



*Member of the FM Global Group*

# **Approval Standard for Storage Buildings and Lockers**

**Class Number 6049**

**December 2013**

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# Foreword

The FM Approvals certification mark is intended to verify that the products and services described will meet FM Approvals' stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of Approval Standards is to present the criteria for FM Approval of various types of products and services, as guidance for FM Approvals personnel, manufacturers, users and authorities having jurisdiction.

Products submitted for certification by FM Approvals shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing shall ensure a consistently uniform and reliable product. Approval Standards strive to be performance-oriented. They are intended to facilitate technological development.

For examining equipment, materials and services, Approval Standards:

- a) must be useful to the ends of property conservation by preventing, limiting or not causing damage under the conditions stated by the Approval listing; and
- b) must be readily identifiable.

Continuance of Approval and listing depends on compliance with the Approval Agreement, satisfactory performance in the field, on successful re-examinations of equipment, materials, and services as appropriate, and on periodic follow-up audits of the manufacturing facility.

FM Approvals LLC reserves the right in its sole judgment to change or revise its standards, criteria, methods, or procedures.

# TABLE OF CONTENTS

|  |    |
|--|----|
| <b>1 INTRODUCTION</b> .....  | 1  |
| <b>1.1 Purpose</b> .....   | 1  |
| <b>1.2 Scope</b> .....   | 1  |
| <b>1.3 Basis for Requirements</b> .....  | 1  |
| <b>1.4 Basis for Approval</b> .....  | 2  |
| <b>1.5 Basis for Continued Approval</b> .....                                    | 2  |
| <b>1.6 Effective Date</b> .....  | 2  |
| <b>1.7 System of Units</b> .....   | 2  |
| <b>1.8 Applicable Documents</b> .....  | 3  |
| <b>1.9 Definitions</b> .....   | 4  |
| <b>2 GENERAL INFORMATION</b> .....   | 5  |
| <b>2.1 Non-Combustible Construction</b> .....                                    | 5  |
| <b>2.2 Fire Rated Construction</b> .....   | 5  |
| <b>2.3 Damage-Limiting Construction</b> .....                                    | 5  |
| <b>2.4 Building Design and Usage</b> .....                                       | 5  |
| <b>2.5 Approval Application Requirements</b> .....                               | 6  |
| <b>2.6 Requirements for Examination</b> .....                                    | 6  |
| <b>3 GENERAL REQUIREMENTS</b> .....  | 7  |
| <b>3.1 General Design Requirements</b> .....                                     | 7  |
| <b>3.2 Damage-Limiting Construction</b> .....                                    | 7  |
| <b>3.3 Fire Ratings</b> .....  | 8  |
| <b>3.4 Wind Loads</b> .....  | 9  |
| <b>3.5 Ignitable Liquid Storage Buildings</b> .....                              | 10 |
| <b>3.6 Flammable Gas, Non-Flammable Gas and General Storage Buildings</b> .....  | 11 |
| <b>3.7 Markings</b> .....  | 11 |
| <b>3.8 Manufacturer’s Installation and Operation Requirements</b> .....          | 12 |
| <b>4 PERFORMANCE REQUIREMENTS</b> .....  | 12 |
| <b>4.1 Structural Analysis</b> .....   | 12 |
| <b>4.2 Damage-Limiting Construction Panels</b> .....                             | 12 |
| <b>4.3 Sump</b> .....  | 13 |
| <b>4.4 Fire Protection Systems</b> .....   | 13 |
| <b>4.5 Fire Rated Walls and Roofs</b> .....                                      | 14 |
| <b>5 OPERATIONS REQUIREMENTS</b> .....   | 14 |
| <b>5.1 Demonstrated Quality Control Program</b> .....                            | 14 |
| <b>5.2 Surveillance Audit</b> .....  | 15 |
| <b>5.3 Installation Inspections</b> .....  | 15 |
| <b>5.4 Manufacturer’s Responsibilities</b> .....                                 | 15 |
| <b>APPENDIX A Units of Measurement</b> .....                                     | 16 |
| <b>APPENDIX B FM Approvals Certification Marks</b> .....                         | 17 |
| <b>APPENDIX C Damage-Limiting Construction Venting Areas and Pressures</b> ..... | 19 |

# 1 INTRODUCTION

## 1.1 Purpose

- 1.1.1 This Standard states Approval requirements for storage buildings. Storage buildings are used in a variety of commercial and industrial applications. Some of these uses are to store and/or dispense ignitable liquids, to store flammable and non-flammable compressed gases in cylinders and to store other types of combustible and non-combustible goods such as chemicals, fertilizers and other general storage.
- 1.1.2 Approval criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies) and audit of quality assurance procedures.

## 1.2 Scope

- 1.2.1 This standard sets performance requirements for structures designed to provide a safe, secure storage and/or dispensing area for ignitable liquids, for the storage of flammable and non-flammable compressed gases in cylinders and for the storage of combustible and/or non-combustible commodities.
  - 1.2.1.1 The structures Approved in this standard are generally referred to as storage buildings. This standard also recognizes a subcategory of structures that shall be referred to as storage lockers. When categorized by this standard as a storage locker, the structure's Approval shall be limited to outdoor usage.
  - 1.2.1.2 Storage structures Approved in this standard shall not be permitted to be referred to as storage cabinets by the manufacturer unless they also meet the requirements of Approval Standard 6050, Storage Cabinets.
- 1.2.2 These buildings are generally considered to be portable. When used outdoors, anchoring means may be necessary to prevent movement under high wind conditions.
- 1.2.3 Storage buildings eligible for Approval fall into the categories shown below:
  - a) For the storage of ignitable liquids **with** provisions for damage-limiting construction;
  - b) For the storage of ignitable liquids **without** provisions for damage-limiting construction;
  - c) For the storage of flammable compressed gases in cylinders **with** provisions for damage-limiting construction;
  - d) For the storage of non-flammable compressed gases in cylinders **without** provisions for damage-limiting constructions;
  - e) For general use without provisions for damage-limiting construction.
- 1.2.4 Manufacturers shall provide a label on the structure indicating the category for which the structure has been approved.

