

ICC/NSSA STANDARD FOR THE DESIGN AND CONSTRUCTION OF STORM SHELTERS

ICC 500-2008

American National Standard

International Code Council
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Washington, DC 20001

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American National Standard

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The cover photo: L'Ouverture Computer Technology Magnet, Unified School District 259, Wichita, Kansas. Designed by PBA Architects, this shelter is one of 30 in the school district. It consists of a precast concrete multipurpose room designed for approximately 450 occupants. Photo by Tom Pott.

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ICC/NSSA

Standard for the Design and Construction of Storm Shelters

FOREWORD

[The information contained in this foreword is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, this foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to this standard.]

Introduction

In May of 2002 the International Code Council (ICC) and the National Storm Shelter Association (NSSA) initiated a joint project to write a standard for the design and construction of storm shelters. A standard development committee was created, and the first meeting of that committee was in May of 2003. The scope of the standard is to provide minimum design and construction requirements for storm shelters that provide a safe refuge from storms that produce high winds, hurricanes and tornadoes. Hurricanes and tornadoes generate high winds that produce wind pressures on buildings and structures and that create flying debris at levels and intensities than are higher than those for which most commercial building and residences are designed. The magnitude of the wind speeds associated with these storms are such that building occupants and residents are required to evacuate the area or seek protection in a shelter designed for resistance to extraordinary loads and flying debris. This standard provides design requirements for the main wind-resisting structural system and components and cladding of these shelters, and provides basic occupant life safety and health requirements for these shelters, including means of egress, lighting, sanitation, ventilation, fire safety and minimum required floor space for occupants.

Development

This is the first edition of the International Code Council (ICC) and National Storm Shelter Association's (NSSA) *Standard for the Design and Construction of Storm Shelters*. This standard was developed by the ICC/NSSA Consensus Committee on Storm Shelters (IS-STM) that operates under ANSI Approved ICC Consensus Procedures for the Development of ICC Standards. The consensus process of ICC for promulgating standards is accredited by ANSI. The Storm Shelter Committee is a balanced committee formed and operated in accordance with ICC rules and procedures.

The meetings of the ICC/NSSA IS-STM Consensus Committee were open to the public and interested individuals and organizations from across the country participated. The technical content of currently published documents on storm shelters, including documents of the National Storm Shelter Association, the Federal Emergency Management Agency (FEMA), the Red Cross, and the State of Florida, was reviewed and considered by the committee. The information from these documents helped form a basis for the regulations installed in this standard, but the exact provisions adopted by the committee were determined based upon the scope and intent of this standard. The requirements of ICC/NSSA 500 are based on the intent to establish provisions consistent with the scope of the ICC family of codes and standards that are written to adequately protect public health, safety and welfare; provisions that do not necessarily increase construction costs; provisions that do not restrict the use of new materials, products or methods of construction; and provisions that do not give preferential treatment to particular types or classes of materials, products or methods of construction.

Adoption

ICC/NSSA 500 *Standard for the Design and Construction of Storm Shelters* is available for adoption and use by any jurisdictions. Its use within a governmental jurisdiction is intended to be accomplished through adoption by reference in accordance with proceedings establishing the jurisdiction's laws. At the time of adoption, jurisdictions should insert the appropriate information in provisions requiring specific local information, such as the name of the jurisdiction.

Formal Interpretations

Requests for Formal Interpretations on the provisions of ICC 500-2008 should be addressed to: ICC, Chicago District Office, 4051 West Flossmoor Road, Country Club Hills, IL 60478.

Maintenance – Submittal of Proposals

All ICC standards are revised as required by ANSI. Proposals for revising this edition are welcome. Please visit the ICC website at www.iccsafe.org for the official “Call for Proposals” announcement. A proposal form and instructions can also be downloaded from www.iccsafe.org.

ICC, its members and those participating in the development of ICC 500-2008 do not accept any liability resulting from compliance or noncompliance with the provisions of ICC 500-2008. ICC does not have the power or authority to police or enforce compliance with the contents of this standard. Only the governmental body that enacts this standard into law has such authority.

International Code Council/National Storm Shelter Association Consensus Committee on Storm Shelters (IS-STM)

Consensus Committee SCOPE: The ICC/NSSA Consensus Committee on Storm Shelter (IS-STM) shall have primary responsibility for minimum requirements to safeguard the public health, safety and general welfare through design, construction and installation requirements for storm shelters.

This standard was processed and approved for submittal to ANSI by the ICC/NSSA Consensus Committee on Storm Shelters (IS-STM). Committee approval of the standard does not necessarily imply that all committee members voted for its approval.

Representatives on the Consensus Committee are classified in one of three voting interest categories. The committee has been formed in order to achieve consensus as required by ANSI Essential Requirements. At the time it approved this standard, the IS-STM Consensus Committee consisted of the following members:

General Interest (G) - User Interest (U) - Producer Interest (P)

Mr. Majed Dabdoub (G), City of Cincinnati, Cincinnati, OH

Mr. Kenneth Ford (P), National Association of Home Builders, Washington, DC

Mr. Jaime D. Gascon (G), Miami-Dade County Building Code Compliance Office, Miami, FL

Mr. Dennis W. Graber (P), National Concrete Masonry Association, Herndon, VA

Mr. John D. Holmes (U), Louisiana State University LSU Hurricane Center, Baton Rouge, LA

Mr. Mitchell Hort (G), Community Development - City of Yukon, Yukon, OK

Dr. Ernst W. Kiesling (U), Wind Engineering Research Center, Texas Tech University, Lubbock, TX

Mr. Danny John Kilcollins (G), Florida Department of Community Affairs, Tallahassee, FL

Dr. Marc L. Levitan (U), Louisiana State University LSU Hurricane Center, Baton Rouge, LA

Mr. Joseph J. Messersmith, Jr. (P), Portland Cement Association, Rockville, VA

Mr. Timothy A. Reinhold (U), Institute for Business and Home Safety, Tampa, FL

Mr. Roger M. Robertson (G), Chesterfield County Department of Building Inspections, Chesterfield, VA

Mr. Kurt A. Roeper (P), Ingersoll-Rand Security & Safety, Cincinnati, OH

Mr. Corey Schultz (U), PBA Architects, P.A., Wichita, KS

Mr. E. Scott Tezak, P.E. (U), URS Corporation, Boston, MA

Mr. James E. Waller, P.E. (P), Remagen Safe Rooms, Monteagle, TN

Mr. Mark Whitaker (G), City of Little Rock, Little Rock, AR

Mr. Robert J. Wills (P), American Iron & Steel Institute, Birmingham, AL

Committee Secretary: **David A. Bowman, P.E.**, Manager, Codes, Codes & Standards, International Code Council, Country Club Hills, IL

Voting Membership in Each Category

Category	Number
General (G)	6
User (U)	6
Producer (P)	6
TOTAL	18

Interest Categories

General Interest: Individuals assigned to the General Interest category are those who represent the interests of an entity, including an association of such entities, representing the general public or entities that promulgate or enforce the provisions within the committee scope. These entities include consumers and government regulatory agencies.

User Interest: Individuals assigned to the User Interest category are those who represent the interests of an entity, including an association of such entities, which is subject to the provisions or voluntarily utilizes provisions within the committee scope. These entities include academia, applied research laboratory, building owner, design professional, government nonregulatory agency, insurance company, private inspection agency and product certification/evaluation agency.

Producer Interest: Individuals assigned to the Producer Interest category are those who represent the interests of an entity, including an association of such entities, which produces, installs or maintains a product, assembly or system subject to the provisions within the committee scope. These entities include builder, contractor, distributor, labor, manufacturer, material association, standards promulgator, testing laboratory and utility.

NOTE — Multiple Interests: Individuals representing entities in more than one of the above interest categories, one of which is a Producer Interest, are assigned to the Producer Interest. Individuals representing entities in the General Interest and User Interest categories are assigned to the User Interest.

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CHAPTER 1

APPLICATION AND ADMINISTRATION

SECTION 101 GENERAL

101.1 Purpose. The purpose of this standard is to establish minimum requirements to safeguard the public health, safety and general welfare relative to the design, construction and installation of storm shelters constructed for protection from high winds associated with tornadoes and hurricanes. This standard is intended for adoption by government agencies and organizations for use in conjunction with model codes to achieve uniformity in the technical design and construction of storm shelters.

101.2 Scope. This standard applies to design, construction, installation, and inspection of storm shelters constructed as separate detached buildings or constructed as safe rooms within buildings for the purpose of providing safe refuge from storms that produce high winds, such as tornadoes and hurricanes. Shelters designed and constructed to this standard shall be designated to be hurricane shelters, tornado shelters or combined hurricane and tornado shelters.

101.3 Requirements not included. Where requirements are not provided by this standard, the applicable provisions of the construction codes adopted by the authority having jurisdiction shall apply to the storm shelter.

101.4 Special needs. Provisions that are necessary for persons with special needs, including any special electrical or mechanical equipment, sanitary facilities or other special features, are outside the scope of this standard.

101.5 Referenced standards. The specific year, date and editions of the standards referenced by this standard are listed in Chapter 9.

SECTION 102 COMPLIANCE ALTERNATIVES

102.1 Compliance alternatives. Nothing in this standard is intended to prevent the use of designs, technologies or products as alternatives to any prescriptions in this standard, provided equivalence is demonstrated and approved by the authority having jurisdiction.

SECTION 103 CONVENTIONS

103.1 Dimensions. All dimensions that are not stated as "maximum" or "minimum" are nominal. All dimensions are subject to conventional industry tolerances unless otherwise noted.

SECTION 104 OCCUPANCY

104.1 Rooms or spaces within other uses. Where storm shelters are designated areas normally occupied for other purposes, the requirements of the applicable construction codes for the occupancy of the building shall apply unless otherwise stated in this standard.

104.2 Dedicated facilities. Where a facility is designed to be occupied solely as a storm shelter, the designated occupancy shall be A-3 as defined by the *International Building Code*® for purposes of determination of applicable requirements that are not included in this standard.

104.3 Combination storm shelters. Where the purpose of a storm shelter is to provide protection from both tornadoes and hurricanes, the entire storm shelter shall be designed and constructed using the most restrictive requirements for each hazard.

SECTION 105 APPLICABLE BUILDING CODE

105.1 Applicable code. Where construction of a storm shelter is to take place where no applicable construction codes are adopted, the provisions of the *International Building Code*® shall apply.

SECTION 106 INSPECTIONS AND STRUCTURAL OBSERVATIONS

106.1 General. Construction of storm shelters and installation of all equipment shall be subject to inspections in accordance with the applicable building code.

106.1.1 Peer review. Construction documents for community shelters designed for greater than 300 occupants shall undergo a peer review by an independent registered design professional for compliance with the requirements of Chapter 3.

106.2 Special inspections. Special inspections shall be provided for construction and installation of materials as required by the applicable building code, and Section 106.3 of this standard.

106.2.1 Inspection of fabricators. Where fabrication of structural load-bearing and debris-impact-resistant components and assemblies is being performed on the premises of a fabricators shop, special inspection of the fabricator shall be provided.

Exception: Prefabricated or panelized storm shelter components that have been inspected and labeled by an

approved agency meeting the requirements of the applicable building code.

106.3 Special cases. Special inspections shall be provided for proposed work comprised of:

1. Construction materials and systems that are alternatives to traditional materials and systems prescribed by the applicable code.
2. Unusual design and construction applications.

106.4 Structural observations. During construction of community shelters, the building owner shall employ a registered design professional to conduct visual observations of the construction of the structural system for general conformance to the approved construction documents at significant construction stages and at completion of the construction of the structural system. Structural observation shall not obviate the need for other inspections or testing required by this standard or the applicable building code.

Deficiencies shall be reported in writing to the owner and to the authority having jurisdiction. At the conclusion of the work, the registered design professional who made the structural observations shall submit to the authority having jurisdiction a written statement that the site visits have been made and shall identify any reported deficiencies which, to the best of the structural observer's knowledge, have not been resolved.

SECTION 107 CONSTRUCTION DOCUMENTS

107.1 General. Where required by the authority having jurisdiction, construction documents shall be prepared. Such documents shall contain information as required by the applicable building code and this section.

107.2 Information required. The following information applicable to construction and operation of the storm shelter shall be supplied on the construction documents.

107.2.1 Design information. For the areas of a building designed for occupancy as a storm shelter, the following information shall be provided within the construction documents:

1. Type of shelter: tornado, hurricane or a combination of both.
2. A statement that the wind design conforms to the provisions of the *ICC/NSSA Standard for the Design and Construction of Storm Shelters*, with the edition year specified.
3. The shelter design wind speed, mph.
4. The importance factor, I .
5. The wind exposure category (indicate all if more than one is used).
6. The internal pressure coefficient, GC_{pi} .
7. The topographic factor, K_z .
8. The directionality factor, K_d .

9. A statement that the shelter has/has not been constructed within an area susceptible to flooding in accordance with Chapter 4 of this standard.
10. The Design Flood Elevation and Base Flood Elevation for the site (if applicable).
11. Documentation showing that components of the shelter envelope will meet the pressure and missile impact test requirements identified in Chapters 3 and 8 of this standard.
12. A floor plan drawing or image indicating location of the storm shelter on a site or within a building or facility; including a drawing or image indicating the entire facility.
13. The lowest shelter floor elevation and corresponding datum, except for residential shelters outside of special flood hazard areas.
14. The occupant load of the storm shelter.
15. The usable storm shelter floor area.
16. Venting area (square inches) provided and locations in the shelter.

107.2.2 Enclosure. When a storm shelter is to be constructed as a portion of a host building, the walls and floors enclosing the shelter shall be clearly indicated on the drawings.

107.2.3 Signage. The type and location of signs required by this standard shall be indicated on the floor plans.

107.2.4 Inspections. Where any special details are utilized in the design of the structure, or where any special investigations are required that are additional to those required by the applicable building code, the construction documents shall contain a schedule of the inspections required and the criteria for the special installation.

107.2.5 Special details. The construction documents shall provide any special manufacturer's details or installation instructions for systems or equipment designed for the storm shelter.

107.2.6 Special instructions. The construction documents shall contain details of special instructions required for the specified functional operation of the storm shelter, such as:

1. Type and location of equipment and amenities required within the shelter, including water supply, sanitary facilities, fire extinguishers, batteries, flashlights, special emergency lighting equipment or any other equipment required to be installed in the shelter.
2. Specifications for any alarm system to be installed.
3. Instructions for the installation or deployment of any special protection equipment such as shutters, screens, special latching of doors or windows, any equipment or switching for mechanical, electrical and plumbing equipment.

107.3 Quality assurance plan. The construction documents for community shelters shall contain a quality assurance plan in accordance with Sections 107.3.1 through 107.3.3.

107.3.1 Detailed requirements. A quality assurance plan shall be provided for the following:

1. Roof cladding and roof framing connections.
2. Wall connections to roof and floor diaphragms and framing.
3. Roof and floor diaphragm systems, including connectors, drag struts and boundary elements.
4. Main wind-force resisting systems, including braced frames, moment frames and shear walls.
5. Main wind-force resisting system connections to the foundation.
6. Fabrication and installation of components and assemblies of the shelter envelope required to meet missile impact test requirements of Chapter 3.
7. Requirements for components and cladding including soffits.
8. Corrosion resistance or protection of metal connectors exposed to the elements that provide load path continuity.
9. Requirements for critical support systems connections and debris impact protection of the components and connections.

107.3.2 Quality assurance plan preparation. The design of each main wind-force resisting system and each wind-resisting component shall include a quality assurance plan prepared by a registered design professional.

The quality assurance plan shall identify the following:

1. The main wind-force resisting systems and wind-resisting components.
2. The special inspections and testing to be required in accordance with Section 106.2.
3. The type and frequency of testing required.
4. The type and frequency of special inspections required.
5. The structural observations to be performed in accordance with Section 106.4.
6. The required distribution, type, and frequency of reports of test, inspections, and structural observations.

107.3.3 Contractor responsibility. Each contractor responsible for the construction of a main wind-force resisting system or any component listed in the quality assurance plan shall submit a written statement of responsibility to the authority having jurisdiction, the responsible design professional, and the owner prior to the commencement of work on the system or component. The contractor's statement of responsibility shall contain:

1. Acknowledgement of awareness of the special requirements contained in the quality assurance plan.
2. Acknowledgement that control will be exercised to obtain compliance with the construction documents.

3. Procedures for exercising control within the contractor's organization, the method and frequency of reporting and the distribution of reports.
4. Identification and qualifications of the person(s) exercising such control and their position(s) in the organization.

Exception: Prefabricated or panelized storm shelter components which have been inspected and labeled by an approved agency meeting the requirements of the applicable building code.

SECTION 108

DESIGN INFORMATION SIGNAGE AND LABELING

108.1 Design information. All shelters shall have a sign on or within the shelter with the name of the manufacturer or builder of the shelter and the storm type(s) and respective design wind speed(s). The sign shall remain legible and visible.

108.2 Labeling. Products, materials or systems shall be labeled by an approved agency when required by the applicable code or jurisdiction.

CHAPTER 2

DEFINITIONS

SECTION 201 GENERAL

201.1 General. For the purposes of this standard, the terms listed in Section 202 shall have the indicated meaning.

201.2 Undefined terms. The terms not specifically defined in this standard or in standards referenced herein shall have ordinarily accepted meanings such as the context implies.

SECTION 202 DEFINITIONS

APPLICABLE CODE. The regulation for design and building construction of buildings and structures adopted by the authority having jurisdiction over the construction of the specific shelter.

AUTHORITY HAVING JURISDICTION. The organization, political subdivision, office or individual charged with the responsibility for administering and enforcing the provisions of this standard.

COLLAPSE HAZARDS. See "Hazards, Collapse."

