAA-70 "Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes," 2004

U.S. Nuclear Regulatory Commission

Regulatory Guide 1.54, "Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants," July 2000

NUREG-0800, *Standard Review Plan*, April 1989

Office of the Federal Register, National Archives and Records Administration

Title 10 of the *Code of Federal Regulations*, Part 50 (10CFR50), Appendix B and Appendix S, 2001

Title 10 of the *Code of Federal Regulations*, Part 830.120 (to be used for Department of Energy Nuclear Facilities), 2001

TABLE NA3.1
Charpy V-Notch Energy Values

Specified Minimum Yield Strength	Charpy V-Notch Energy Value	
	Average of Three Specimens, Minimum	One Individual Specimen, Minimum
Equal to or less than 36 ksi (250 MPa)	15 ft-lb (21 J)	10 ft-lb (14 J)
Greater than 36 ksi (250 MPa), less than 44 ksi (300 MPa)	20 ft-lb (27 J)	15 ft-lb (21 J)
Equal to or greater than 44 ksi (300 MPa)	30 ft-lb (41 J)	25 ft-lb (34 J)

NA3. MATERIAL

1. Structural Steel Materials

Replace section with the following:

In addition to satisfying the appropriate ASTM specification, the specification of the material of those structures or structural components that may be subject to suddenly applied impact loads, for example, *jet shields*, pipe restraint supports, *pipe whip impact barriers*, etc., shall be supplemented by the requirement that the material be subjected to Charpy V-notch impact tests, using the procedures described in ASTM A20/A20M. The Charpy V-notch impact test shall be conducted at a temperature not less than 30 °F (17 °C) below the lowest service metal temperature of the structural component. The acceptance criteria shall be that the material withstand not less than the energy values (average of three specimens value and individual specimen value) indicated in Table NA3.1, in addition to satisfying the appropriate ASTM specification.

Certified material test reports or certified reports of tests made by the fabricator or a qualified testing laboratory shall validate that the material meets the specification.

In lieu of the above requirements, the material supplier or fabricator shall, if approved by the *owner*, provide a *certificate of compliance* stating that the material furnished has been tested and conforms to the specification.

Traceability by heat or production lot is not required unless stipulated by the plans and/or specifications.

1a. ASTM Designations

Modify this section as follows:

(3) Pipe

Add the following:

ASTM A106/A106M

ASTM A312/A312M