## 1.3 Basis for Requirements

- 1.3.1 The requirements of this standard are based on experience, research and testing and/or the standards of other national and international organizations. The advice of manufacturers, users and loss control specialists was also considered.
- 1.3.2 The requirements of this standard reflect tests and practices used to examine characteristics of storage buildings for the purpose of obtaining Approval. These requirements are intended primarily as guides and strict conformity is not always mandatory. Buildings having characteristics not anticipated by this standard may be FM Approved if performance equal or superior to that required by this standard is demonstrated, or if the intent of the standard is met. Alternatively, buildings which do meet all the requirements identified in this standard may not be FM Approved if other conditions which adversely affect performance exist or if the intent of this standard is not met.

#### 1.4 Basis for Approval

Approval is based upon satisfactory evaluation of the building and the manufacturer in the following major areas:

- 1.4.1 Examination and analysis of building construction shall be performed to evaluate:
- the suitability of the building;
  - the proper operation and performance of the building as specified by the manufacturer and required by FM Approvals; and, as far as practical;
  - the durability and reliability of the building.
- 1.4.2 If an assembly submitted for Approval incorporates a component for which a separate Approval Standard exists, then that component shall be examined, at minimum, to the extent required by its own Approval Standard. Components already separately FM Approved which are submitted as part of an assembly to be Approved need only be examined to the extent necessary to assure proper functioning as part of the assembly.
- 1.4.3 An examination of the manufacturing facilities and audit of quality control procedures shall be made to evaluate the manufacturer's ability to produce the building which is examined and tested, and the marking procedures used to identify the building. These examinations are repeated as part of FM Approvals' follow-up program.

#### 1.5 Basis for Continued Approval

Continued Approval is based upon:

- production or availability of the building as currently FM Approved;
- the continued use of acceptable quality control procedures;
- satisfactory field experience;
- compliance with the terms stipulated in the Master Agreement; and
- re-examination of production buildings for continued conformity to requirements.

#### 1.6 Effective Date

The effective date of an Approval Standard mandates that all products tested for Approval after the effective date shall satisfy the requirements of that standard. Products FM Approved under a previous edition shall comply with the new version by the effective date or else forfeit Approval. The effective date shall apply to the entire Approval standard, or, where so indicated only to specific paragraphs of the standard.

The effective date of this Standard is *October 1, 2014* for full compliance with all requirements.

#### 1.7 System of Units

Units of measurements are U.S. customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. Appendix B lists the selected units for quantities dealt with in testing these products; conversions to SI units are included. Conversion of customary English units is in accordance with ASTM E380.

## 1.8 Applicable Documents

American Iron and Steel Institute (AISI)

AISI North American *Specifications for the Design of Cold Formed Steel Structural Members* (NASPEC 2001)

American Institute for Steel Construction, Inc. (AISC)

AISC *Steel Construction Manual* 14<sup>th</sup> edition

American Society of Civil Engineers (ASCE)

ASCE 7- 10, *Minimum Design Loads for Buildings and Other Structures*

American Society for Testing and Materials (ASTM)

ASTM E84- 12c, *Standard Test Method for Surface Burning Characteristics of Building Materials*

ASTM E119- 12a, *Standard Test Methods for Fire Tests of Building Construction and Materials*

ASTM E136- 12, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*

ASTM E 1529-13, *Standard Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural members and Assemblies*

American National Standards Institute (ANSI)

ANSI/UL 555, *Standard for Fire Dampers*

FM Global Data Sheets

FM Global Property Loss Prevention Data Sheet 1-28, *Wind Design*, January 2012

FM Global Property Loss Prevention Data Sheet 1-44, *Damage-Limiting Construction*, April 2012

FM Global Property Loss Prevention Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers*, April 2012

FM Global Property Loss Prevention Data Sheet 7-32, *Ignitable Liquid Operations*, April 2012

FM Global Property Loss Prevention Data Sheet 7-50, *Compressed Gases in Cylinders*, January 2012

FM Global Property Loss Prevention Data Sheet 7-83, *Drainage and Containment Systems for Ignitable Liquids*, April 2012

National Fire Protection Association (NFPA)

NFPA 13-2013, *Standard for the Installation of Sprinkler Systems*

NFPA 30-2012, *Flammable and Combustible Liquids Code*

NFPA 55-2013, *Compressed Gases and Cryogenic Fluids Code*

NFPA 68-2013, *Standard on Explosion Protection by Deflagration Venting*

NFPA 70-2014, *National Electrical Code*

## 1.9 Definitions

### *Compressed Gas*

A material, or a mixture of materials, that 1) is a gas at 68°F (20°C) or less at an absolute pressure of 14.7 psi (101.3 kPa) and 2) has a boiling point of 68°F (20°C) or less at an absolute pressure of 14.7 psi (101.3 kPa) and that is liquefied, non-liquefied or in solution, except that those gases that have no health or physical hazard properties are not considered to be compressed gases until the pressure in the packaging exceeds an absolute pressure of 40.6 psi (280 kPa) at 68°F (20°C).