CRITICAL SUPPORT SYSTEMS. Structures, systems and components required to ensure the health, safety and well-being of occupants. Critical support systems include, but are not limited to, potable and waste water systems, electrical power systems, life safety systems and HVAC systems.

DESIGN WIND PRESSURE. The wind pressure on a specific location of the shelter envelope, as determined in accordance with Section 304, Wind Loads, which controls the design of components and cladding (C & C) of the shelter envelope or the main wind-force resisting system (MWFRS) for the shelter.

FIRE BARRIER. A fire-resistance-rated vertical assembly of materials designed to restrict the spread of fire in which openings are protected.

HAZARDS

Collapse. Debris from wind damage to adjacent, taller structures which could fall onto the shelter.

Laydown. Nearby structures such as towers or large trees that could fall onto the shelter, if the shelter is within the laydown radius of the structure.

Rollover. Vehicles and small buildings, such as temporary classroom buildings, that could roll over due to extreme winds and impact the shelter.

HOST BUILDING. A building which is not designed or constructed as a storm shelter that totally or partially encloses a storm shelter.

INTERIOR SURFACE OF THE SHELTER COMPONENT. The inside surface of any structural component of the storm shelter envelope.

LABEL. An identification applied on a product by the manufacturer that contains the name of the manufacturer, the function and performance characteristics of the product or material, and the name and identification of an approved agency, and that indicates that the representative sample of the product or material has been tested and evaluated by an approved agency.

LAYDOWN HAZARDS. See "Hazards, Laydown."

LOCAL EMERGENCY PLANNING COMMITTEE. A group of citizens defined by the community as having responsibility for local emergency planning. The committee shall be recognized by the governing body as having this responsibility.

NATURAL VENTILATION. Passive ventilation, not requiring a power source, resulting from convection of heated air, movement of inside air and movement of outside air over and around the storm shelter resulting in air exchange through vent openings.

OCCUPANT SUPPORT AREAS. The areas required to ensure the health, safety and well-being of occupants. Occupant support areas include, but are not limited to, shelter management, food preparation, water and food storage, electrical and mechanical rooms, toilet and other sanitation rooms and first-aid stations.

OCCUPIED SHELTER AREAS. The designated storm shelter area.

ON-SITE. Either inside, immediately adjacent to, or on the same site as the designated storm shelter facility, and under the control of the owner or lawful tenant.

PROTECTED OCCUPANT AREA. The portions of the shelter area that are protected from intrusion of storm debris by alcove or baffled entry systems in accordance with Section 804.9.7.

REBOUND IMPACT. The rebound impact by a test missile, or fragments thereof, on a portion of the shelter protective envelope after the test missile has impacted another surface of the shelter protective envelope.

ROLLOVER HAZARDS. See "Hazards, Rollover."

SHELTER ENTRY SYSTEM, ALCOVE. An entry system that uses walls and passageways to allow access and egress to the shelter interior while providing shielding from windborne debris in accordance with Section 306.5.

SHELTER ENTRY SYSTEM, BAFFLED. See definition of "Shelter Entry System, Alcove."

SHELTER ENVELOPE. The protective walls, roofs, doors and other protected openings which are designed to meet the requirements of Chapter 3 to provide protection to occupants during a severe windstorm.

STORM SHELTER. A building, structure or portion(s) thereof, constructed in accordance with this standard, desig-

DEFINITIONS

nated for use during a severe wind storm event such as a hurricane or tornado.

Community Storm Shelter. Any storm shelter not defined as a Residential Storm Shelter.

Residential Storm Shelter. A storm shelter serving occupants of dwelling units and having an occupant load not exceeding 16 persons.

STORM SHELTER DESIGN WIND SPEED. The maximum wind speed for which the shelter has been designed. Values shall be the nominal 3-second gust wind speed in miles per hour (km/h) at 33 feet (10 m) above ground for open terrain (Exposure C).

STORM SHELTER OCCUPANT LOAD. The occupant load intended for a room or space when that space is in use as a storm shelter.

CHAPTER 3

STRUCTURAL DESIGN CRITERIA

SECTION 301 GENERAL

301.1 Scope. Loads and load combinations shall be determined in accordance with ASCE 7 unless otherwise noted.

Structural elements of the storm shelter shall be designed in accordance with the appropriate material design standard specified in the applicable building code to sustain the loads prescribed in ASCE 7, as modified by this chapter, and combined in accordance with the load combinations of ASCE 7, as modified by Section 302.

301.1.1 Design or testing. Where the strength requirements cannot be determined by engineering calculations in accordance with appropriate material design standards referenced by the applicable building code, roof and wall assemblies shall meet the pressure requirements of Section 805.

SECTION 302 LOAD COMBINATIONS

302.1 Strength design. For Strength Design or Load and Resistance Factor Design (LRFD), use the load combinations stated in ASCE 7, Section 2.3.2, with the following additional load combinations with W in these additional load combinations being based on Section 304:

1. In load combination 3, replace $0.8W$ with $0.5W$.
2. In load combinations 4 and 6, replace $1.6W$ with $1.0W$.
3. Exception 1 shall not apply.

302.2 Allowable stress design. For Allowable Stress Design (ASD), use the load combinations stated in ASCE 7, Section 2.4.1 with the following additional load combinations with W in these additional load combinations being based on Section 304:

In load combinations 5, 6 and 7, replace W with $0.6W$.

SECTION 303 LOADS

303.1 Rain loads. Rain loads shall be determined in accordance with ASCE 7.

303.1.1 Rainfall rate. For hurricane shelters, rainfall rate shall be determined by adding a rate of 3 inches (76.2 mm)

of rainfall per hour to the rainfall rate established from Figure 303.2.

303.2 Roof live loads. Storm shelter roofs shall be designed for minimum live loads specified in ASCE 7, but not less than the following:

Tornado shelters: 100 pounds per square foot (4.8 kN/m²)

Hurricane shelters: 50 pounds per square foot (2.4 kN/m²)

303.3 Hydrostatic loads. Underground portions of storm shelters shall be designed for buoyancy forces and hydrostatic loads assuming that the groundwater level is at the surface of the ground at the entrance to the storm shelter, unless adequate drainage is available to justify designing for a lower groundwater level.

SECTION 304 WIND LOADS

304.1 General. Design wind pressures shall be determined using Method 2, Analytical Procedure, from Section 6 of ASCE 7 except as modified by this section.

304.2 Design wind speed. For tornado shelters, the design wind speed shall be in accordance with Figure 304.2(1). For hurricane shelters, the design wind speed shall be in accordance with Figure 304.2(2).

304.3 Wind directionality factor. The directionality factor shall be taken as $K_d = 1.0$.

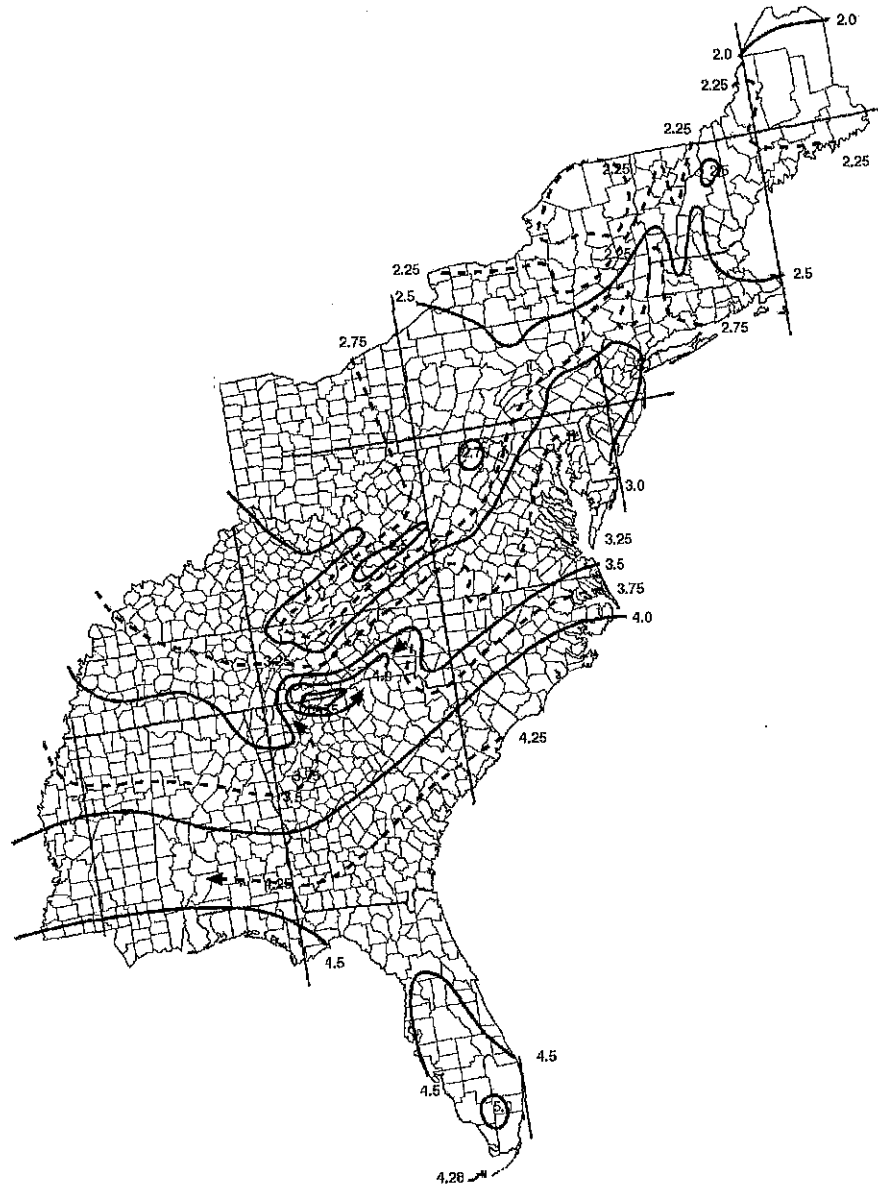
304.4 Importance factor. The importance factor, I , shall be taken as 1.0.

304.5 Exposure. Wind pressures shall be based on exposure category C.

Exception: For hurricane shelters, where exposure category B exists for all wind directions, MWFRS wind pressures shall be permitted to be based upon exposure category B.

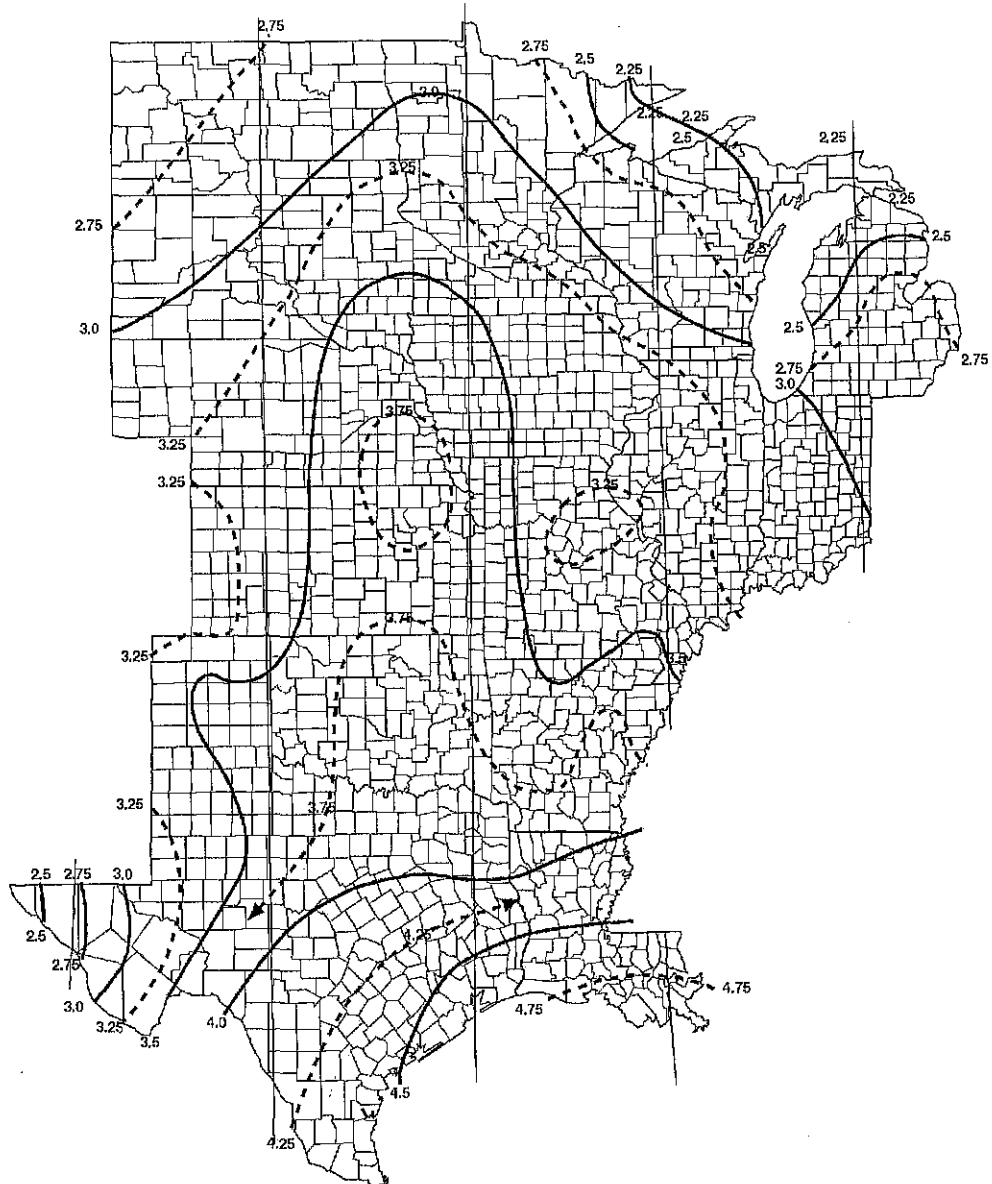
304.6 Topographic effects. For tornado shelters, the topographic factor K_z need not exceed 1.0.

304.7 Enclosure classifications. Enclosure classifications for storm shelters shall be determined in accordance with ASCE 7, Section 6.2. For determining the enclosure classification for community storm shelters, the largest door or window on a wall that receives positive external pressure shall be considered as an opening.



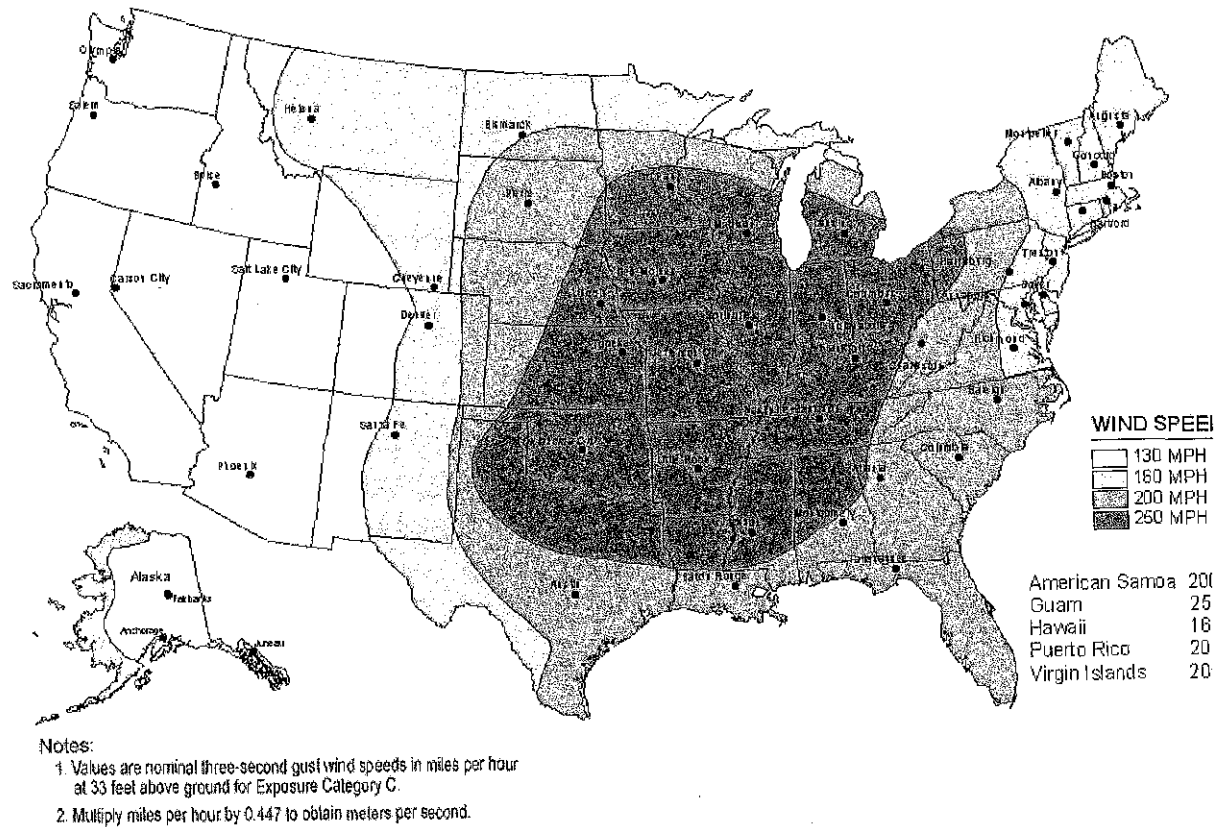
For SI: 1 inch = 25.4 mm.

