RACK MANUFACTURERS INSTITUTE

PART I
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SPECIFICATION FOR THE DESIGN TESTING AND UTILIZATION OF INDUSTRIAL STEEL STORAGE RACKS

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American National Standard for the Design, Testing, Utilization and Application of Industrial Grade Steel Shelving - Specifications

SECTION 1 - SCOPE

1.1 Scope

This specification applies to shelving made entirely of cold-formed or hot-rolled steel members designed to be loaded by hand. When used in conjunction with automatic or man aboard storage/retrieval equipment special criteria beyond the scope of this specification must be considered. (Reference Section 2.4.)

1.2 Materials

This specification contemplates the use of steel as defined by the specifications of the American Society for Testing and Materials (ASTM), as listed in the Specification for the Design of Cold-Formed Steel Structural Members, latest adoptions, of the American Iron and Steel Institute (AISI), and in the Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, latest adoption, of the American Institute of Steel Construction (AISC).

Steels not listed in the above specifications are not excluded, provided they conform to the chemical and mechanical requirements of one of the listed specifications, or other published specifications which establish their properties and structural suitability, and provided they are subjected by either the producer or the purchaser to analyses, tests, and other controls to the extent and in the manner prescribed by one of the listed specifications, as applicable.

1.3 Applicable Design Specifications

Except as either modified in Section 6 or supplemented herein, the Specification for the Design of Cold-Formed Steel Structural Members, AISI (henceforth referred to as the AISI Specification) and the Specification for the Design, Fabrication and Erection of Structural Steel Buildings, AISC (henceforth referred to as the AISC Specification) of latest adoption, as respectively applicable should be applied to the design of steel shelving.

1.4 Recommended Practices in the Use of Shelving

1.4.1 Shelving assemblies and individual components thereof should conform with this specification.

1.4.2 It is the end users' responsibility to provide adequate flooring support for the system and its application. Upright assembly anchoring will be required when the top loaded shelf is over eight feet (2440 mm) high and the height to depth ratio of shelving exceeds four (4). When the upright assembly ratio is exceeded, back to back sections should be firmly tied together at a minimum of two places (near top and bottom), and single row sections should be attached to some firm restraint such as the floor, wall, or tied overhead across the aisle to an opposite upright assembly. "Depth" here relates to the overall depth (front to back) of the upright assembly and "height" refers to the height from the floor to the highest point of the upright assembly or top of load on the section, both in the same units of measure.

1.4.3 If the shelving is attached to the building structure, the horizontal and vertical forces imposed by the shelving on the building must be calculated for the effects listed in Section 7. The shelving user, building owner, or their agents, should be informed of these forces and their locations.

1.4.4 The shelving should be installed with a maximum tolerance from the vertical of 1/2" (13 mm) in 10 feet (3050 mm) or more of height, unless tighter tolerances are specified.

for ASD

$$F'_p = 0.7f'_c$$

for LRFD

$$P_p = 1.7f'_c A_{\text{Effective Base Bearing Area}}$$

$$\phi_c = 0.60$$

where f'_c = the minimum 28-day compression strength of the concrete floor which, unless otherwise brought to the attention of the rack fabricator, shall be assumed to be 3,000 psi.

Once the required bearing area has been determined from the allowable bearing stress F'_p, the minimum thickness of the base plate is determined by rational analysis or by appropriate test using a test load 1.5 times the design load. Upon request, information shall be given to the owner, or the owner's agent on the location, size, and pressures under the bearing plates of each type of upright frame in the installation.

8. SPECIAL RACK DESIGN PROVISIONS.

8.1 Overturning.

Overturning is to be considered for the most unfavorable combination of vertical and horizontal loads. Stabilizing forces provided by the anchors to the floor are not considered in checking overturning, unless anchors and floor are specifically designed and installed to meet these uplift forces (see 2.6 and 2.7).

Unless all columns are so anchored, the ratio of the restoring moment to overturning moment shall not be less than 1.5.

The height-to-depth ratio of a storage rack shall not exceed 6 to 1 measuring to topmost beam position unless the rack is properly anchored or braced externally.

Rack that exceed the 6 to 1 ratio defined above, shall also be designed to resist a 350 pound side force applied to any single frame at the top shelf level in a direction perpendicular to the aisle. For LRFD design method, the load factor applied to this force shall be 1.6. This force is to be applied to an empty frame. Anchors and base plates will be designed to resist uplift forces from this force when applied to an empty frame. Frame columns need not be designed for the additional axial load from this force.

Unless it can be shown to be unnecessary because of such factors as soil, slab and frame stiffness, single rows of rack exceeding a height to depth ratio of 8 to 1 must be tied externally to the building or cross-aisle to another rack. Stabilizing a single rack with a height to depth ratio of over 8 to 1 with anchoring alone is not recommended unless designed and certified by an engineer.

The 350 pound side force in this section need not be applied concurrently with the horizontal forces of sections 2.5, 2.6 and 2.7.

8.2 Connections to Buildings.

Connections of racks to buildings, if any, shall be designed and installed to prevent reactions or displacements of the buildings from damaging the racks or the reactions or displacements of the racks from damaging the building (see also 1.4.10).