### *Cylinder*

A pressure vessel designed for absolute pressures higher than one atmosphere and having a circular section.

### *Damage-Limiting Construction*

A combination of pressure-relieving (venting) and pressure-resisting exterior construction which is intended to mitigate over-pressure damage to the building in case of a vapor-air deflagration. The design of relieving and resisting features must be engineered to account for fuel, surface area of the enclosure, vent area and structural loads imposed by the deflagration.

### *Flammable Gas*

A material that is a gas at 68°F (20°C) or less at an absolute pressure of 14.7 psi (101.3 kPa) when in a mixture of 13% or less by volume with air, and that has a flammable range at an absolute pressure of 14.7 psi (101.3 kPa) with air of at least 12%, regardless of the lower limit.

### *Ignitable Liquid*

For purposes of this standard, the term ignitable liquid is used to represent any liquid that burns.

### *Indoor Usage*

An arrangement when the Approved storage building is physically located inside of another building and acts as a cut-off room.

### *Non-Combustible Materials*

Materials that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion or release flammable vapors when subjected to fire or heat. Such materials meet the criteria of ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*.

### *Non-Flammable Gas*

A gas that does not meet the definition of a flammable gas.

### *Storage Building*

A prefabricated structure designed to provide a safe and secure storage area.

### *Storage Locker*

Similar to a storage building but generally smaller in size. Lockers do not allow personnel to enter the structure and are designed such that containers for which it is designed to store cannot be placed within ½ the height of the container from the door opening. The Approval of storage lockers shall be limited to outdoor usage.

## 2 GENERAL INFORMATION

### 2.1 Non-Combustible Construction

2.1.1 Building walls, roofs and doors shall be of steel construction or utilize other non-combustible materials.

2.1.2 The basic test that building officials consider when determining non-combustibility of most building materials is ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*. This test method exposes the material being tested to a stream of air heated to 750°C (1382°F). To qualify as non-combustible, four specimens must be tested, and three must pass the following criteria:

- The surface or interior temperature must not exceed the furnace temperature by more than 30°C (54°F);
- After 30 seconds into the test, no flaming of the specimen is allowed; and
- If the sample loses more than 50 percent of its weight during the test, its temperature cannot exceed 750°C (1382°F) and it cannot flame.

2.1.3 The International Building Code allows layered building materials to be considered noncombustible if:

- The core of the material passes the test procedure set forth in ASTM E136;
- The material surfacing is not more than 1/8 inch (3.2 mm) thick, and;
- The composite material has a flame-spread rating not greater than 50 when tested in accordance with ASTM E84, “Standard Test Method for Surfacing Burning Characteristics of Building Materials.”

2.1.3.1 The Uniform Building Code references a UBC standard, UBC 2-1, in lieu of E136; however, UBC 2-1 reflects essentially the same criteria as E136. The UBC contains the same alternate definition criteria for non-combustibility as described above for the IBC.

### 2.2 Fire Rated Construction

2.2.1 Walls are generally of steel stud construction covered in turn by gypsum board and light gauge sheet metal. Roofs are constructed of non-combustible materials and insulating material supported by steel joists and lined with light gauge sheet metal. Doors are generally of light gauge sheet metal – and are provided with a label indicating that they are fire rated by an independent certification agency. Other methods of construction are not excluded by the preceding statements. All methods shall be considered on an individual basis.

2.2.2 Buildings are not required to be fire rated. When buildings are fire rated, the components (exterior walls, exterior sump walls, roof, doors, dampers or opening protectives) shall be rated as evidenced by a fire test or a published listing shown in a listing agency publication that is acceptable to FM Approvals.

### 2.3 Damage-Limiting Construction

Buildings shall be permitted to be designed for damage-limiting construction. When so designed, it shall be done in accordance with Paragraph 3.2 and Appendix C.

### 2.4 Building Design and Usage

2.4.1 Building shall be designed for and limited to outdoor use unless specifically designed for indoor use in accordance with Paragraph 3.5.



- 2.4.2 When designed for indoor use only, the structure shall bear a label clearly denoting that it has been designed for indoor use only.
- 2.4.3 Storage buildings that incorporate damage-limiting construction features shall be Approved for outdoor use only.

## 2.5 Approval Application Requirements

To apply for an Approval examination the manufacturer, or its authorized representative, should submit a request to

Materials, Group Manager  
FM Approvals  
1151 Boston-Providence Turnpike  
PO Box 9102  
Norwood, MA 02062  
U.S.A.

The manufacturer shall provide the following preliminary information with any request for Approval consideration:

- A complete list of all models, types, sizes, and options for the products or services being submitted for Approval consideration;
- General assembly drawings, complete set of manufacturing drawings, materials list, anticipated marking format, nameplate format and design conditions. All documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided with English translation;
- The number and location of manufacturing facilities.

## 2.6 Requirements for Examination

The manufacturer shall provide:

- A structural analysis relative to the design of the building in accordance with accepted structural engineering practices.
- All drawings relating to the structure of the building. Drawings shall show the location of structural members, their nominal sizes and applied design loads. The maximum height, width and length for which Approval is desired shall be covered by the calculations.
- Size, location, and fastening method for damage-limiting construction.
- A drawing of door(s) showing construction, latching, hinging, and locking provisions. Specification sheets for doors and fire dampers, if of fire rated construction, indicating the manufacturer, model number, and that fire ratings are in accordance with applicable Approval standards. Fire rated doors shall bear a label indicating their fire rating. The label shall denote a third party certification agency acceptable to FM Approvals.
- Drawings of all data plates, warning labels and the Approval label, including information as to where the labels are located on the building.