FIGURE 303.2
100-YEAR, 1-HOUR RAINFALL (INCHES), EASTERN UNITED STATES



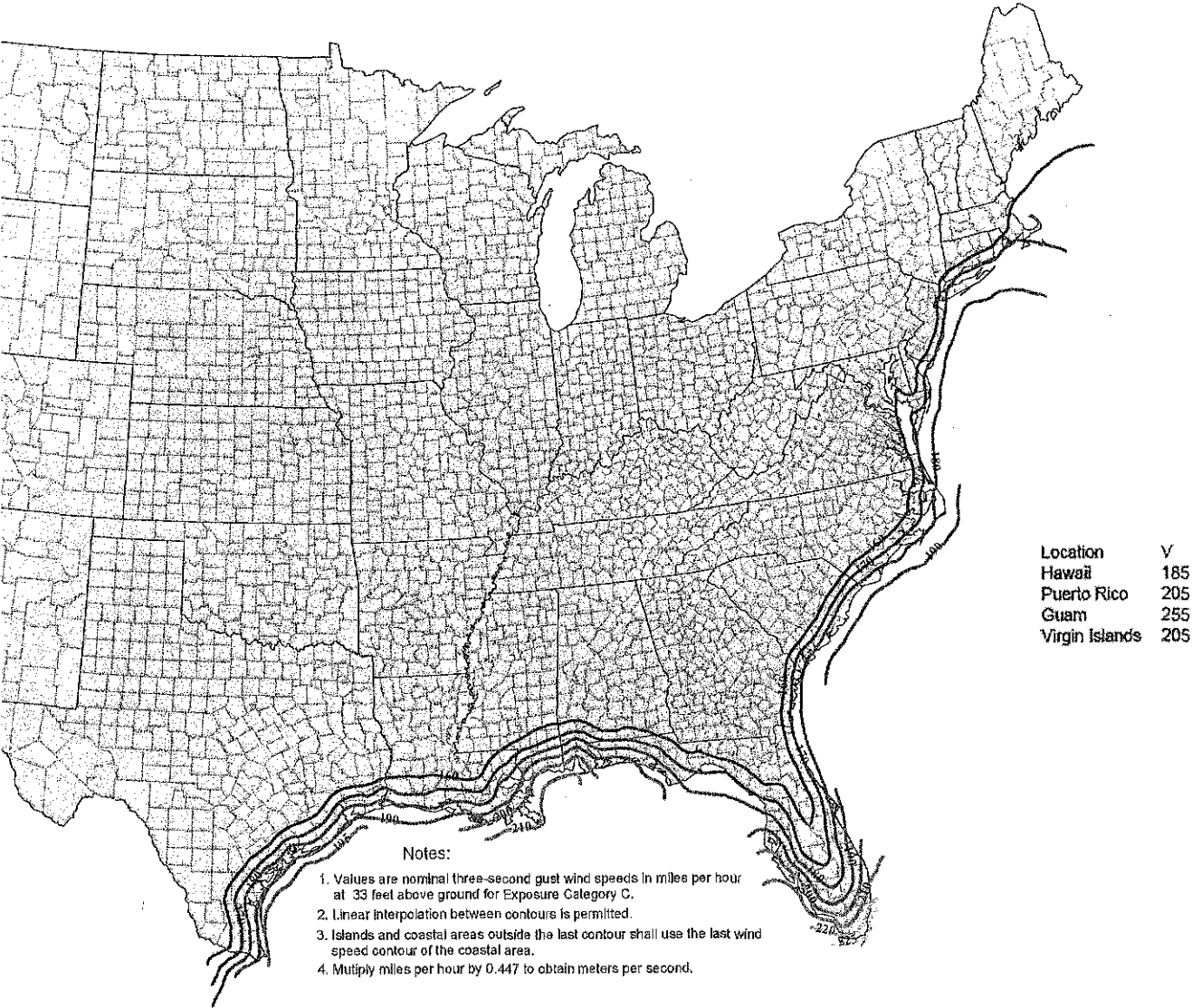
For SI: 1 inch = 25.4 mm.

FIGURE 303.2—continued
100-YEAR, 1-HOUR RAINFALL (INCHES), CENTRAL UNITED STATES



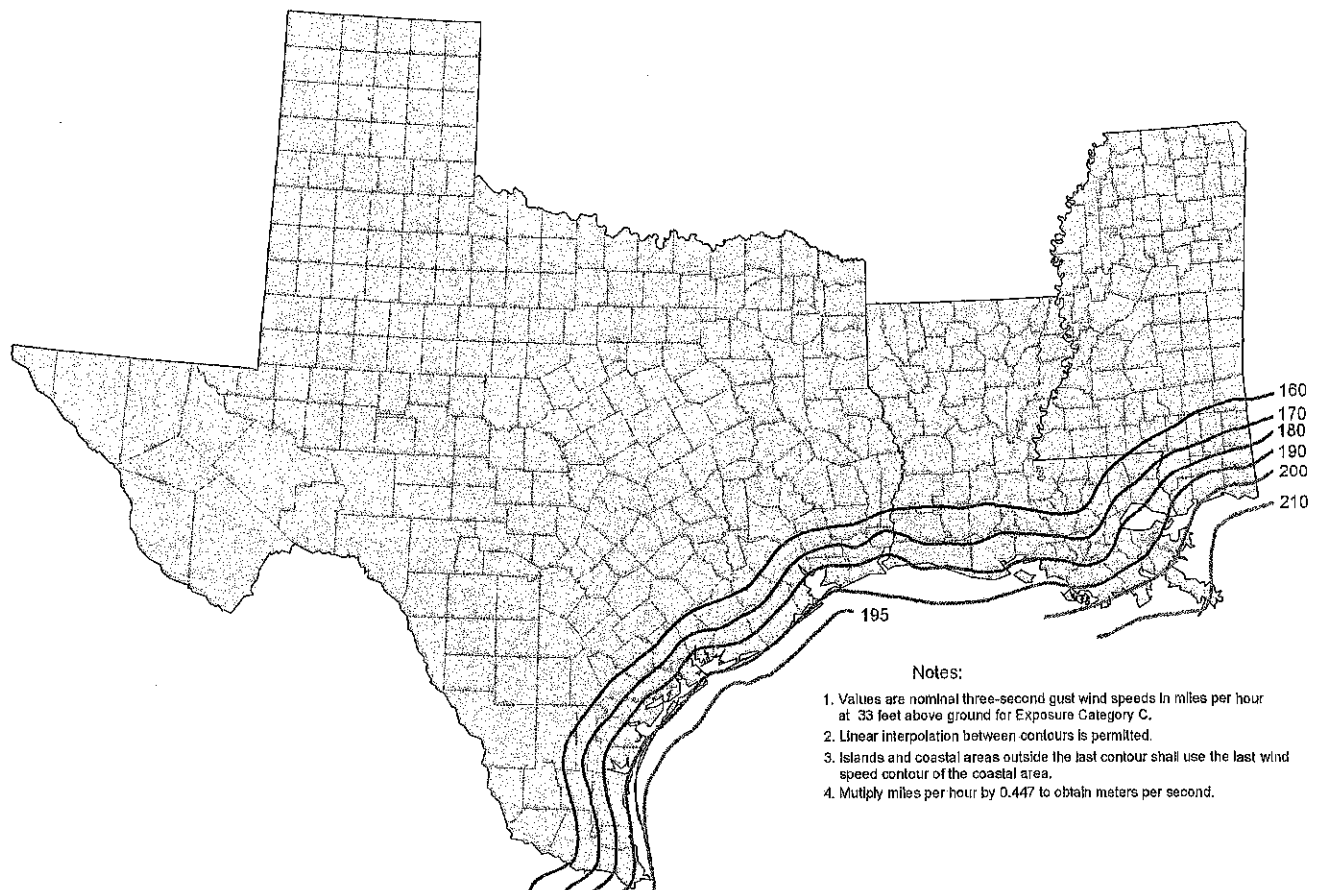
For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

FIGURE 304.2(1)
SHELTER DESIGN WIND SPEEDS FOR TORNADOES



For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

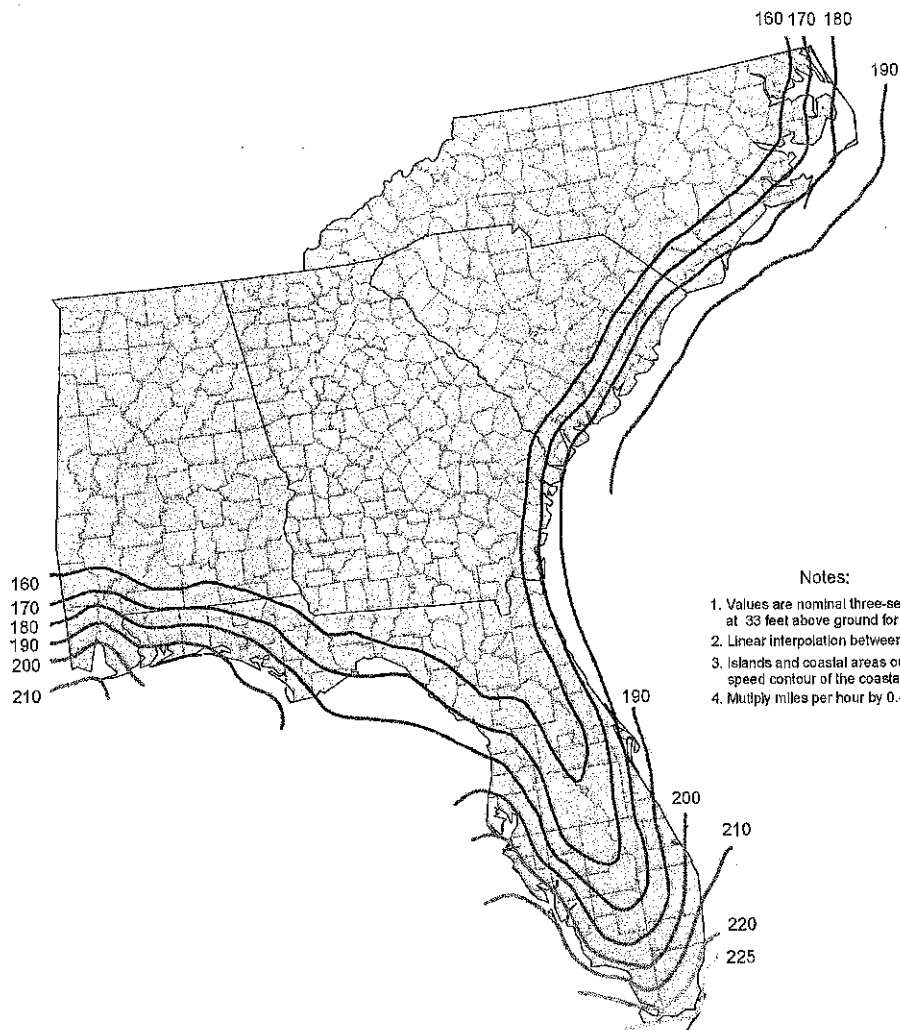
FIGURE 304.2(2)
SHELTER DESIGN WIND SPEEDS FOR HURRICANES



For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

FIGURE 304.2(2)—continued
SHELTER DESIGN WIND SPEEDS FOR HURRICANES—WESTERN GULF OF MEXICO

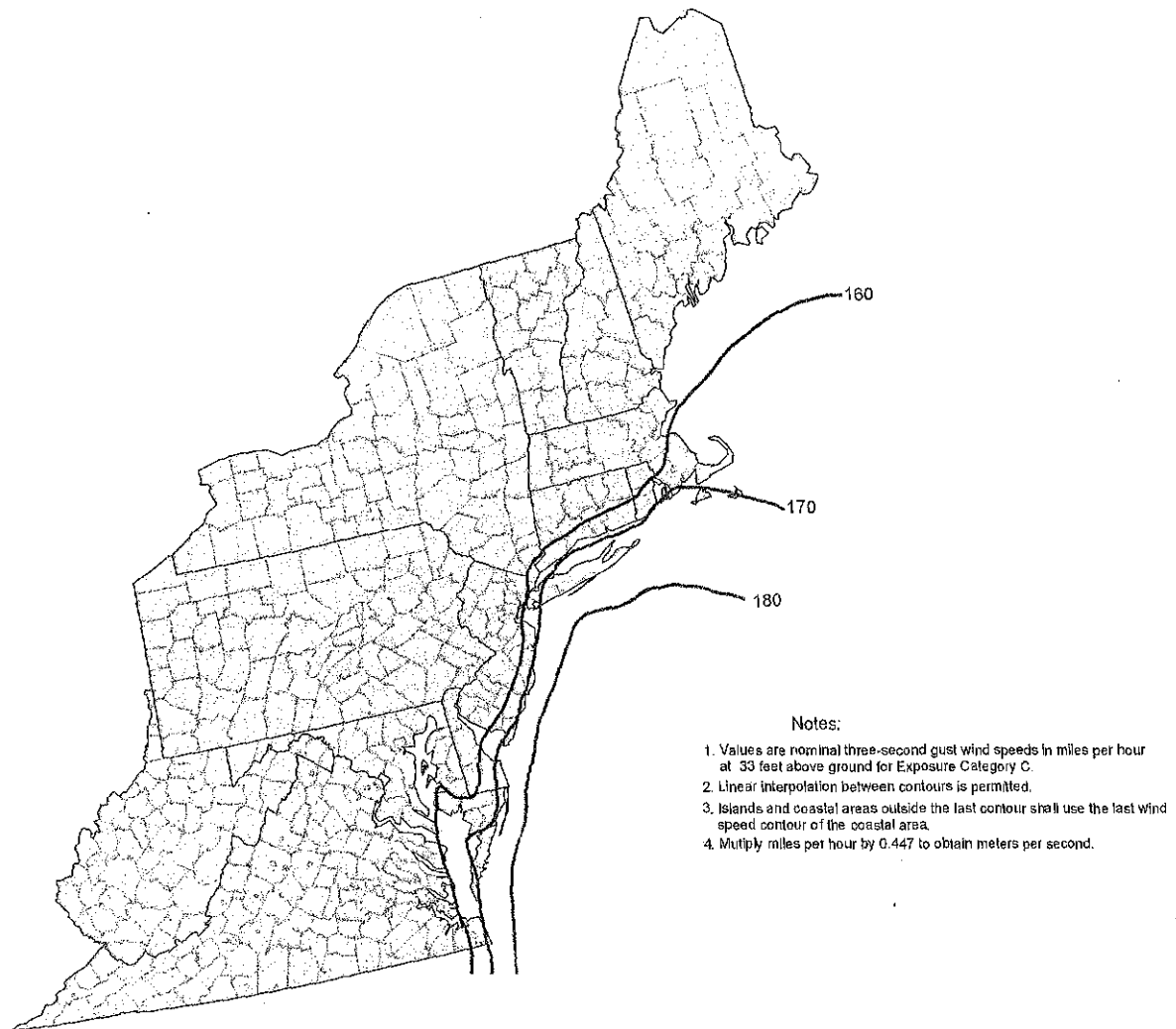
160
170
180
190
200
210



wind

For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

FIGURE 304.2(2)—continued
SHELTER DESIGN WIND SPEEDS FOR HURRICANES—EASTERN GULF OF MEXICO



For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

FIGURE 304.2(2)—continued
SHELTER DESIGN WIND SPEEDS FOR HURRICANES—MID-NORTHERN ATLANTIC

304.8 Atmospheric pressure change (APC). For tornado shelters classified as enclosed buildings, the additional internal pressures caused by atmospheric pressure change shall be considered. The internal pressure coefficient, GC_{pi} , shall be taken as ± 0.18 when APC venting area of 1 square foot (0.0929 m^2) per 1,000 cubic feet (28.3 m^3) of interior shelter volume is provided. APC venting shall consist of openings in the shelter roof having a pitch not greater than 10 degrees from the horizontal or openings divided equally (within 10 percent of one another) on opposite walls. A combination of APC venting meeting the above requirements is permitted.

Exception: Calculation of venting area to relieve APC is not required for hurricane shelters or for tornado shelters classified as partially enclosed buildings. An internal pressure coefficient of $GC_{pi} = \pm 0.55$ shall be used for tornado shelters where APC venting meeting the requirements of Section 304.8 is not provided, or where APC venting area requirements are not calculated.

SECTION 305 DEBRIS HAZARDS

305.1 Windborne debris. All shelters shall be designed for the impact of windborne debris in accordance with this section.

305.1.1 Missile criteria for tornado shelters. The debris impact test missile for all components of the shelter envelope of tornado shelters shall be a 15-pound (6.8 kg) sawn lumber 2 by 4 traveling at the speeds shown in Table 305.1.1.

TABLE 305.1.1
SPEEDS FOR 15-lb SAWN LUMBER 2 x 4 MISSILE FOR
TORNADO SHELTERS

DESIGN WIND SPEED	MISSILE SPEED AND SHELTER IMPACT SURFACE
130 mph	80 mph Vertical Surfaces 53 mph Horizontal Surfaces
160 mph	84 mph Vertical Surfaces 56 mph Horizontal Surfaces
200 mph	90 mph Vertical Surfaces 60 mph Horizontal Surfaces
250 mph	100 mph Vertical Surfaces 67 mph Horizontal Surfaces

For SI: 1 mile per hour = 0.447 m/s.

305.1.2 Missile criteria for hurricane shelters. The debris impact test missile for all components of the shelter envelope of hurricane shelters shall be a 9-pound (4.1 kg) sawn lumber 2 by 4. The speed of the test missile impacting vertical shelter surfaces shall be a minimum of 0.40 times the shelter design wind speed. The speed of the test missile impacting horizontal surfaces shall be 0.10 times the shelter design wind speed.

305.2 Testing for missile impacts. Testing for missile impact of all components of the shelter envelope shall be in accordance with Section 305 following the test procedures of Section 804.

305.2.1 Vertical or horizontal surfaces. Walls, doors, and other shelter envelope surfaces inclined 30 degrees (.52 rad) or more from the horizontal shall be considered vertical sur-

faces. Surfaces inclined less than 30 degrees (.52 rad) from the horizontal shall be treated as horizontal surfaces.