TABLE 16-O—HORIZONTAL FORCE FACTORS, a_p AND R_p

ELEMENTS OF STRUCTURES AND NONSTRUCTURAL COMPONENTS AND EQUIPMENT[1]	a_p	R_p	FOOTNOTE
1. Elements of Structures			
A. Walls including the following:			
(1) Unbraced (cantilevered) parapets.	2.5	3.0	
(2) Exterior walls at or above the ground floor and parapets braced above their centers of gravity.	1.0	3.0	2
(3) All interior-bearing and nonbearing walls.	1.0	3.0	2
B. Penthouse (except when framed by an extension of the structural frame).	2.5	4.0	
C. Connections for prefabricated structural elements other than walls. See also Section 1632.2.	1.0	3.0	3
2. Nonstructural Components			
A. Exterior and interior ornamentations and appendages.	2.5	3.0	
B. Chimneys, stacks and trussed towers supported on or projecting above the roof:			
(1) Laterally braced or anchored to the structural frame at a point below their centers of mass.	2.5	3.0	
(2) Laterally braced or anchored to the structural frame at or above their centers of mass.	1.0	3.0	
C. Signs and billboards.	2.5	3.0	
D. Storage racks (include contents) over 6 feet (1829 mm) tall.	2.5	4.0	4
E. Permanent floor-supported cabinets and book stacks more than 6 feet (1829 mm) in height (include contents).	1.0	3.0	5
F. Anchorage and lateral bracing for suspended ceilings and light fixtures.	1.0	3.0	3, 6, 7, 8
G. Access floor systems.	1.0	3.0	4, 5, 9
H. Masonry or concrete fences over 6 feet (1829 mm) high.	1.0	3.0	
I. Partitions.	1.0	3.0	
3. Equipment			
A. Tanks and vessels (include contents), including support systems.	1.0	3.0	
B. Electrical, mechanical and plumbing equipment and associated conduit and ductwork and piping.	1.0	3.0	5, 10, 11, 12, 13, 14, 15, 16
C. Any equipment laterally braced or anchored to the structural frame at a point below their center of mass.	2.5	3.0	5, 10, 14, 15, 16
D. Anchorage of emergency power supply systems and essential communications equipment. Anchorage and support systems for battery racks and fuel tanks necessary for operation of emergency equipment. See also Section 1632.2.	1.0	3.0	17, 18
E. Temporary containers with flammable or hazardous materials.	1.0	3.0	19
4. Other Components			
A. Rigid components with ductile material and attachments.	1.0	3.0	1
B. Rigid components with nonductile material or attachments.	1.0	1.5	1
C. Flexible components with ductile material and attachments.	2.5	3.0	1
D. Flexible components with nonductile material or attachments.	2.5	1.5	1

[1]See Section 1627 for definitions of flexible components and rigid components.

[2]See Sections 1633.2.4 and 1633.2.8 for concrete and masonry walls and Section 1632.2 for connections for panel connectors for panels.

[3]Applies to Seismic Zones 2, 3 and 4 only.

[4]Ground supported steel storage racks may be designed using the provisions of Section 1634. Chapter 22, Division VI, may be used for design, provided seismic design forces are equal to or greater than those specified in Section 1632.2 or 1634.2, as appropriate.

[5]Only anchorage or restraints need be designed.

[6]Ceiling weight shall include all light fixtures and other equipment or partitions that are laterally supported by the ceiling. For purposes of determining the seismic force, a ceiling weight of not less than 4 psf (0.19 kN/m^2) shall be used.

[7]Ceilings constructed of lath and plaster or gypsum board screw or nail attached to suspended members that support a ceiling at one level extending from wall to wall need not be analyzed, provided the walls are not over 50 feet (15 240 mm) apart.

[8]Light fixtures and mechanical services installed in metal suspension systems for acoustical tile and lay-in panel ceilings shall be independently supported from the structure above as specified in UBC Standard 25-2, Part III.

[9]W_p for access floor systems shall be the dead load of the access floor system plus 25 percent of the floor live load plus a 10-psf (0.48 kN/m^2) partition load allowance.

[10]Equipment includes, but is not limited to, boilers, chillers, heat exchangers, pumps, air-handling units, cooling towers, control panels, motors, switchgear, transformers and life-safety equipment. It shall include major conduit, ducting and piping, which services such machinery and equipment and fire sprinkler systems. See Section 1632.2 for additional requirements for determining a_p for nonrigid or flexibly mounted equipment.

[11]Seismic restraints may be omitted from piping and duct supports if all the following conditions are satisfied:

11.1 Lateral motion of the piping or duct will not cause damaging impact with other systems.

11.2 The piping or duct is made of ductile material with ductile connections.

11.3 Lateral motion of the piping or duct does not cause impact of fragile appurtenances (e.g., sprinkler heads) with any other equipment, piping or structural member.

11.4 Lateral motion of the piping or duct does not cause loss of system vertical support.

11.5 Rod-hung supports of less than 12 inches (305 mm) in length have top connections that cannot develop moments.

11.6 Support members cantilevered up from the floor are checked for stability.

(Continued)