- 2.6.1 Individual fire rated products shall bear a label indicating FM Approval whenever such a category of product is listed in the FM Approval Guide. In cases when FM Approvals does not have any listings for the particular type of fire rated product, the products shall be permitted to bear a label of an independent certification agency acceptable to FM Approvals.

### 3 GENERAL REQUIREMENTS

#### 3.1 General Design Requirements

- 3.1.1 When designed for outdoor use, the structure shall be capable of withstanding, as a minimum, inward and outward acting wind pressures of 15 lbs/ft<sup>2</sup> (0.7 kPa) and 21 lbs/ft<sup>2</sup> (1.0 kPa) respectively and a downward vertical (snow) load of 40 psf (195 kg/m<sup>2</sup>), plus its own weight. See Paragraph 3.4 for further information.
- 3.1.2 When designed for indoor use only, the structure shall be capable of withstanding, as a minimum, inward and outward acting lateral pressures of 15 lbs/ft<sup>2</sup> (0.7 kPa) and a downward vertical (live) load of 20 psf (98 kg/m<sup>2</sup>) plus its own weight.
- 3.1.3 The floor support system shall be capable of supporting a minimum load of 250 psf (1220 kg/m<sup>2</sup>) under dry conditions.
- 3.1.4 All electrical equipment located on or within the building shall provide appropriate ratings to meet local codes and the Authority Having Jurisdiction.
- 3.1.5 Gross floor area shall not exceed 1500 ft<sup>2</sup> (139 m<sup>2</sup>). Structures shall be permitted to be shipped as smaller units and field assembled.
- 3.1.6 The appropriate type and capacity of ventilation shall be provided to meet FM Global Property Loss Prevention Data Sheets 7-29, 7-32 and/or local codes and the Authority Having Jurisdiction.
- 3.1.7 A suitable means of grounding the building and individual liquid containers shall be provided. All such grounding shall be in accordance with NFPA 70.

#### 3.2 Damage-Limiting Construction

- 3.2.1 Buildings shall be permitted to be designed for damage-limiting construction. The determination of the need for damage-limiting construction shall be in accordance with FM Global Loss Prevention Data Sheet 1-44, *Damage-Limiting Construction* and be acceptable to the Authority Having Jurisdiction.
- 3.2.2 When damage-limiting construction features are required, they shall be designed in accordance with Appendix C. As an alternative, the structure shall be permitted to be designed in accordance with FM Global Property Loss Prevention Data Sheet 1-44, *Damage--Limiting Construction*, Table 4.
- 3.2.2.1 Appendix C was developed by FM Global based on the results of an extensive study of vented deflagrations. The use of this method to determine the required venting area shall be the prerogative of the Authority Having Jurisdiction.
- 3.2.3 Venting panels shall be as evenly distributed and centrally located as practicable. When venting only one end of an elongated enclosure, see Appendix C for special considerations.
- 3.2.4 Damage-limiting construction relief panels shall be of lightweight construction and shall release at a maximum internal pressure between 20-40 psf (0.96 – 1.92 kPa) but above the expected wind pressures (see 3.4). The use of FM Approved damage-limiting construction components such as fasteners and latches shall be required.
- 3.2.4.1 The weight of damage-limiting construction venting panels shall be limited to a maximum weight of 4 lbs/ft<sup>2</sup> (19.6 kg/m<sup>2</sup>).

3.2.5 Buildings that incorporate damage-limiting construction features shall be for outdoor use only.

### 3.3 Fire Ratings

3.3.1 Buildings shall be permitted to be fire rated. If they are fire rated, the rating shall be determined as shown in 3.3.2.

3.3.2 Fire endurance ratings for walls and roofs shall be determined according to ASTM E119; for doors, NFPA 252; for fire dampers, ANSI/UL 555; and fire characteristic ratings for roofs ASTM E108 or other test standards acceptable to FM Approvals. Other test methods with equivalent exposures and performance criteria shall be permitted at the sole discretion of FM Approvals. Prescriptive fire resistant construction specified in building codes acceptable to FM Approvals shall be permitted.

3.3.2.1 When the exterior of the roof is of all metal construction, fire ratings in accordance with ASTM E108 shall not be required.

3.3.2.2 ASTM E-119 is the standard fire test used to qualify walls, floors, beams, columns and other structural members. This test method is based on what is called a cellulosic time-temperature curve. There is another test method, ASTM E1529, that was developed for more severe conditions. It includes a more critical time-temperature curve based on a hydrocarbon type of exposure. When ignitable liquids and gases are intended to be stored in these units, consideration shall be given to basing the fire ratings on the more critical time-temperature curve used in ASTM E1529.

3.3.3 For a building that is designed for damage-limiting construction, the manufacturer shall provide written guidelines on where the building should be located in relation to other buildings on the owner's property.

3.3.4 When a building is fire rated, the label indicating FM Approved shall be prominently marked with the building's fire rating.

3.3.5 Sump walls shall be of non-combustible construction. Extending the interior walls of the building into the sump is prohibited unless the portion of the wall in the sump area is protected by a suitable liner and an exterior sump wall of heavy gauge steel, or by an interior sump wall of heavy gauge steel continuously welded to the sump floor and at the corners.