305.2.2 Soil-covered portions of shelters. Portions of soil-covered shelters, with less than 12 inches (304.8 mm) of soil cover protecting shelter horizontal surfaces, or with less than 36 inches (914.4 mm) of soil cover protecting shelter vertical surfaces, shall be tested for resistance to missile perforation as though the surfaces were exposed. To qualify for shielding from soil cover, the soil surfaces shall slope away from the entrance walls or other near-grade enclosure surfaces of underground shelters at a slope of not more than 2 inches per foot for a horizontal distance of not less than 3 feet (914 mm) from the exposed portions of the shelter or unexposed portions deemed to be protected by soil cover. See Figure 305.2.2.

305.3 Other debris hazards. Lay down, rollover and collapse hazards shall be considered by the design professional when determining the location of shelters on the site.

SECTION 306 COMPONENT DESIGN AND TESTING

306.1 Shelters meeting tornado impact test requirements. Shelter envelope components meeting missile impact test requirements for tornado shelters shall be considered acceptable for hurricane shelters provided they meet structural design load requirements for hurricane shelters.

306.2 Roof and wall assemblies. Roof and wall assemblies shall meet the missile impact criteria of Section 305.1, and the pressure requirements of Section 304.1.

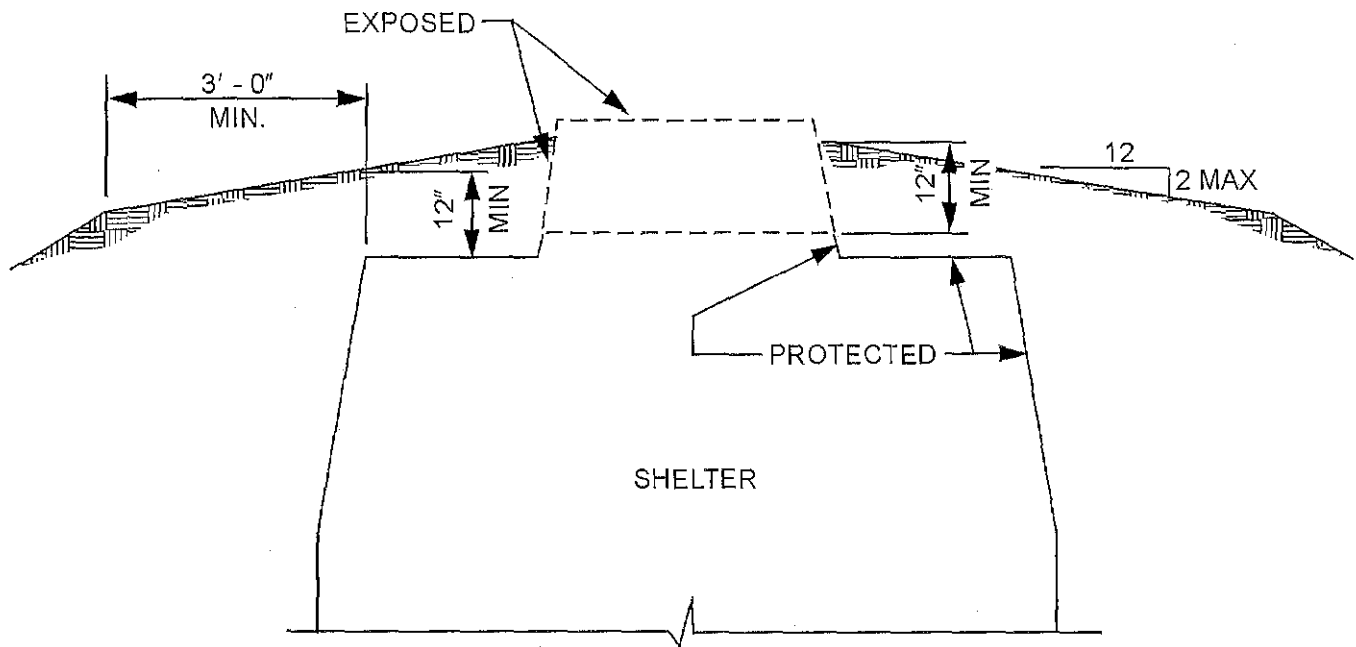
306.3 Wall and roof openings. All openings in the shelter envelope shall be protected by doors complying with Section 306.3.1, windows complying with Section 306.3.2, other opening protective device complying with Section 306.4, or baffled to prevent windborne debris from entering the shelter protected occupant area in accordance with Section 306.5.

306.3.1 Testing of shelter door assemblies. Door assemblies for use in the shelter envelope shall be tested in accordance with missile impact and pressure test procedures described in Chapter 8.

306.3.2 Testing of window assemblies and other glazed openings. Window assemblies (operable and nonoperable) and other glazed openings including skylights, side lights and transoms, shall be tested for missile impact in accordance with Section 804 and pressure in accordance with Section 805 and with cyclic pressures in accordance with ASTM E 1996.

Exceptions:

1. Missile impact testing shall not be required for window assemblies and other glazed openings where the opening is protected by a device conforming to Section 306.4 located on the exterior side of the opening.
2. Missile impact testing and pressure testing shall not be required for window assemblies and other glazed openings where the opening is protected by



For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

FIGURE 305.2.2
UNDERGROUND SHELTER

a device conforming to Section 306.4 located on the interior side of the opening.

306.3.2.1 Window and skylight assemblies for tornado shelters. Window and skylight assemblies for use in tornado shelters shall comply with the missile impact requirements of Section 305.1.1 and the pressure requirements of Section 304. Window and skylight assemblies for use in tornado shelters shall be tested for missile impact in accordance with Section 804 and pressure in accordance with Sections 805.4 and 806.4.1.

306.3.2.2 Window and skylight assemblies for hurricane shelters. Window and skylight assemblies for use in hurricane shelters shall comply with the missile impact requirements of Section 305.1.2 and the pressure requirements of Section 304. Window and skylight assemblies for use in hurricane shelters shall be tested for missile impact in accordance with Section 804 and cyclic pressure test in accordance with Section 805.3, 805.4, and 806.4.2.

306.4 Opening protective devices. Opening protective devices such as shutters and protective screens shall be tested for missile impact in accordance with Chapter 8.

Exception: Nonoperable, permanently affixed shields or cowlings are excluded from pressure testing requirements of Section 806.5.

306.4.1 Opening protective devices in tornado shelters. Opening protective devices in tornado shelters shall be permanently affixed, and manually operable from inside the shelter.

306.5 Alcove or baffled entry systems. All protective elements of alcove or baffled entry systems shall be designed to meet the wind load requirements of Section 304 and the debris impact test requirements of Section 305. Where a door is employed as part of the protection in such an entry system, the door shall meet the debris impact test requirements of Section 804.9.7 and the pressure testing requirements of Sections 805 and 806.6. The enclosure classification for shelters with baffled or alcove entries shall be determined in accordance with Section 304.7.

Exception: When the entry system for a residential shelter is equipped with a door assembly that meets the pressure requirements of Section 304, the enclosure classification shall remain unchanged by the alcove or baffled entry system.

SECTION 307 WEATHER PROTECTION

307.1 Exterior cladding of hurricane shelters. All exposed components and cladding assemblies and roof coverings of hurricane shelters shall be designed to resist rainwater penetration during the design windstorm and shall be designed and installed to meet the wind load requirements of Section 304.

307.2 Electrical grounding of shelters. Exposed metal interior surfaces of shelters which are electrically grounded and electrical fixtures within shelters shall be grounded only to the host building external grounding system.

SECTION 308 SHELTERS ENCLOSED OR PARTIALLY ENCLOSED IN A HOST BUILDING

308.1 Connection of shelter elements to a host building. Where the host building does not otherwise qualify as a storm shelter under the provisions of this standard, connection of shelter elements shall be permitted to host building framing which is designed for wind forces equal to or greater than the design wind forces for the storm shelter.

308.1.1 Stability. In addition to structural stability requirements of Section 309, structural stability of a storm shelter shall also be determined for building code design wind speeds (wind speeds which are below the shelter design wind speeds) where the host building could transmit forces in connections to the storm shelter that are equal to 1.5 times the nominal strength of the connections.

308.2 Storm shelters enclosed in host buildings. Storm shelters enclosed in host buildings shall be designed and installed to meet the wind load requirements of Section 304.

SECTION 309 CONNECTION OF STORM SHELTERS TO FOUNDATIONS OR SLABS

309.1 Connection of storm shelters to foundations or slabs. Shelters shall be designed to resist the combined uplift and lateral forces resulting from the design wind speed and transfer those forces into the ground.

309.1.1 Structural stability of storm shelter foundations. Other than host buildings designed in accordance with Section 308.1.1, foundations and slabs that provide structural stability for storm shelters shall be designed to resist the combined uplift and lateral forces on the shelter that are calculated for the storm shelter design wind speed assuming the host building is totally destroyed by the windstorm.

309.1.2 Calculation of resistance. Structural stability of storm shelters shall be determined by engineering calculations for design wind pressures determined in accordance with Section 304. For storm shelters anchored to foundations or slabs on grade whose top surfaces extending outward from the shelter walls are at grade shall not be considered to have wind uplift forces acting on top surfaces of the slab.

309.1.2.1 Slabs on grade. Slabs on grade shall be designed for the applicable loads in accordance with Section 301. Where a slab on grade is being used to resist loads, the minimum thickness shall be 3 1/2 inches (88.9 mm) and the minimum steel reinforcement for slabs on grade resisting forces on the storm shelter shall be 6 by 6 - W1.4 by W1.4 or No. 4 bars, 18 inches on center in either direction.

Exception: Concrete and concrete masonry storm shelters shall be permitted to be constructed within existing one- and two-family dwellings on existing slabs on grade without a foundation, under the following conditions:

1. Calculated soil pressure under the slabs on grade supporting the storm shelter walls does not exceed 2000 psf (95.8 kN/m²) for design loading conditions other than design storm shelter events and 3000 psf (143.7 kN/m²) for design storm shelter events.
2. The storm shelter is anchored to the slab on grade at each corner of the structure and on each side of the doorway opening minimum.
3. The reinforcement requirements in the slab on grade are waived if dead load of the slab is not required to resist overturning.

309.1.2.2 Joints in concrete slabs on grade. Design calculations shall include the effect of expansion joints, contraction joints, or construction joints that are utilized to resist loads in concrete slabs on grade supporting storm shelters.

309.1.2.3 Elevated storm shelter foundations. Where storm shelters are constructed with the top of the supporting foundation structure located at an elevation higher than the surrounding finished grade level, the structural stability of the storm shelter and elevated supporting foundation structure shall be computed assuming that both are fully exposed to the shelter design wind and flood forces. Where applicable, and in accordance with ASCE 7, the impacts of windborne and flood-borne debris on stability of the foundation shall be considered.

SECTION 310 PENETRATIONS OF STORM SHELTER ENVELOPE BY SYSTEMS AND UTILITIES

310.1 Penetrations of storm shelter envelope by systems and utilities. Penetrations through the storm shelter envelope larger than 3 1/2 square inches (2258 mm²) or 2 1/16 inches (52.38 mm) for systems and utilities installed for any purpose, shall be considered openings and shall be protected in accordance with Section 306.3. Penetrations of the storm shelter envelope shall not degrade the structural integrity of the storm shelter and missile impact resistance of the storm shelter envelope.

Penetrations of the shelter envelope by hazardous gas or liquid lines shall have automatic shutoffs to protect against leakage due to movement of the utility line. The threshold movements for shutoff shall be as defined by the codes and standards governing such utility lines.

CHAPTER 4

SITING

SECTION 401 FLOOD ELEVATION CRITERIA

401.1 Minimum floor elevation of storm shelters. The minimum floor elevations of storm shelters shall be determined in accordance with Section 401.1.1 or 401.1.2, as applicable.

401.1.1 Minimum floor elevation of community shelters. The lowest floor used for the occupied shelter and occupant support areas of a community shelter shall be elevated to the higher of the elevations determined by:

1. The flood elevation, including coastal wave effects, having a 0.2-percent annual chance of being equaled or exceeded in any given year; or
2. Two feet (609.6 mm) above the flood elevation having a 1-percent annual chance of being equaled or exceeded in any given year; or
3. Two feet (609.6 mm) above the flood elevation corresponding to the highest recorded flood elevation if the area is not in a mapped special flood hazard area; or
4. The maximum inundation elevation associated with a Category 5 hurricane event in an area subject to storm surge inundation.

Exception: Item 1 shall not apply to tornado shelters.

401.1.2 Minimum floor elevation of residential shelters. The lowest floor used for the occupied shelter area of a residential shelter shall be determined by:

1. The minimum elevation of the lowest floor required by the floodplain ordinance of the community; or
2. One foot (304.8 mm) above the flood elevation corresponding to the highest recorded elevation if the area is not in a mapped special flood hazard area or is in a mapped nonparticipating community.

401.3 Design criteria. Storm shelters or portions thereof subject to flooding shall be designed in accordance with the provisions of this chapter, ASCE 7, Section 5, and ASCE 24.

SECTION 402 HAZARDOUS MATERIALS

402.1 Proximity to hazardous materials. Occupants of community shelters that are located within a precautionary zone that includes facilities that manufacture, use or store hazardous materials shall be provided with protection from hazardous materials releases as deemed necessary by the Local Emergency Planning Committee and the authority having jurisdiction.

SECTION 403

SITING PROXIMITY FOR RESIDENTIAL SHELTERS

403.1 Residential shelter siting. Residential tornado shelters shall be located within the residence or located on the site within 150 feet (45 720 mm) of the residence that the shelter is intended to serve.

CHAPTER 5

OCCUPANCY, MEANS OF EGRESS, ACCESS AND ACCESSIBILITY

SECTION 501 COMMUNITY SHELTERS

501.1 General. A community shelter shall comply with the requirements of this section. A residential shelter shall comply with the requirements of Section 502.

501.1.1 Occupant density. The minimum required shelter floor area per occupant shall be determined in accordance with Table 501.1.1, and this section. The number of standing, seated, wheelchair, or bedridden spaces shall be determined based upon the needs of the shelter determined by the applicable authority having jurisdiction and the designer.

TABLE 501.1.1
OCCUPANT DENSITY – COMMUNITY SHELTERS

TYPE OF SHELTER	MINIMUM REQUIRED USABLE SHELTER FLOOR AREA ^a IN SQUARE FEET PER OCCUPANT
Tornado	
Standing or seated	5
Wheelchair	10
Bedridden	30
Hurricane	
Standing or seated	20
Wheelchair	20
Bedridden	40

For SI: 1 square foot = 0.0929 m².

a. See Section 501.1.2 for requirements for minimum required usable shelter floor area.

501.1.2 Usable storm shelter floor area. The usable storm shelter floor area shall be determined by Section 501.1.2.1 or 501.1.2.2.

501.1.2.1 Calculation of usable floor area. The usable shelter floor area shall be determined by using the following percentages:

1. Reducing the gross floor area of shelter areas with concentrated furnishings or fixed seating by a minimum of 50 percent.
2. Reducing the gross floor area of shelter areas with unconcentrated furnishings and without fixed seating by a minimum of 35 percent.
3. Reducing the gross floor area of shelter areas with open plan furnishings and without fixed seating by a minimum of 15 percent.

501.1.2.2 Alternative calculation of usable floor area. The usable shelter floor area shall be determined by subtracting from the gross floor area, the floor area partitions and walls, columns, fixed or movable objects, furniture, equipment or other features that under probable conditions cannot be removed.

501.1.3 Wheelchair spaces. Each storm shelter shall be sized to accommodate a minimum of one wheelchair space for every 200 shelter occupants or portion thereof.

501.2 Number of doors. The number of means of egress doors from a space shall be determined based upon the occupant load for the normal occupancy of the space in accordance with the applicable building code. For facilities used solely for shelters, the number of doors shall be determined in accordance with the applicable building code based upon the occupant load as calculated in Section 501.1.

Where the applicable building code requires only one means of egress door, an emergency escape opening shall be provided in accordance with Section 501.4.

501.3 Direction of swing. The direction of the swing of doors shall be as required by the applicable building code for the normal occupancy of the space.

501.4 Emergency escape opening. The emergency escape opening shall be an additional door or an opening that is a minimum of 5.7 square feet (0.530 m²) in area. Such opening shall have a minimum height of 24 inches (610 mm) and a minimum width of 20 inches (508 mm). The emergency escape opening shall be operable from the inside without the use of tools or special knowledge. Where the emergency escape opening is located more than 44 inches (1117.6 mm) above the finished floor level, vertical access to the opening shall be provided by a stair complying with Section 502.3.1 or a ladder complying with Section 502.3.2, or an alternating tread device complying with Section 502.3.3. The emergency escape opening shall be located away from the means of egress door by a minimum distance of one-third of the length of the maximum overall diagonal dimension of the area to be served.

501.4.1 Ladders for community shelters. Ladders for community shelter, which are required for access to emergency escape openings above the level of normal egress, shall comply with the requirements of Section 502.3.2. When the access opening is located on a vertical surface (see Section 305.2.1), the height of the opening shall be not less than 30 inches (762 mm).

501.5 Door operation. Means of egress doors shall be operable from the inside without the use of keys or special knowledge or effort.

501.6 Accessible route. Shelters shall be provided with an accessible route in accordance with ICC A117.1.

SECTION 502 RESIDENTIAL SHELTERS

502.1 General. A residential shelter shall comply with the requirements of this section. A community shelter shall comply with the requirements of Section 501.

502.2 Access openings. All residential shelters shall be provided with a method of entry and egress with minimum clear opening dimensions of 24 inches by 30 inches (610 mm by 762 mm).

502.3 Vertical access. Where required, vertical access to a residential shelter shall be by a stair complying with Section 502.3.1, or by a ladder complying with Section 502.3.2, or an alternating tread device complying with Section 502.3.3.

502.3.1 Stairs for residential shelters. Treads for stairs in residential shelters shall have a minimum depth of 8 inches (203 mm). The maximum height of risers shall be $9\frac{9}{16}$ inches (243 mm). Surfaces of steps shall be slip-resistant. The minimum width of stairs shall be 22 inches (559 mm). The angle of the stairway from horizontal shall be a maximum of 50 degrees (0.87 rad). Stairs shall be constructed such that a foot is prevented from sliding off either side of the stairway. Stair treads shall not be required to have a nosing.

502.3.1.1 Overhead clearance. The minimum clearance above any stair tread to an overhead obstruction shall be 6 feet, 8 inches (2032 mm), measured vertically above the leading edge of the tread.

Exceptions:

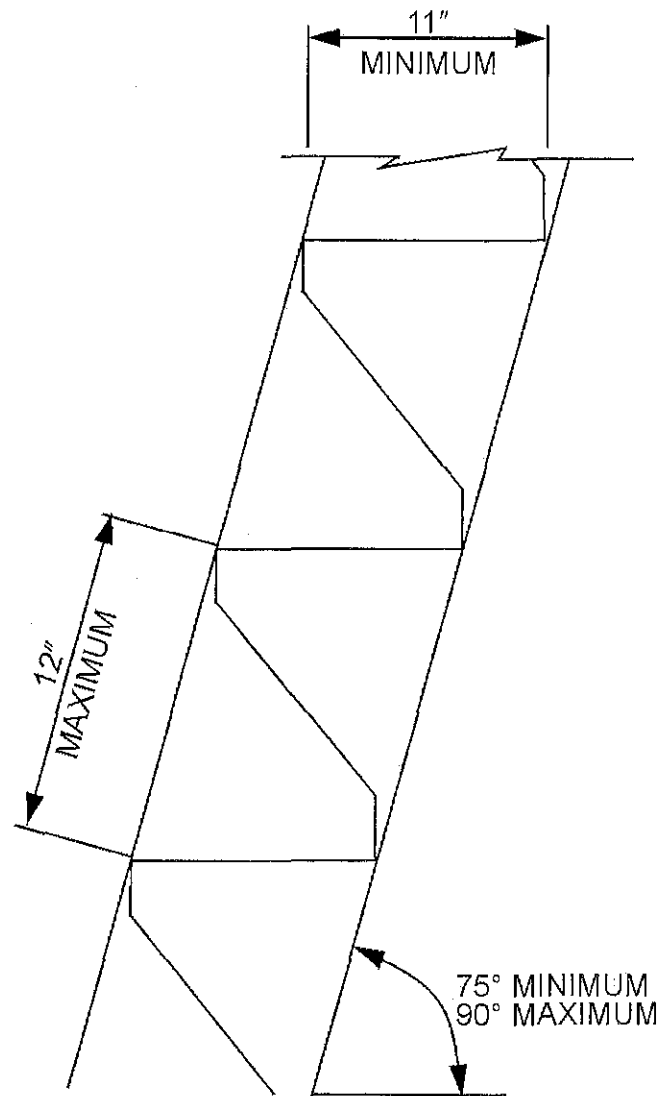
1. The minimum overhead clearance is permitted to be reduced to 5 feet (1524 mm) where signage is provided at the top and bottom of the stairs conspicuously warning the user of low headroom.
2. Entrances that are entered by persons seated on the entrance threshold and that are not high enough for a person to enter standing erect shall not be required to provide minimum headroom provided that there is no more than two stair risers leading into the shelter.

502.3.1.2 Stair handrails. A continuous handrail shall be located on one side of a stairway having more than three risers.

502.3.2 Ladders for residential shelters. The clear length of rungs for ladders shall be not less than 16 inches (406 mm). Rungs shall be constructed such that a foot cannot slide off the end of the rung. Ladder rungs shall be a minimum of $\frac{3}{4}$ inches (19 mm) in diameter and shall be spaced uniformly at not greater than 12 inches (305 mm). Ladder wells or cages shall have a minimum of 15 inches (381 mm) clear on either side of the centerline of the ladder and a minimum of 27 inches (686 mm) clear from the centerline of the rungs to a ladder well or cage on the climbing side of the ladder. Where obstructions occur in the ladder well, this distance shall be increased to 30 inches (762 mm). The distance between the centerline of the rungs or steps to the nearest permanent object in back of the ladder (on the toe side) shall be no less than 7 inches (178 mm). Ladders shall have a maximum slope of 90 degrees (1.57 rad) from horizontal and a minimum slope of 75 degrees (1.31 rad) from horizontal where measured on the toe side of the ladder.

Exception: No minimum clearance is required on the back side of the ladder where there is no obstruction on

the climbing side of the ladder, and where ladder steps or 11 inches (279 mm) or greater in width are molded or fabricated in a continuous series of treads and risers in which the foot can neither slip through the riser nor be trapped by the riser or next higher ladder stair tread. The maximum slope shall be 90 degrees (1.57 rad) from horizontal and the minimum slope shall be 75 degrees (1.31 rad) from horizontal. See Figure 502.3.2.



For SI: 1 inch = 25.4 mm, 1 degree = 0.0174 rad.

FIGURE 502.3.2

502.3.2.1 Cages or wells. Ladder cages or ladder wells shall be provided for vertical climbs extending more than 8 feet (2438 mm).

502.3.2.2 Overhead hatches. Where provided, hatches at the tops of ladders shall have minimum clear dimensions of 24 inches by 30 inches (610 mm by 762 mm). A clear opening of 24 inches (610 mm) minimum from the

SECTION 504**SIGNAGE FOR COMMUNITY SHELTERS**

504.1 Signage requirements. Community storm shelter areas shall be marked by signage in accordance with this section. Signage is required within a facility to direct occupants to storm shelter areas.

504.1.1 Signage location. At every entrance to a storm shelter, signage indicating "Tornado Shelter," or "Hurricane Shelter," or appropriate symbols as applicable, shall be installed. The sign shall be both tactile and visual, meeting the requirements of ICC A117.1. The sign shall be no smaller than 8.5 inches by 11 inches (216 mm by 279 mm). The sign shall be mounted on or adjacent to the door, located in accordance with ICC A117.1.

504.1.2 Identifying sign. A sign depicting the general location of storm shelter area(s) and access ways shall be displayed in all of the following locations:

1. Adjacent to access doors on the inside of the storm shelter;
2. The office of the facility manager, where provided; and
3. In the designated shelter manager's area within the storm shelter, where provided.

504.1.2.1 Location of identifying sign. The identifying sign shall be posted in a prominent location 60 inches (1524 mm) above the finished floor to the centerline of the sign.

centerline of the ladder rungs on the climbing side of the ladder and a minimum of 15 inches (372 mm) on either side of the centerline of the rungs shall be provided. Hatches shall open a minimum of 60 degrees (1.04 rad) from the closed position. Hatches shall be counterweighted or otherwise held in the open position when opened.

502.3.3 Alternating tread devices for residential shelters. Alternating tread devices for residential shelters shall comply with the applicable requirements listed in *International Building Code (IBC)*.

502.3.3.1 Overhead clearance. The minimum clearance requirements for stairs (including exceptions) listed in Section 502.3.1.1 shall also apply to alternating tread devices.

502.4 Occupant density. The required usable shelter floor area per occupant for residential shelters shall be determined in accordance with Table 502.4.

**TABLE 502.4
OCCUPANT DENSITY—RESIDENTIAL SHELTERS**

TYPE OF SHELTER	MINIMUM REQUIRED USABLE SHELTER FLOOR AREA* IN SQUARE FEET PER OCCUPANT
Tornado	
One- and two-family dwelling	3
Other residential	5
Hurricane	
One- and two-family dwelling	7
Other residential	10

For SI: 1 square foot = 0.0929 m².

502.4.1 Usable tornado shelter floor area. The usable tornado shelter floor area shall be the gross floor area, minus the area of sanitary facilities, if any, and shall include the protected occupant area between the shelter walls at the level of fixed seating, where fixed seating exists.

502.5 Door operation. Means of egress doors shall be operable from the inside without the use of keys or special knowledge or effort.

SECTION 503 LOCKS AND LATCHING

503.1 Locks and latching mechanisms. Locking and other latching mechanisms shall be permanently mounted on the assembly. Such mechanisms shall require no tools to be engaged in the locked position. Devices such as pins shall be permanently secured to the specimen through the use of chains or wires which must be of corrosion-resistant material.

503.2 Multi-latching systems. Products that are not categorized as means of egress/escape and are provided with more than one single-action locking mechanism shall be provided with permanently posted instructions on latching.

CHAPTER 6

FIRE SAFETY

SECTION 601

FIRE-RESISTANT CONSTRUCTION

601.1 Fire separation. Fire barriers and horizontal assemblies separating spaces or areas designated as storm shelters from other building areas shall have a minimum fire-resistance rating of 2 hours and shall be constructed in accordance with the applicable building code.

Exception: Fire separation assemblies are not required for residential shelters.

SECTION 602

FIRE EXTINGUISHERS

602.1 General. A fire extinguisher shall be required within all community shelters.

602.2 Requirements. Fire extinguishers shall meet the requirements of NFPA 10. Installation of fire extinguishers shall not compromise the structural or missile impact performance of the exterior shelter envelope.

CHAPTER 7

SHELTER ESSENTIAL FEATURES AND ACCESSORIES

SECTION 701 GENERAL

701.1 Protection of critical support systems. Critical support systems shall remain functional for the design storm event and minimum period of shelter occupancy (24 hours for hurricane shelters, 2 hours for tornado shelters). Critical support systems located outside of the storm shelter areas shall be protected by a means that meets the wind pressure and missile impact requirements of Chapter 3, and, as applicable, the flood-resistance requirements of Chapter 4.

SECTION 702 TORNADO SHELTERS

702.1 Ventilation. Occupied space in tornado shelters shall be ventilated by natural means in accordance with Section 702.1.1 or by mechanical ventilation in accordance with Section 702.1.2. Openings used for atmospheric pressure change (APC) are permitted to be counted as ventilation for the purposes of this section.

702.1.1 Natural ventilation. Tornado shelters that rely on natural ventilation shall be provided with the minimum ventilation area in accordance with Table 702.1.1.

TABLE 702.1.1
VENTING AREA REQUIRED FOR TORNADO SHELTERS

TORNADO SHELTER TYPE	VENTING AREA (PER OCCUPANT)
Residential	2* square inches
Community (≤ 50 occupants)	5 square inches
Community (> 50 occupants)	6 square inches

* See exception to Section 702.1.1.1.

For SI: 1 square inch = 645.2 mm².

702.1.1.1 Location of ventilation openings. Configuration of natural ventilation openings required for tornado shelters shall be such that a minimum of 25 percent of the required area is located within 46 inches (2581 mm) of the floor, or in the lower one-half of the height of the shelter, whichever is less, with the balance, but not less than 50 percent of the required area located a minimum of 72 inches (1829 mm) above the floor, or in the upper one-fourth of the height of the shelter, whichever is greater.

Exception: Air intake openings for residential tornado shelters shall be permitted to be located entirely in the upper half of the shelter provided that the venting area provided is increased to 4 square inches (1290 mm²) per shelter occupant.

702.1.2 Mechanical ventilation. Tornado shelters that rely on mechanical ventilation shall be provided with the minimum mechanical ventilation rate of required outdoor air in accordance with the applicable building code provisions for

the normal use of the space. The mechanical ventilation system shall be connected to an emergency power system.

702.1.3 Intake openings. Outside air intake openings located in the same wall shall be located a minimum of 10 feet (3048 mm) horizontally and separated from any hazardous or noxious contaminant, such as emergency or back-up generator vents or exhaust, fuel storage tank vents and containers, maintenance or custodial storage facilities.

702.1.4 Exhaust or intake opening protection. Air exhaust or intake openings that terminate outside of occupied shelter areas and occupant support areas shall comply with the provisions of Section 306.3 for exterior wall and roof opening protectives.

702.2 Sanitation facilities. Toilet and hand-washing facilities shall be located within the tornado shelter area and provided in the minimum number shown in Table 702.2.

TABLE 702.2
REQUIRED SANITATION FACILITIES, TORNADO SHELTERS

STORM SHELTER TYPE	TOILET FACILITIES	HAND-WASHING FACILITIES
Residential, one- and two-family dwellings	Not Required	Not Required
Residential, other	1	Not Required
Community (≤ 50 occupants)	1	Not Required
Community (> 50 occupants)	2 minimum and 1 per 500 occupants or portions thereof	1 per 1000 occupants

702.2.1 Required toilets and hand-washing facilities. Sanitation facilities provided for the normal occupancy installed within the shelter shall be included in the overall shelter sanitation facility count.

702.2.2 Additional facilities for storm shelters. Where the required number of sanitation facilities for the tornado shelter exceeds the number of facilities provided for the normal occupancy of the space, the additional facilities shall be permitted to be temporary sanitary fixtures, chemical toilets or other means approved by the authority having jurisdiction.

702.2.3 Sanitation facilities support systems. Support systems for the sanitation facilities (e.g., bladders, storage tanks or vessels, etc.), shall be capable of supplying water and containing waste for the design capacity of the tornado shelter.

702.2.4 Conversion of plumbing systems. Plumbing and valve systems of fixtures located within the tornado shelter shall be permitted to be designed for conversion to emergency operation to meet the required demand.

702.3 Emergency lighting. Community tornado shelters shall be provided with an emergency lighting system. The emergency lighting system shall provide an average of 1 foot-candle

(11 lux) of illumination in occupied shelter areas, occupant support areas, required corridors, passageways and means of egress.

702.3.1 Capacity. The emergency electrical power system shall have adequate capacity and rating to supply all required systems and circuits intended to be operated at one time.

702.3.2 Duration. The emergency electrical power system shall be designed to provide continuously the required output capacity for a minimum of 2 hours.

Exception: Personal-use flashlights shall be permitted for the emergency lighting system requirement for tornado shelters with an occupant load of less than or equal to 50, when provided at a quantity not less than one (1) flashlight per 10 occupants. Personal-use flashlights shall be a minimum of two "D" cell size or equivalent light output, and readily accessible from within the occupied shelter areas or immediately adjacent occupant support areas.

702.4 First aid kit. A first aid kit shall be supplied in all tornado shelters with a shelter occupant load of greater than 50.

SECTION 703 HURRICANE SHELTERS

703.1 Ventilation. Every occupied space in community hurricane shelters with an occupant load greater than 50 shall be ventilated by mechanical means in accordance with Section 703.1.1. All hurricane shelters shall be provided with natural ventilation in accordance with Section 703.1.2.

703.1.1 Mechanical ventilation. The minimum mechanical ventilation rate of required outdoor air shall be determined in accordance with the applicable building code provisions for the normal use of the space.

703.1.2 Natural ventilation. All shelters shall be provided with openings to facilitate minimum natural ventilation in accordance with this section. The area of ventilation openings shall comply with Table 703.1 and the location of openings shall be in accordance with Section 703. Where hurricane shelters are also designed as tornado shelters, openings provided to relieve internal pressure for atmospheric pressure change (APC) per Section 304.8 shall be permitted to be counted as natural ventilation openings.

TABLE 703.1
VENTING AREA REQUIREMENTS FOR HURRICANE SHELTERS

SHELTER TYPE	VENTING AREA (PER OCCUPANT)
Residential	4 square inches
Community (≤ 50 occupants)	8 square inches
Community (> 50 occupants)	12 square inches

For SI: 1 square inch = 645.2 mm².

703.1.3 Location of ventilation openings. Configuration of natural ventilation openings required for hurricane shelters shall be such that a minimum of 25 percent of the

required area is located within 46 inches (1168 mm) of floor, or in the lower one-half of the height of the shelter, whichever is less, with the balance, but not less than 50 percent of the required area, located a minimum of 72 inches (1829 mm) above the floor, or in the upper one-fourth of height of the shelter, whichever is greater.

703.1.4 Intake openings. Outside air intake openings located in the same wall shall be located a minimum of 3048 mm horizontally and separated from any hazardous or noxious contaminant, such as emergency or back-generator vents or exhaust, fuel storage tank vents and containers, maintenance or custodial storage facilities.

703.1.5 Exhaust or intake opening protection. Exhaust or intake openings that terminate outside of occupied shelter areas and occupant support areas shall comply with the provisions of Section 306.3 for exterior wall and roof opening protectives.

703.2 Sanitation facilities. Toilet and hand-washing facilities shall be located within the storm shelter area and provided the minimum number shown in Table 703.2.

703.2.1 Required toilets and hand-washing facilities. Sanitation facilities provided for the normal occupancy installed within the shelter shall be included in the overall shelter sanitation facility count.

703.2.2 Additional facilities for storm shelters. Where required sanitation facilities for the hurricane shelter exceeds the required number of facilities provided for normal occupancy of the space, the additional facilities shall be permitted to be temporary sanitary fixtures, chemical toilets or other means that are deemed acceptable by the authority having jurisdiction.

703.2.3 Sanitation facilities support systems. Support systems for the sanitation facilities (e.g., bladders, storage tanks or vessels, etc.), shall be capable of supplying water and containing waste for the design capacity of the storm shelter.

TABLE 703.2
REQUIRED SANITATION FACILITIES FOR
HURRICANE SHELTERS

HURRICANE SHELTER TYPE	TOILET FACILITIES	HAND-WASHING FACILITIES
Residential, one-and two-family dwellings	Not Required	Not Required
Residential, other	1	Not Required
Community shelters (≤ 50 occupants)	1	Not Required
Community shelters (> 50 occupants)	1 per 50 occupants	1 per 100 occupants

703.3 Water supply and storage. The capacity of plumbing and waste disposal systems to supply potable water and contain or dispose of waste water or solid wastes shall be determined in accordance with Table 703.3.