3.3.6 At the time of this publication of this document, there were no known venting panels that have been successfully fire tested using a nationally recognized fire test method. In such cases, it is necessary to allow non-fire rated panels to be used in fire rated walls – subject to the acceptance of the Authority Having Jurisdiction. Non-fire rated panels in a fire wall are to be treated as an unprotected opening and may compromise the fire rating of any wall that incorporates such panels. This requires the end user to give careful consideration on where such structures are located and how they are oriented on the property. The building needs to be oriented such that the fire walls that do not contain these panels are adjacent to other structures that need to be protected from a fire exposure. Conversely, walls containing the damage-limiting construction panels must be oriented such that if an explosion occurs, the direction of the venting is away from the main building or other occupied areas.

3.3.7 When buildings are fire rated and designed for indoor use, the rating of the fire walls and the roof/ceiling shall not less than one (1) hour.

3.3.8 When buildings are fire rated, the relationship between the rating of the fire walls and the fire rating of the roof/ceiling shall be the prerogative of the Authority Having Jurisdiction.

3.3.9 Openings in fire rated walls shall be permitted to be rated at 75% of the wall in which it is located.

- 3.3.10 At the time this standard is published, there were a limited number of fire rated roof/ceiling assemblies that incorporated lighter weight roof supports that is typical of the relatively short spans found in these products. As a result, fire rated roof-ceiling assemblies shall be permitted to incorporate ceiling membrane ratings in lieu of listed assemblies.
- 3.3.10.1 A ceiling membrane rating is derived from fire tests conducted in accordance with ASTM E119. The ceiling membrane rating represents the time required for the back (unexposed) surface of the gypsum board to reach one of the limiting temperature rise performance criteria as stated in ASTM E119.
- 3.3.10.2 When a ceiling membrane rating is utilized, it shall be so noted on the design drawings submitted by the manufacturer.
- 3.3.10.3 Ceiling membrane ratings do not take into consideration the temperature of the structural steel supports in the ceiling. Consideration as to the acceptability of ceiling membrane ratings is the prerogative of the Authority Having Jurisdiction because fire rated roof/ceiling assemblies are available.

### 3.4 Wind Loads

- 3.4.1 All buildings submitted for Approval shall have a wind load rating.
- 3.4.2 The wind pressure applied to the building shall be referred to as  $P_{inward}$  and  $P_{outward}$ .
- 3.4.2.1 The *Inward Wind Pressure*,  $P_{inward}$ , is a condition created on the windward side of a building. It is caused by wind forces and places forces toward the building. It is referred to by some entities as positive pressure.
- 3.4.2.2 The *Outward Wind Pressure*,  $P_{outward}$ , is a condition created on the leeward side of a building. It is caused by wind forces and places forces away from the building. It is referred to by some entities as negative pressure.
- 3.4.3 Anticipated design conditions at a particular location vary depending on the intensity of the event, the surrounding terrain and elevation. Components on the windward side of a building are subjected to design wind pressures  $P_{inward}$  which increase as the elevation of the building increases. Pressures on the leeward side  $P_{outward}$  of a building are greater than the wind pressure normally found on the windward face of the building at the same elevation but act in the opposite direction.
- 3.4.4 The wind load rating shall be expressed as a pair of inward and outward acting pressures ( $P_{inward}$  and  $P_{outward}$ ). The minimum inward acting design pressure,  $P_{inward}$  shall be 15 lbs/ft<sup>2</sup> (0.7 kPa). The minimum outward acting design pressure,  $P_{outward}$  shall be 1.4 times  $P_{inward}$ . The ratings shall be given in increments of 5 lbs/ft<sup>2</sup> (0.25 kPa) based on the inward pressure.
- 3.4.5 Figure 1 shows a typical building and the two zones of greatest interest. These are shown as Zones 4 and 5.
- 3.4.5.1 The design pressure  $P_{inward}$  shall be applied to the full height and width of wall areas shown as Zone 4 in Figure 1. The design pressure  $P_{outward}$  shall be applied to the full height and width of the wall areas shown as Zone 5 in Figure 1. The width of Zone 5 shall be defined by the distance 'a' shown in Figure 1. This distance shall be taken as 0.4 h.
- 3.4.6 As an alternative, the building may be designed using the Zone 5  $P_{outward}$  applied to the entire building. In such cases, the design pressure shall be shown as  $\pm P$  where  $P = P_{inward} \times 1.4$  and  $P_{inward}$  is a minimum of 15 lbs/ft<sup>2</sup> (0.7 kPa) increasing in increments of 5 lbs/ft<sup>2</sup> (0.25 kPa).

- 3.4.6.1 For example, if  $P^{inward} = 20 \text{ lbs/ft}^2$  (0.9 kPa), the minimum design pressures and rating shall be  $+20 \text{ lbs/ft}^2$  /  $-28 \text{ lbs/ft}^2$  ( $+0.9 \text{ kPa}$  /  $-1.3 \text{ kPa}$ ). Alternatively, the building shall be permitted to be designed and rated at  $\pm 28 \text{ lbs/ft}^2$  /  $\pm 1.3 \text{ kPa}$ .
- 3.4.7 If the building needs to be anchored to resist overturning caused by the design wind pressures, the manufacturer shall supply sufficient information to the end user so that proper footings or a foundation can be designed.
- 3.4.8 Refer to the wind maps in FM Global Property Loss Prevention Data Sheet 1-28, *Wind Design* for guidance in determining the design wind pressures needed for a specific location.