TABLE 703.3
WATER SUPPLY AND WASTE WATER STORAGE
HURRICANE SHELTERS

STORM SHELTER TYPE	POTABLE WATER	WASTE WATER
Residential, one- and two-family dwellings	Not Required	Not Required
Residential, other	Not Required	Not Required
Community (≤ 50 occupants)	Not Required	Not Required
Community (> 50 occupants)	1 gallon per occupant	1.5 gallons per occupant

For SI: 1 gallon = 3.785 L.

703.4 Emergency lighting. Community hurricane shelters shall be provided with an emergency lighting system. The emergency lighting system shall provide an average of 1 foot-candle of illumination (11 lux) in occupied shelter areas, occupant support areas, required corridors, passageways and means of egress.

Exception: Personal-use flashlights shall be permitted for the emergency lighting system requirement for hurricane shelters with an occupant load of less than or equal to 50, when provided at a quantity not less than one (1) flashlight per 10 occupants. Personal-use flashlights shall be a minimum of two "D" cell size or equivalent light output, and readily accessible from within the occupied shelter areas or immediately adjacent occupant support areas.

703.5 Standby lighting. Community hurricane shelters with a shelter occupant load greater than 50 shall be provided with a standby lighting system. The standby lighting system shall provide an average of 10 foot-candles illumination (110 lux) in occupied shelter areas, occupant support areas, required corridors, passageways and means of egress.

703.6 Standby power. Community hurricane shelters with a shelter occupant load greater than 50 shall be provided with a standby electrical power system. The standby electrical power system shall support occupied hurricane shelter areas, occupant support areas, and critical support systems. At a minimum, the standby electrical power system shall supply power to life safety systems and critical branch lighting circuits. Where required by the authority having jurisdiction, the standby electrical power system shall also supply power to selected HVAC circuits.

703.6.1 Capacity. The standby electrical power system shall have adequate capacity and rating to supply all required systems and circuits intended to be operated at one time.

703.6.2 Duration. The standby electrical power system shall be designed to provide continuously the required output capacity for a minimum of 24 hours.

703.6.3 Independence. The standby electrical power supply shall be located on-site, and shall be independent of off-site sources of fuel or water.

703.6.4 Protection of components. Standby electrical power supply, transformers, distribution panels, cabling, fuel supply storage tanks, fuel lines and other critical system

components shall be protected from design event conditions.

703.6.5 Location. Standby electrical power supply shall be accessible by a protected access route. The access route shall be located within the hurricane shelter or shall meet the provisions for exterior wall and roof opening protectives in accordance with this standard.

703.7 First aid kit. A first aid kit shall be supplied in all community hurricane shelters.

CHAPTER 8

TEST METHODS FOR IMPACT AND PRESSURE TESTING

SECTION 801 GENERAL

801.1 Scope This testing protocol covers procedures for conducting impact and pressure testing of components of the shelter envelope required to meet windborne debris impact provisions, as detailed in Section 305 of this standard.

SECTION 802 TERMINOLOGY

802.1 General terminology. General terminology of building construction used in this test method is defined in ASTM E 631.

802.2 Definitions of terms specific to this test method.

OPENING PROTECTIVE DEVICE. Shutter, door or other device mounted on the inside or outside of the exterior wall of a shelter.

SPECIMEN. The entire assembled unit submitted for test, including but not limited to anchorage devices and structure to which product is to be mounted.

TEST CHAMBER. An airtight enclosure of sufficient depth to allow unobstructed deflection of the specimen during pressure cycling, including ports for air supply and removal, and equipped with instruments to measure test pressure differentials.

SECTION 803 TEST SPECIMENS

803.1 Test specimen. All parts of the test specimen shall be full size, using the same materials, details, methods of construction and methods of attachment as proposed for actual use. Testing of components consisting of wall, roof, door or window assemblies shall be allowed in lieu of testing entire shelters. Except where failure of framing members may control the impact performance, wall and roof sections subjected to debris impact testing shall be a minimum of 4 feet (1219 mm) wide by 4 feet (1219 mm) high unless dimensions of the actual assembly are less than these dimensions. Wall and roof sections subjected to pressure testing and wall sections where impact resistance may be controlled by framing members shall be a minimum of 4 feet (1219 mm) wide and the full length of the span of the wall section from support to support.

Doors and windows shall be tested at the maximum size proposed for use. Operable doors or windows shall be tested for the conditions of swing and latching as specified for use of the product. The specimen shall consist of the entire assembled unit and shall, when practical, be mounted as it will be installed in a shelter, and shall contain all devices used to resist wind forces and windborne debris. When it is not practical to install for testing a door or window frame as it will be mounted in a shelter, then the unit or assembly shall be mounted in a test

buck to connect the specimen to the test frame/stand/chamber. Details of the mounting shall be described in the test report.

803.2 Number of test specimens. Where both pressure and impact tests are required, testing of a single specimen subjected separately to each effect or two specimens, one subject to each load effect, shall be permitted.

803.3 Specimen conditioning. Samples shall be conditioned at ambient temperature [59° to 95° F (15° to 35° C)] for a minimum of 2 hours prior to testing.

803.4 Specifications/drawings. The manufacturer or constructor shall provide the test laboratory with applicable product specifications and/or drawings detailing materials of construction and applicable installation details. The testing agency shall verify conformance of the test specimen to the product specifications and/or drawings.

SECTION 804 MISSILE IMPACT TESTING

804.1 Apparatus. The general description of the apparatus for performing the missile impact testing requirements of this standard is detailed in Section 6 of ASTM E 1886. Any equipment, properly certified, calibrated and approved by a qualified lab capable of performing this test within the allowable tolerance is permitted.

804.2 Calibration. Calibration of the speed measuring system shall be performed per the procedure detailed in Section 9 of ASTM E 1886.

804.3 Missile impact procedure. Test specimens shall be impact tested with test missiles of size and speed as specified in Section 305 of this standard. Impact procedure shall be performed as detailed in Sections 11.1 through 11.3 of ASTM E 1886. The minimum number of impact locations shall be as detailed in Section 804.9.

804.4 Missile properties. The test missile weight shall be selected to meet the requirements of Section 305 of this standard and shall comply with Sections 804.4.1 through 804.4.3.

804.4.1 Wood species. Any common softwood lumber species as defined by DOC PS 20 shall be permitted to be used provided it meets length tolerances detailed below. The lumber shall be grade stamped No. 2 or better and be free of splits, checks, wane or other significant defects. The 2 by 4's used shall be straight such that any bow or warp measured by stretching a string or wire on the side of the board from end to end is within 0.5 inches of the 2 by 4's surface over its entire length.

804.4.2 Missile length and weight tolerance. The wood density, including moisture content, shall be such that the required 15 ± 0.25 pound (6.8 ± 0.11 kg) weight is met with a length of 13.5 feet \pm 6 inches (4115 mm \pm 152 mm) and the 9 ± 0.25 pound (4.1 ± 0.11 kg) weight is met with a length of

8 feet \pm 4 inches (2438 mm \pm 102 mm). The sabot and attachment screws shall be included in the missile weight when it is permanently attached. Missile weights shall be confirmed within 2 hours prior to their use.

804.4.3 Conditioning. The test missile shall be conditioned at ambient temperature [59°F to 95°F (15°C to 35°C)] for a minimum of 2 hours prior to testing.

804.5 Sabot size and weight. Where the missile launching system requires the use of a sabot for the effective launching of the missile, the sabot shall weigh no more than $\frac{1}{2}$ pound (0.226 kg), and shall be included in the weight of the missile, unless it is stripped away during flight prior to impact.

804.6 Missile speed. Missile speed measurement and speed tolerances shall be in accordance with the following.

804.6.1 Missile speed measurement. The missile speed shall be measured by a device capable of measuring the missile velocity to within ± 1 foot per second (0.305 m/s).

804.6.2 Missile speed tolerance. The missile test speed tolerance is 4 mph above and 0 mph below the missile speed prescribed in Section 305.

804.7 Impact angle. Missile impacts shall be within 5-degrees of normal to the primary plane of the test specimen. This requirement is deemed to be met when the barrel of the cannon is aligned within ± 2 -degrees of perpendicular in the horizontal plane and between level and a 3-degree upward incline in the vertical plane.

804.8 Testing temperature. The testing shall be conducted at ambient temperature in the range of [59°F to 95°F (15°C to 35°C)].

804.9 Impact locations and the number of impacts. Impacts are to be located as indicated in the following sections.

804.9.1 Panel or framed walls/roofs. Panel or framed wall and roof sections shall be impacted in the center of a wall/roof section, and at one interface corner as detailed in Figures 804.9.1(1) and 804.9.1(2).

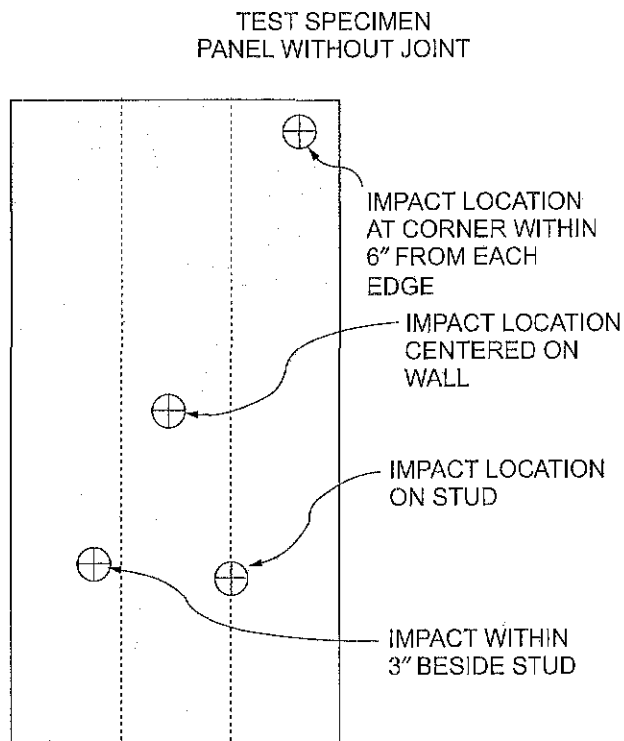
When an interior stud or support is present, additional impacts shall be performed near the stud/support, a directly on the stud support as detailed in Figures 804.9.1(1) and 804.9.1(2).

Interface joints used for attachment or joining at corners at panel-to-panel sections, or at panel-to-roof shall be impacted, directly on the interface joints as detailed in Figure 804.9.1(2) for each type of joint.

When a section contains lapped materials, the center impact shall be adjusted to strike the center of any lap, and an additional impact shall be performed beside the lap on the panel that laps behind the seam as detailed in Figure 804.9.1(2).

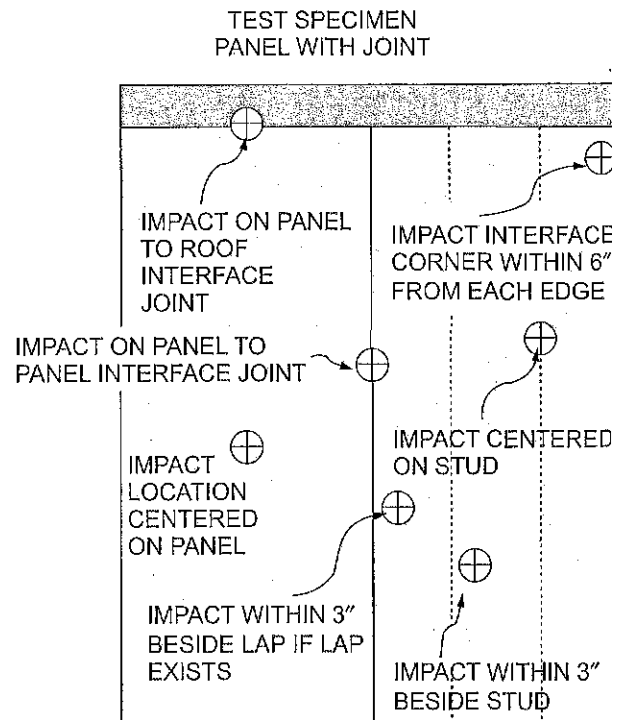
No more than three impacts shall be made on one specimen. Where more than three impacts are required, multiple identical test specimens shall be provided.

Exception: More than three impacts may be made on test specimen by mutual consent of owner and test laboratory.



For SI: 1 inch = 25.4 mm.

FIGURE 804.9.1(1)
PANEL OR FRAMED WALLS/ROOF



For SI: 1 inch = 25.4 mm.

FIGURE 804.9.1(2)
PANEL OR FRAMED WALLS/ROOF

804.9.2 Solid wall/roof sections of concrete or other materials. Wall and roof sections of solid concrete or other solid material shall be impacted in the center of the wall/roof section, and at one interface corner as detailed in Figures 804.9.2(1) and 804.9.2(2). When interface joints are used for joining at corners or panel-panel joints, an additional section shall be impacted directly on the interface joints as detailed in Figure 804.9.2(2).

Where an interior stud or support is present, additional impacts shall be performed within 3 inches (76.2 mm) of the stud/support, and directly on the stud support as detailed in Figures 804.9.2(1) and 804.9.2(2).

No more than three impacts shall be made on one specimen. Where more than three impacts are required, multiple identical test specimens shall be provided.

Exception: More than three impacts may be made on a test specimen by mutual consent of owner and test laboratory.

804.9.3 Masonry unit walls/roofs. Walls and roof sections of masonry units shall be impacted in the center of the wall/roof section, and at one interface corner or joint as detailed in Figure 804.9.3(1). Mortared joints shall be

impacted directly on the interface joints as detailed in Figure 804.9.3(2).

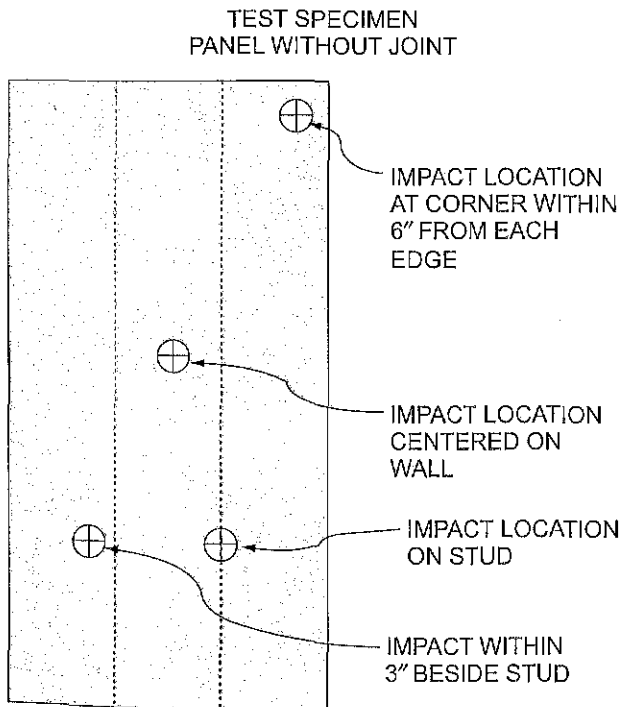
No more than three impacts shall be made on one specimen or specimen panel. Where more than three impacts are required, multiple identical test specimens shall be provided.

Exception: More than three impacts may be made on a test specimen by mutual consent of owner and test laboratory.

804.9.4 Windows and other glazed openings. All window assemblies and other glazed openings shall be impacted in the center of the smallest glazed section, and at one interface corner as detailed in Figure 804.9.4(1). Where interior mullions or other glazed section joints and/or latches are present, additional impacts shall be applied on these features as shown in Figure 804.9.4(2).

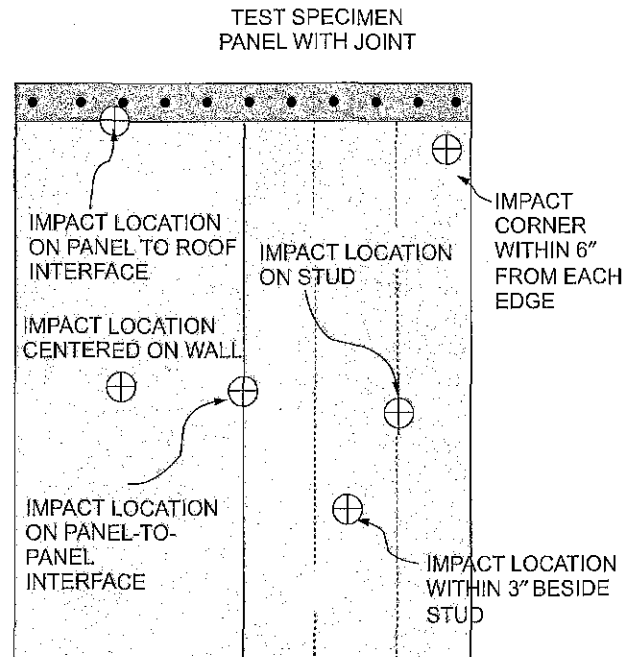
No more than two impacts shall be made on one specimen. Where more than two impacts are required, multiple identical test specimens shall be provided.

Exception: More than two impacts may be made on a test specimen by mutual consent of owner and test laboratory.



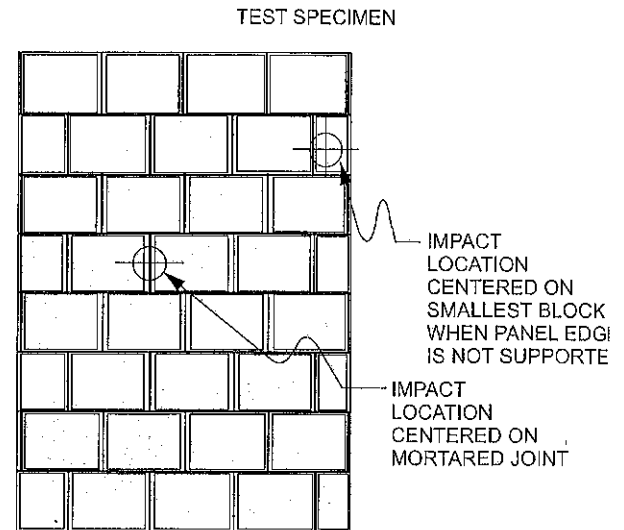
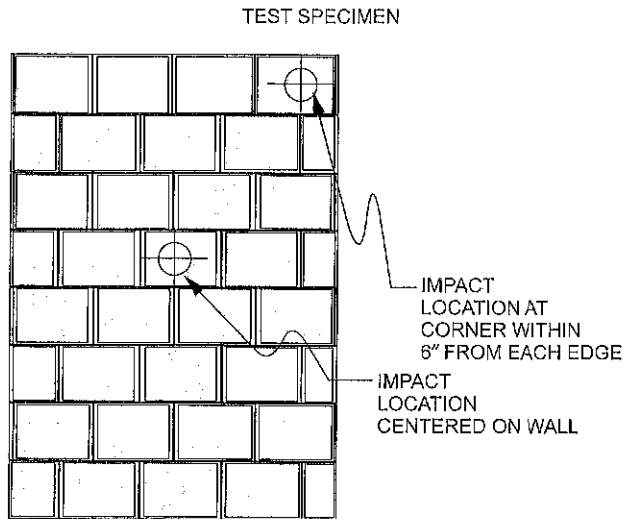
For SI: 1 inch = 25.4 mm.

FIGURE 804.9.2(1)
SOLID WALLS/ROOF SECTION OF CONCRETE
OR OTHER MATERIALS



For SI: 1 inch = 25.4 mm.

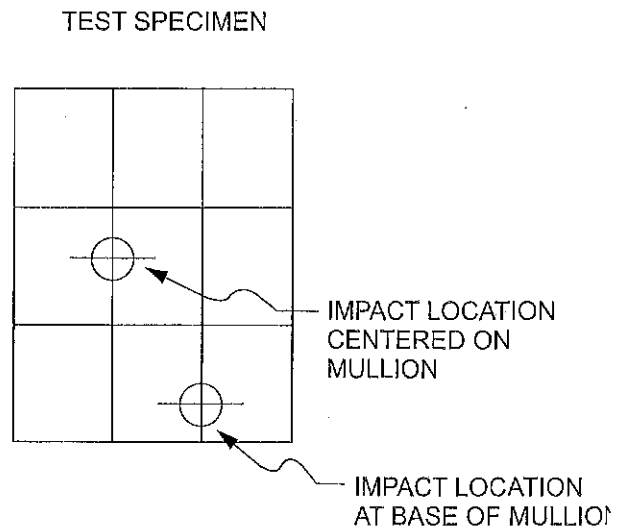
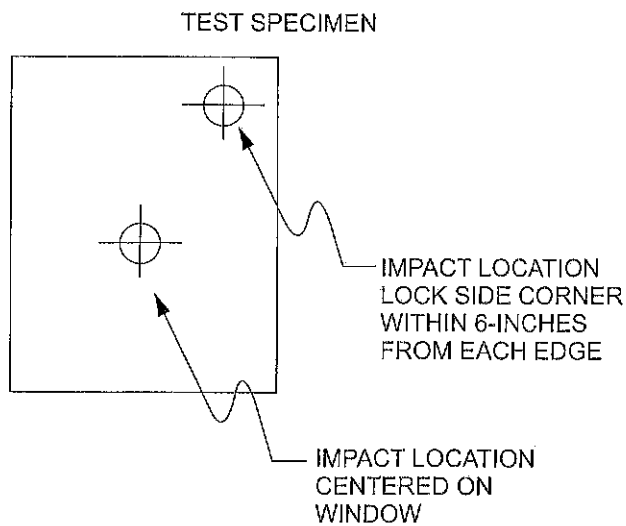
FIGURE 804.9.2(2)
SOLID WALLS/ROOF SECTION OF CONCRETE
OR OTHER MATERIALS



For SI: 1 inch = 25.4 mm.

FIGURE 804.9.3(1)
MASONRY UNIT WALLS/ROOFS

FIGURE 804.9.3(2)
MASONRY UNIT WALLS/ROOFS



For SI: 1 inch = 25.4 mm.

FIGURE 804.9.4(1)
WINDOWS AND OTHER GLAZED OPENINGS

FIGURE 804.9.4(2)
WINDOWS AND OTHER GLAZED OPENINGS

804.9.5 Doors or other entry/egress systems. All door assemblies and other entry/egress systems shall be impacted within 6 inches (152.4 mm) of an interface hinge joint, within 6 inches (152.4 mm) of an upper latch point and within 6 inches (152.4 mm) of center primary latches or operators as shown in Figure 804.9.5(1).

For double door assemblies, a single door leaf shall receive three impacts as shown in Figure 804.9.5(2) plus an additional impact on a center meeting point or mullion.

Where the door contains glazed openings with a size less than or equal to 12 inches (305 mm) by 12 inches (305 mm), an additional sample shall be impacted in the center of the glazed opening. Where glazed openings have a dimension greater than 12 inches (305 mm), the glazed opening shall be treated as a window and tested in accordance with Section 804.9.4 of this standard.

804.9.6 Opening protective devices. All shutter assemblies and other impact protection systems shall be impacted in the center of the closed opening, and at one interface corner as detailed in Figure 804.9.6(1). Panels and interface joints shall be impacted as shown in Figure 804.9.6(2). Interface hinge joints and primary latches, where present, shall be impacted as shown in Figure 804.9.5(2) on an additional specimen.

Where an interior stud or support is present, additional impacts shall be performed within 3 inches (76.2 mm) of the stud/support, and directly on the stud support as detailed in Figures 804.9.2(1) or 804.9.2(2).

804.9.7 Alcove or baffled entry systems. Debris impact testing described in this section is required for alcove/baffled access/egress systems meeting the requirements of Sections 304 and 305. Figure 804.9.7 illustrates an alcove/baffle system. Debris impact test requirements are presented for systems for which:

1. Storm debris impacts at least two shelter protective elements meeting the requirements of Section 306.2 prior to entering the protected occupant area. Straight missile paths and elastic impacts are assumed in determining missile trajectories. Test requirements for this type of system are presented in Section 804.9.7.1. Examples of this type of system are shown in Figure 804.9.7.1. The boundary between the protected occupant area and the unprotected occupant area shall be clearly marked on the floor and walls of the shelter.
2. Storm debris impacts initially a shelter protective element meeting the requirements of Section 306.2 and possibly rebounds to impact an entry door. Straight missile paths and elastic impacts are assumed in determining missile trajectories. The debris test requirements for this type of system are presented in Section 804.8.7.2. Examples of this type of system are shown in Figures 804.9.7.2(1) and 804.9.7.2(2).
3. Storm debris impact on an entry door is limited to an angle less than 90 degrees (1.57 rad) by a protective element. The debris test requirements for this type of system are presented in Section 804.8.7.3. Examples of this type of system are shown in Figure 804.9.7.3.

TEST SPECIMEN
PANEL WITHOUT JOINT

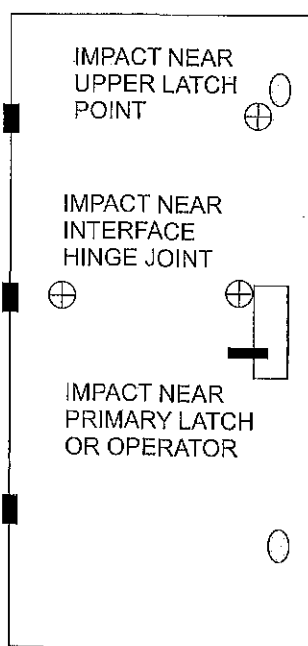


FIGURE 804.9.5(1)
DOORS AND OTHER ENTRY/EGRESS SYSTEMS

TEST SPECIMEN
PANEL WITH JOINT

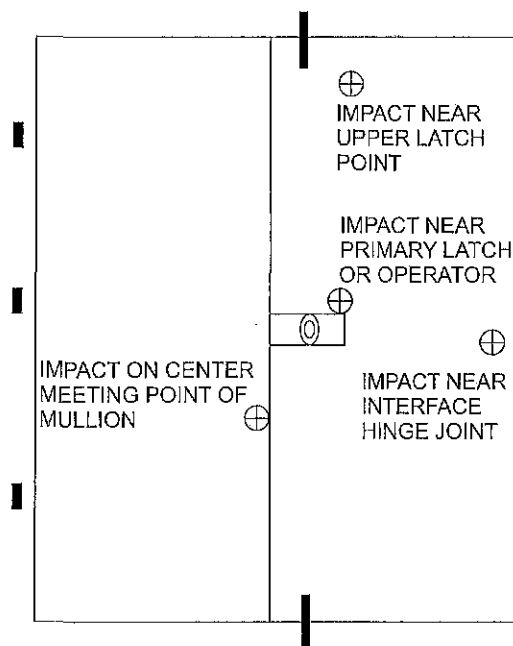
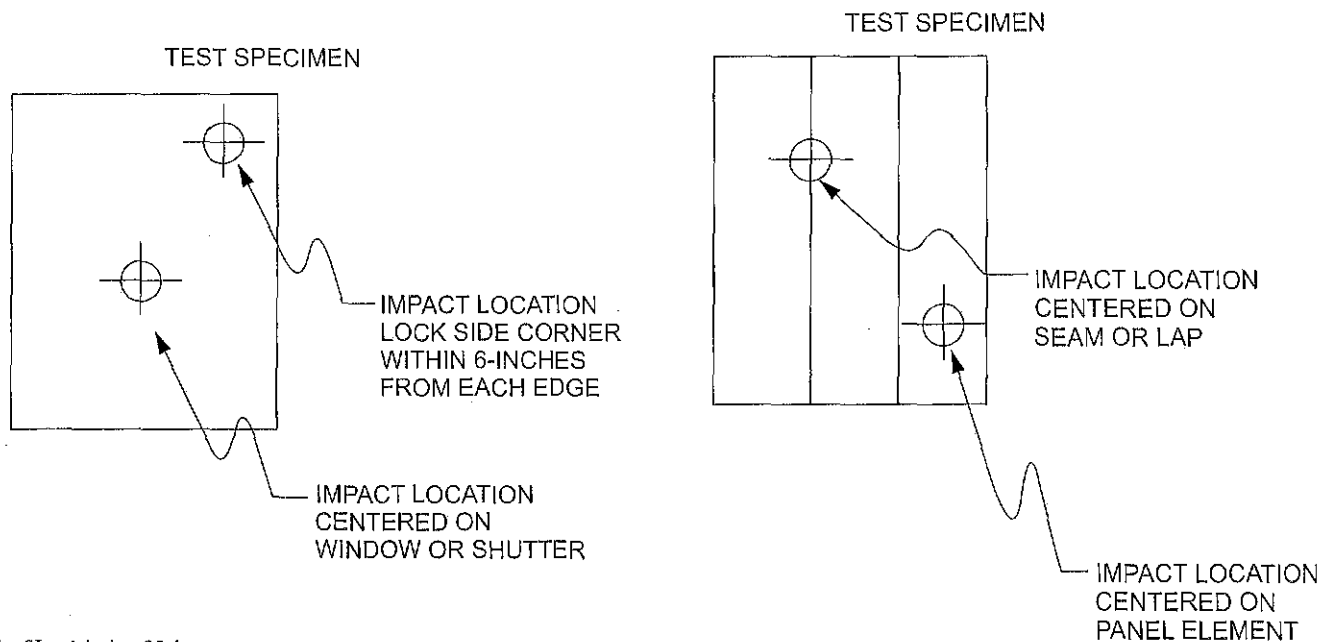


FIGURE 804.9.5(2)
DOORS AND OTHER ENTRY/EGRESS SYSTEMS



For SI: 1 inch = 25.4 mm.

FIGURE 804.9.6(1)
SHUTTERS OR OTHER IMPACT PROTECTION SYSTEMS

FIGURE 804.9.6(2)
SHUTTERS OR OTHER IMPACT PROTECTION SYSTEMS

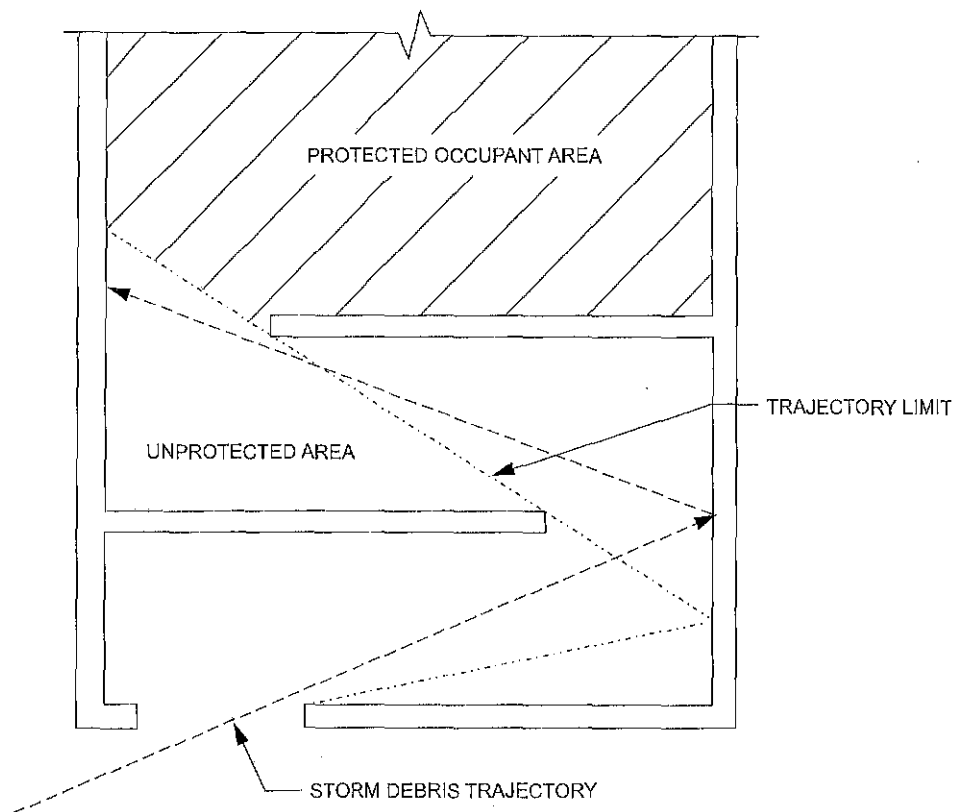


FIGURE 804.9.7
ALCOVE/BAFFLED ENTRY SYSTEM

804.9.7.1 Alcove/baffled entry systems for which no testing is required. Shelter entrances, whether provided with a door or not, that are protected by an alcove or baffled entry system that require missiles to impact at least two surfaces meeting the requirements of Section 306.2 prior to arriving at the protected occupant area shall not be required to undergo debris impact testing. See Figure 804.9.7.1. When a solid door is installed as a closure for this type of entry system, the door need not meet the wind load requirements of Section 304.

804.9.7.2 Door subject to rebound impact. Where the alcove or baffled entry system prevents a first impact of the design missile on the door but the door is subject to a rebounded impact of the design missile after it has impacted one surface meeting the requirements of Section 306.2 (See Figure 804.9.7.2), then a door assembly shall meet the wind load requirements of Section 304 and the debris impact requirements of Section 305 except that the missile shall be, at a minimum, a 9-pound sawn lumber 2 by 4 traveling at 50 feet per second (15.2 m/s). Entry systems having doors that are protected from the initial and first rebounded impacts of debris shall comply with the requirements of Section 804.9.7.1.

804.9.7.3 Door subject to first impact. If a first-strike angle missile impact on the door is possible (see Figure 804.9.7.3) then the door is deemed suitable if the door assembly meets the wind load requirements of Section

304 and the door assembly meets one of the following debris impact criteria:

1. The door withstands the impact of a missile specified in Section 305 striking the door assembly at an angle closest to perpendicular to the plane of the door that the missile might strike in the shelter application; or
2. The door assembly is tested following procedures specified in Section 305 or a door assembly is selected that has withstood missile impacts by the design missile striking perpendicular to the surface with speed equal to or greater than the shelter design missile's velocity component perpendicular to the door assembly for the most critical angle that can occur in the application.

The minimum debris impact criterion for the door shall be an impact perpendicular to the door of a 9-pound sawn lumber 2 by 4 traveling at 50 feet per second [34 mph (15.2 m/s)].

804.10 Pass/fail. The pass/fail criteria for missile impact testing shall be in accordance with this section.

804.10.1 Perforation. Any perforation of the interior surface of the tested component of the shelter envelope by the design missile shall constitute a failure. For opening protective devices, perforation or deflection that would result in impact of the protected component constitutes a failure.