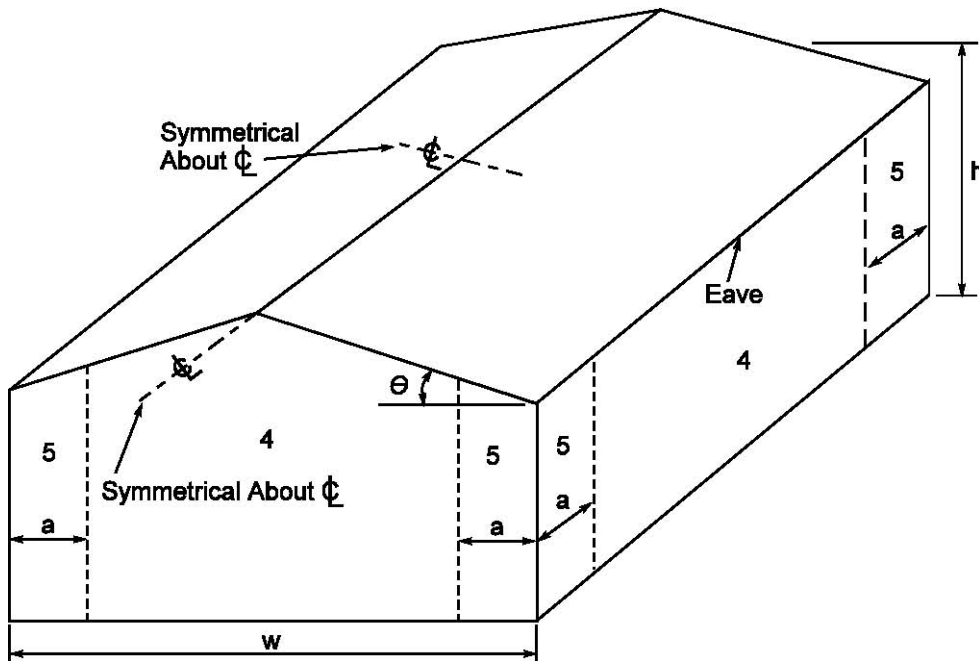


Figure 1. Building Wind Zones

**3.5 Ignitable Liquid Storage Buildings**

- 3.5.1 When designed for outdoor use only, the structure shall incorporate a leak-tight sump capable of containing at least 25 percent of the rated liquid storage capacity of the structure, 100% of the largest individual container or as mandated by any local codes or Authorities Having Jurisdiction, whichever is greater.
- 3.5.2 When designed for indoor usage, the structure shall:
  - a) be fire rated in accordance with Paragraph 3.3.7.
  - b) contain a leak-tight sump capable of containing at least 25 percent of the liquid storage capacity or at least 100% of the largest individual container, whichever is greater.
  - c) be designed to accommodate personnel to enter the structure.
  - d) be provided with or designed to accommodate an automatic sprinkler system. Other fire protection systems shall be permitted to supplement the sprinkler system.

- e) be designed such that containers can be placed at least ½ the storage height away from the door opening.
- f) be provided with drainage connections to accommodate sprinkler discharge.

3.5.3 Flooring above the sump shall utilize non-combustible grating.

### **3.6 Flammable Gas, Non-Flammable Gas and General Storage Buildings**

3.6.1 When designed for the storage of gases that are lighter than air, heavier than air or lighter and heavier than air, vent(s) shall be provided. The location and amount of ventilation needed shall be as mandated by local codes or the Authorities Having Jurisdiction.

3.6.2 Structures shall be equipped with strapping or framing members such that cylinders can be secured upright and in place to prevent falling by using chains, straps, stands or carts. Such strapping or framing system is allowed to be on skids or wheels incorporating a locking mechanism to prevent unwanted movement.

3.6.3 Sumps shall be permitted but are not required to be provided.

3.6.4 Sumps shall not be allowed when the structure has been designed for gases that are heavier than air.

3.6.5 Floor surfaces shall be permitted to have a solid surface.

3.6.6 When designed for general use, buildings shall be permitted to be designed without a floor. In such cases, the structure shall be installed and anchored to a suitable concrete pad.

### **3.7 Markings**

3.7.1 Buildings shall, as a minimum, be labeled with the manufacturer's name, address, model number, what the structure is designed to store (example – ignitable liquids or flammable gases) and the maximum liquid storage capacity, when applicable. Buildings of fire rated construction shall be labeled with the fire rating as defined in Section 3.3. The roof live (snow) load and design wind pressures shall also be shown. Additional labels required for material classification shall be as required by the Authority Having Jurisdiction.

3.7.1.1 When buildings are designed for general storage, the label shall indicate that it is not intended for the storage of ignitable liquids, flammable gases or non-flammable gases.

3.7.2 All FM Approved buildings shall be labeled with an Approval Mark (see Appendix B). This may be accomplished by a separate label or incorporated onto the label defined in Section 3.7.1.

3.7.3 Buildings that have been designed to include provisions for damage-limiting construction shall indicate 'Damage-Limiting Construction designed in accordance with FM Approval Standard 6049, Appendix C, Table C-'X' where 'X' is either 1 or 2. As an alternate, when so used, the label shall indicate that it has been designed in accordance with FM Global Loss Prevention Data Sheet 1-44, Table 'X' where 'X' is either 2, 3, or 4 as appropriate.

3.7.4 The building marking shall identify the hazardous location rating (Class, Division, Group or Zone and Temperature Class in accordance with Article 500 or 505 of the National Electrical Code) of the electrical equipment installed either inside the building or on the exterior of the building. For example – Internal electrical equipment is suitable for Class I, Division 1, Groups C and D, T4 or External electrical equipment is suitable for Class I, Division 2, Groups C and D, T4.

- 3.7.5 The labels for structures designed for indoor use only shall contain the words “FOR INDOOR USE ONLY”.-The labels for structures designed for both indoor and outdoor usage shall contain the words “FOR INDOOR OR OUTDOOR USE”.

### **3.8 Manufacturer’s Installation and Operation Requirements**

- 3.8.1 The manufacturer shall provide instructions pertaining to building location, building site preparation, and building relocation.
- 3.8.2 The manufacturer shall provide maintenance/repair instructions for the building and ancillary equipment such as lighting, ventilation systems, and fire suppression systems.

## **4 PERFORMANCE REQUIREMENTS**

### **4.1 Structural Analysis**

#### 4.1.1 Requirement

- A. A structural analysis shall be submitted in order to determine whether the structure’s design complies with the requirements of this Standard. The examination and review shall include verification of calculations, and that valid formulas for stress and strain have been used. In general, formulas may be excerpted from Roark, *Formulas for Stress and Strain*, AISC Manual of Steel Construction, or AISI Specifications for the Design of Cold Formed Steel Structural Members.
- B. Inward and outward wind pressures shall be determined in accordance with FM Global Loss Prevention Data Sheet 1-28, Wind Design.

#### 4.1.2 Test/Verification

- A. Stresses imposed upon the building structural components due to dead and live loads applied to the structure shall not exceed those allowed using standard design formulas with no increase in allowable design pressures.
- B. Stresses imposed upon the building structural components due to wind loads applied to the structure shall be allowed to be increased 33% provided that they satisfy 4.1.2.A for normal dead and live load conditions.
- C. When determining loads and stresses resulting from the live (snow) load, the full live load shall be applied uniformly over the entire roof.
- D. When determining overturning moments for potential wind uplift or resistance to sliding, the building shall be assumed to be empty with no live (snow) load applied.
- E. Stresses imposed by internal pressures shall not exceed 2/3 of the ultimate strength of the material.

### **4.2 Damage-Limiting Construction Panels**

#### 4.2.1 Requirement

Buildings designed for damage-limiting construction shall meet the following requirements:

- A. The panels shall be constructed of light weight material in order to minimize panel inertia in the event of an explosion. The maximum panel weight shall be 4.0 lbs/ft<sup>2</sup> (19.5 kg/m<sup>2</sup>).
- B. The methodology for determining the amount of vent area needed and the minimum internal design pressures for a particular building shall be determined in accordance with Appendix C. As an alternative, the vent area shall be permitted to be designed in accordance with FM Global Property Loss Prevention Data Sheet 1-44, Damage-Limiting Construction.

#### 4.2.2 Test/Verification

- A. Verification of panel release force is not required if FM Approved fasteners, latches, or panels are used.
- B. Panel release force shall be verified if Approved fasteners, latches, or panels are not used. Release force shall be determined on at least 6 samples. Panels shall be tested under “as installed” conditions. Maximum measured release force shall comply with the criteria noted in Paragraph 4.2.1 above.
- C. The vented area, the enclosed surface area, vent release pressure and design pressure for resistant walls shall be verified in accordance with Appendix C of this Standard.
- D. The release pressure of the panels shall be such that they can resist the anticipated wind loads.

### 4.3 Sump

#### 4.3.1 Requirement

Buildings designed for the storage of ignitable liquids shall be provided with a sump. The sump shall be constructed of heavy gauge steel with continuously welded leak-tight seams. The interior of the sump shall be coated with a corrosion-resistant material. A non-metallic liner may be provided as an option. For fire rated designs, heavy gauge steel sheet with continuously welded, leak tight seams shall be installed after the installation of the interior portion of the fire rated exterior wall system. Buildings designed for the storage of flammable gases, non-flammable gases and general storage shall be permitted to be provided without a sump.

#### 4.3.2 Test/Verification

- A. When designed for outdoor use, the sump capacity shall be verified by calculation as being capable of containing at least 25 percent of the specified maximum liquid storage capacity of the building or the largest individual container, whichever is greater.
- B. When designed for indoor use, the sump shall be cable of containing 25% of the specified maximum liquid storage or 100% of the largest container, whichever is greater. Such sumps shall also be provided with drainage connections in accordance with FM Global Loss Prevention Data Sheet 7-83, Drainage and Containment Systems for Ignitable Liquids.

### 4.4 Fire Protection Systems

#### 4.4.1 Requirements

- A. Sprinkler systems, if provided, shall conform to NFPA 13 standards, FM Global Loss Prevention Data Sheets and sprinkler manufacturer’s recommendations for sprinkler quantity, orifice size, type and location. Sprinklers shall be FM Approved.
- B. Special protection systems, if offered, shall conform to the appropriate NFPA Standard, FM Global Loss Prevention Data Sheet and/or system manufacturer’s requirements for detection, nozzle size, nozzle quantity and nozzle location. The systems shall be FM Approved.
- C. Sprinkler/nozzle location in relation to indoor lighting fixture location shall be reviewed. The relationship, in both plan and elevation, shall be such as to preclude or minimize interference with the distribution patterns of sprinklers or nozzles.
- D. Ignitable liquid storage buildings Approved for indoor use shall be provided with a fire protection system. Dry chemical or gaseous systems shall not be permitted.
- E. Ignitable liquid storage buildings Approved for outdoor use shall be permitted to be provided with dry chemical or gaseous systems; however, dry chemical systems shall not be used when sprinklers have been provided.
- F. The specific design and adequacy of a fire protection system is not covered by this Approval Standard, but shall be designed in accordance with the appropriate NFPA Standard and/or the appropriate FM Global Loss Prevention Data Sheet and the fire protection system manufacturer’s recommendations.