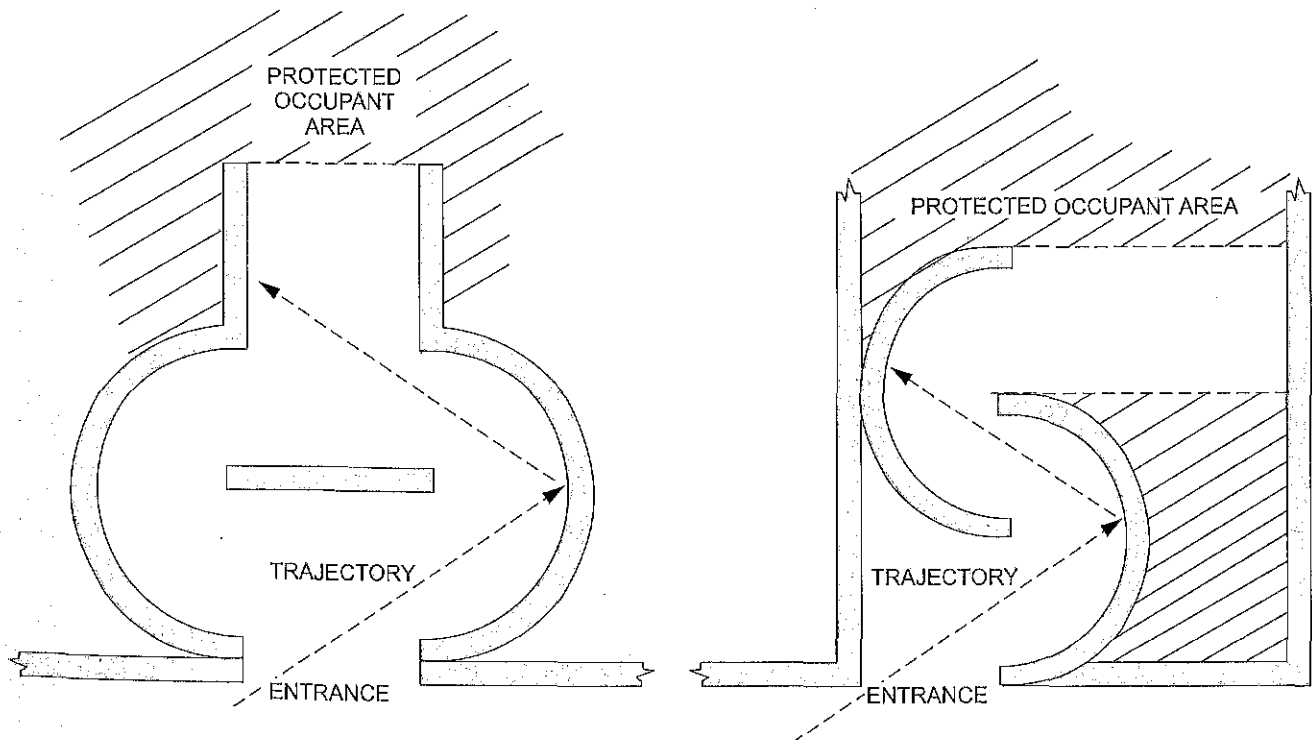


FIGURE 804.9.7.1
ALCOVE/BAFFLED ENTRY SYSTEMS FOR WHICH NO DOOR IS REQUIRED

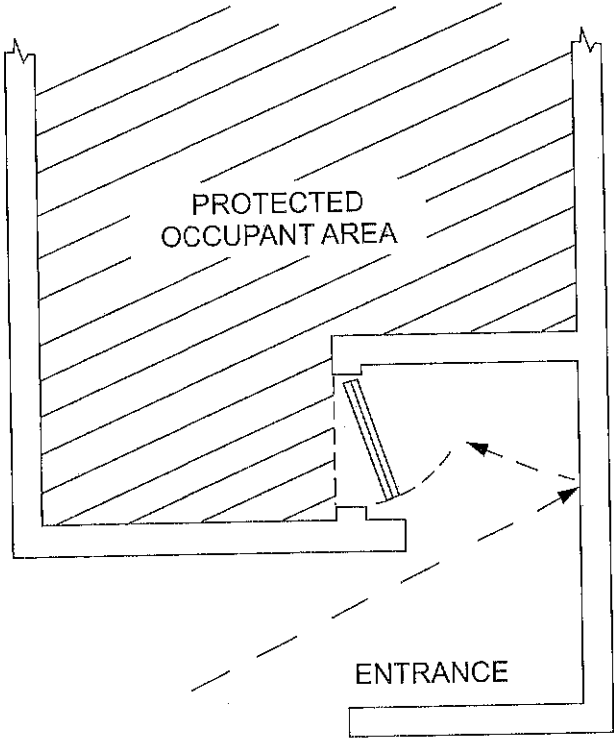
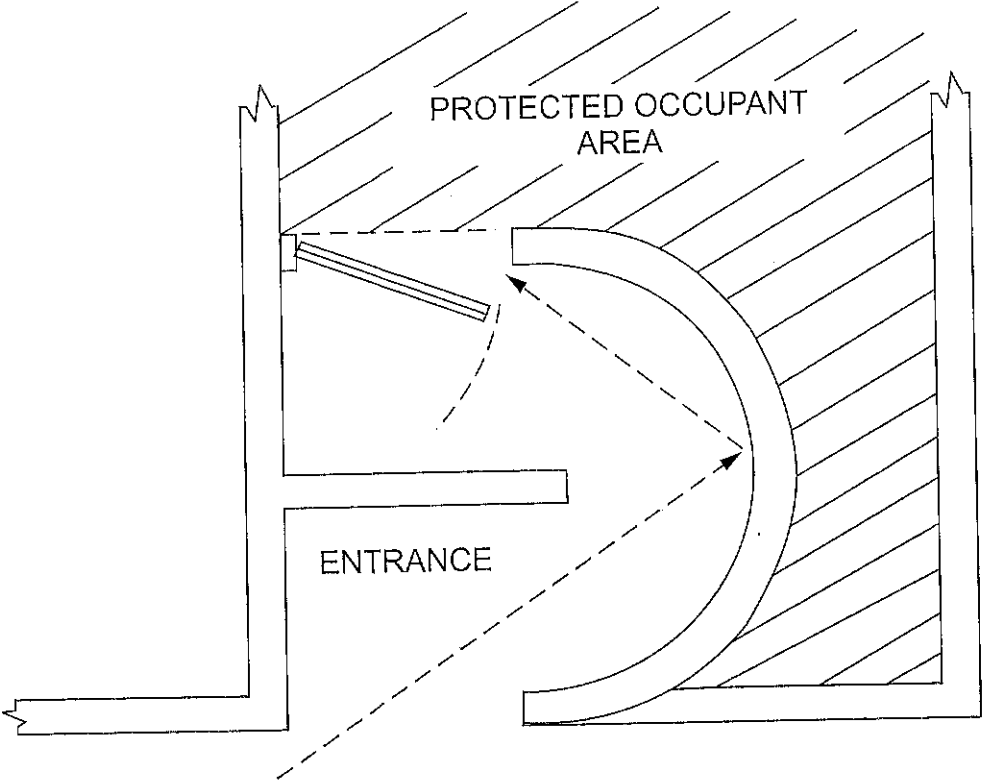


FIGURE 804.9.7.2
DOORS SUBJECT TO REBOUND IMPACT

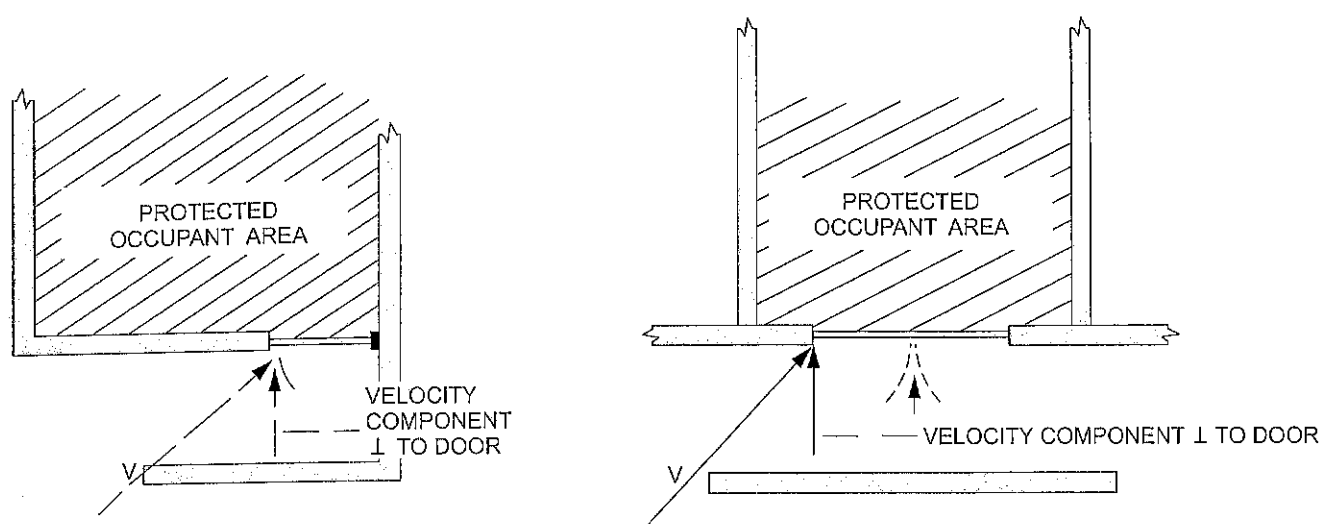


FIGURE 804.9.7.3
DOORS SUBJECT TO FIRST IMPACT

804.10.2 Dislodgment and disengagement. Specimens and load-bearing fasteners, where used, shall not become disengaged or dislodged during the test procedures so as to endanger occupants. Dislodgment that occurs in a test shall be demonstrated to be harmless by failing to perforate a #70 unbleached kraft paper witness screen with its surface secured in place on a rigid frame installed within 5 inches (127 mm) of the interior surface of the shelter component. The rigid frame shall maintain tautness of the kraft paper and shall have continuous supports in one direction at intervals no greater than 3 feet (914 mm).

804.10.3 Spall. Excessive spall shall not be released from the interior surface of any specimen. Excessive spall is defined as that which perforates a #70 unbleached kraft paper witness screen with its surface secured in place on a rigid frame 5 inches (127 mm) from the interior surface of the test specimen. The witness screen rigid frame shall maintain tautness of the kraft paper and shall have continuous supports in one direction at intervals no greater than 3 feet (914 mm).

Exception: Where warnings are to be provided marking the protected occupant area, beyond the 5-inch (127 mm) limit defined above the witness screen is permitted to be positioned at the boundary of the protected area, and excessive spall defined as that which will perforate the witness screen in this position.

804.10.4 Permanent deformation. Permanent deformation of an interior surface of the test specimen shall be determined by measuring the distance from a straight edge held between two undeformed points on the specimen. The maximum permanent deformation shall be measured to the nearest $\frac{1}{8}$ inch (3.2 mm) and shall not exceed 3 inches (76.2 mm) inches.

SECTION 805 PRESSURE TESTING

805.1 Apparatus. The general description of the apparatus for performing the pressure testing requirements of this standard is detailed in Section 6 of ASTM E 330 when performing the static pressure test, or ASTM E 1886 when performing the cyclic test. Any equipment, properly certified, calibrated and approved by a qualified lab, capable of performing this test, within the allowable tolerance, is permitted.

805.2 Calibration. Calibration of the pressure measuring system shall be performed in accordance with the procedure detailed in Section 9 of ASTM E 330 or ASTM E 1886.

805.3 Cyclic pressure testing after impact. Test specimens requiring cyclic pressure testing to establish the ability to meet the wind pressure requirements set forth in Section 304 of this standard, shall be cyclic tested using the loading sequence detailed in ASTM E 1886 specified to the design wind pressure as defined in Section 304.1. Pressure testing procedures shall be performed as detailed in Sections 11.1 through 11.2.11 of ASTM E 1886.

805.4 Testing temperature. The testing shall be conducted at room temperature in the range of 59°F (15°C) to 95°F (35°C).

SECTION 806

PRESSURE TESTING PROCEDURES

806.1 Pressure testing procedures. Procedures for pressure testing wall assemblies, roof assemblies, door assemblies, window assemblies, and opening protective devices requiring pressure testing are presented in this section.

806.2 Roof and wall assemblies. When testing of roof and wall assemblies is required, they shall be pressure tested in the as-supplied condition. Required pressure testing shall be done

as detailed in ASTM E 330 to a pressure equal to or higher than 1.2 times the pressures specified in Section 304.

806.3 Door assemblies. Door assemblies shall be pressure tested in the as-supplied condition, and, when required, they shall be static pressure tested or cyclically tested as specified in the following sections.

806.3.1 Door assemblies without glazing. Door assemblies without glazing that require testing to meet the qualification of Section 306.3 shall be pressure tested according to procedures specified in this section.

806.3.1.1 Door assemblies without glazing for tornado shelters. Door assemblies without glazing for use in tornado shelters shall be static pressure tested away from the door stops to a pressure of at least 1.2 times the pressures specified in Section 304. Pressure tests are permitted to be conducted separately from missile impact tests.

806.3.1.2 Door assemblies without glazing for hurricane shelters. Door assemblies without glazing for use in hurricane shelters shall be static pressure proof tested away from the door stops to a pressure of at least 1.2 times the design wind pressure, then subjected to required debris impact tests, and then to cyclic pressure tests following procedures of ASTM E1886.

Alternatively, door assemblies without glazing for hurricane shelters shall be statically pressure tested away from the door stops to a pressure of 1.5 times the design wind pressure before impact tests and then to required debris impact tests. Cyclic pressure testing after impact tests is not required for these door assemblies that have been pressure tested to pressures equal to or greater than 1.5 times the design wind pressure.

806.3.2 Door assemblies with glazing, sidelights, or transoms. Door assemblies with glazing, sidelights, or transoms shall be pressure tested according to procedures specified in this section. Where glazed openings are present, with a size of less than or equal to 12 inches by 12 inches (304.8 mm by 304.8 mm), an additional sample shall be impacted in the center of the glazed opening in accordance with Section 804 and cyclic pressure tested as detailed in Section 805.5. Where glazed openings have a dimension greater than 12 inches (304.8 mm), the glazed opening shall be treated as a window and tested in accordance with Section 806.5 of this standard.

806.3.2.1 Door assemblies with glazing, sidelights, or transoms for tornado shelters. Door assemblies with glazing, sidelights, or transoms for tornado shelters shall be static pressure tested away from the door stops following procedures of ASTM E 330 to a pressure of at least 1.2 times the pressures specified in Section 304. Pressure tests are permitted to be conducted separately from debris impact tests.

806.3.2.2 Door assemblies with glazing, sidelights, or transoms for hurricane shelters. Door assemblies with glazing, sidelights, or transoms for hurricane shelters shall be static pressure proof tested away from the door stops to a pressure of at least 1.2 times the design wind

pressure. Any required debris impact tests shall follow pressure proof testing. After impact tests the door assembly shall be subjected to cyclic pressure tests following procedures of ASTM E 1886.

806.4 Window assemblies and other glazed openings. Window assemblies and other glazed openings shall be pressure tested according to procedures specified in this section.

806.4.1 Window assemblies and other glazed openings for tornado shelters. Window assemblies and other glazed openings for tornado shelters shall be static pressure tested away from stops following procedures detailed in ASTM 330 to the pressures specified in Section 304. Pressure tests are allowed to be conducted separately from debris impact tests.

806.4.2 Window assemblies and other glazed openings for hurricane shelters. Window assemblies and other glazed openings for hurricane shelters shall be static pressure tested away from stops to a pressure of at least 1.2 times the design wind pressure. Any required debris impact tests shall follow pressure proof testing. After impact tests the window assembly shall be subjected to cyclic pressure tests following procedures of ASTM E 1886.

806.5 Opening protective devices. External opening protective devices such as shutters and protective screens shall be tested for the ability to withstand prescribed pressures if withstanding pressure is critical to their function when installed. Devices such as nonoperable, permanently affixed shields, cowlings whose only function is to protect against debris intrusion need not be pressure tested.

806.5.1 Opening protective devices for tornado shelters. External protective devices for tornado shelters whose ability to withstand wind-induced pressure when installed is critical to their function shall be static pressure tested following procedures specified in ASTM E 330 to a pressure at least 1.2 times the pressures specified in Section 304. Debris impact tests and pressure tests are permitted to be conducted separately.

Exception: Protective devices with a jamb or stop need be tested only with pressure away from the stop.

806.5.2 Opening protective devices for hurricane shelters. External protective devices for hurricane shelters whose ability to withstand wind-induced pressure when installed is critical to their function shall be static pressure tested to a pressure of at least 1.2 times the shelter design wind pressures specified in Section 304 following the procedures specified in ASTM E 330. Cyclic pressure tests conducted in accordance with Section 805.5 shall be conducted after debris impact tests.

806.6 Alcove or baffled entry systems. Any element of an entry system whose ability to resist wind-induced pressure is critical to the function of the entry system shall be designed to meet the requirements of Section 304 or shall be pressure tested in accordance with Section 806.

CHAPTER 9

REFERENCED STANDARDS

This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the section or sections of this document that reference the standard.

American Society of Civil Engineers
Structural Engineering Institute
1801 Alexander Bell Drive
Reston, VA 20191-4400

ASCE

Standard reference number	Title	Referenced in code section number
7-05	Minimum Design Loads for Buildings and Other Structures including Supplement No. 1	301.1, 302.1, 302.2, 303.1, 303.2, 304.1, 304.7
24-05	Flood Resistant Design and Construction401.3

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959

ASTM

Standard reference number	Title	Referenced in code section number
E 330-02	Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference	805.1, 805.2, 806.2, 806.3.2.1, 806.4.1, 806.5.1, 806.5.2
E 631-05	Terminology of Building Constructions802.1
E 1886-04	Standard Test Method for the Performance of Exterior Windows, Curtain Walls, Doors and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials	805.1, 805.2, 805.3, 806.3.1.2, 806.3.2.2, 806.4.2
E 1996-02	Specification for Performance of Exterior Windows306.3.2

U.S. Department of Commerce
National Institute of Standards and Technology
100 Bureau Drive Stop 3460
Gaithersburg, MD 20899

DOC

Standard reference number	Title	Referenced in code section number
PS 20-99	American Softwood Lumber Standard804.4.1

International Code Council, Inc.
500 New Jersey Ave, NW
6th Floor
Washington, D.C. 20001

ICC

Standard reference number	Title	Referenced in code section number
IBC-06	International Building Code®501.6
ICC A117.1-03	Accessible and Usable Buildings and Facilities504.1.1

REFERENCED STANDARDS

NFPA

National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02269-9101

Standard reference number	Title	Referenced in code section number
NFPA—10-02	Portable Fire Extinguishers	602.2