#### 4.4.2 Test/Verification

The fire protection system design, if provided, shall be reviewed to verify conformance with 4.4.1. As an alternative, the building manufacturer's design drawings shall be permitted to contain a note stating that the fire protection system shall be designed in accordance with the appropriate NFPA Standard, FM Global Loss Prevention Data Sheets and/or the fire protection system manufacturer's recommendations.

### 4.5 Fire Rated Walls and Roofs

#### 4.5.1 Requirements

Materials and method of construction for all fire rated walls, roofs and other components shall be as illustrated in the FM Approvals Specification Tested Products Guide under the heading ASTM E 119 Standard, or the equivalent thereof. In addition, gypsum board surfaces shall be covered by light gauge sheet metal panels and flashing coated with a corrosion-resistant material. The seams shall be caulked prior to applying the corrosion resistance material.

#### 4.5.2 Test/Verification

All fire rated walls, roofs and other components shall be reviewed to verify that they have been qualified by an appropriate test method or are designed in accordance with a listing agency acceptable to FM Approvals. No change in component size, type or materials of construction shall be allowed unless reviewed and authorized in writing from FM Approvals.

## 5 OPERATIONS REQUIREMENTS

### 5.1 Demonstrated Quality Control Program

5.1.1 A Quality Control Program is required to assure that each subsequent storage building produced by the manufacturer shall present the same quality and reliability as the specific samples examined. Design quality, conformance to design, and performance are the areas of primary concern.

- Design quality is determined during the examination and tests and is documented in the Approval Report.
- Continued conformance to this Standard is verified by the Surveillance Audit.
- Quality of conformance is determined by field performance and by periodic re-examination and testing.

5.1.2 The manufacturer shall demonstrate a quality assurance program which specifies controls for at least the following areas:

- existence of corporate quality assurance guidelines;
- incoming assurance, including testing ;
- in-process assurance, including testing;
- final inspection and tests;
- equipment calibration;
- drawing and change control;
- packaging and shipping; and
- handling and disposition of non-conforming discrepant materials.

#### 5.1.3 Records

To assure adequate traceability of materials and products, the manufacturer shall maintain a record of all quality assurance tests performed, for a minimum period of two years from the date of manufacture.

#### 5.1.4 Drawing and Change Control

- The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents, identified in the Approval Report, must be reported to, and authorized by, FM Approvals prior to implementation for production.
- The manufacturer shall assign an appropriate person or group to be responsible for, and require that, proposed changes to FM Approved or Listed products be reported to FM Approvals before implementation. The manufacturer shall notify FM Approvals of changes in the product or of persons responsible for keeping FM Approvals advised by means of FM Approvals' Form 797, FM Approved Product/ Specification-Tested Revision Report or Address/Main Contact Change Report.
- Records of all revisions to all FM Approved products shall be maintained.

### 5.2 Surveillance Audit

- 5.2.1 An audit of the manufacturing facility is part of the Approval investigation to verify implementation of the quality assurance program. Its purpose is to determine that the manufacturer's equipment, procedures, and quality program are maintained to insure a uniform product consistent with that was tested and FM Approved.
- 5.2.2 These audits shall be conducted periodically but at least annually by FM Approvals or its representatives.
- 5.2.3 FM Approved products or services shall be produced or provided at or from the location(s) audited by FM Approvals and as specified in the Approval Report. Manufacture of products bearing the Approval Mark is not permitted at any other location without prior written authorization by FM Approvals.

### 5.3 Installation Inspections

Field inspections may be conducted to review an installation. The inspections are conducted to assess ease of application, and conformance to written specifications. When more than one application technique is used, one or all may be inspected at the discretion of FM Approvals.

### 5.4 Manufacturer's Responsibilities

The manufacturer shall notify FM Approvals of changes in product construction, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation.

**APPENDIX A Units of Measurement**

|              |  |
|--------------|--|
| LENGTH:      | in. - "inches"; (mm - "millimeters")<br>$\text{mm} = \text{in.} \times 25.4$<br><br>ft - "feet"; (m - "meters")<br>$\text{m} = \text{ft} \times 0.3048$  |
| AREA:        | $\text{in}^2$ - "square inches"; ( $\text{mm}^2$ - "square millimeters")<br>$\text{mm}^2 = \text{in}^2 \times 6.4516 \times 10^2$<br><br>$\text{ft}^2$ - "square feet"; ( $\text{m}^2$ - "square meters")<br>$\text{m}^2 = \text{ft}^2 \times 0.0929$  |
| MASS:        | lb - "pounds"; (kg - "kilograms")<br>$\text{kg} = \text{lb} \times 0.454$  |
| PRESSURE:    | psi - "pounds per square inch"; (bar - "bar")<br>$\text{kPa} = \text{psi} \times 6.895$<br><br>psf - "pounds per square foot"; ( $\text{kg}/\text{m}^2$ - kilogram per square meter)<br>$\text{kg}/\text{m}^2 = \text{psf} \times 4.88$<br><br>bar - "bar"; (kPa - "kilopascals")<br>$\text{bar} = \text{kPa} \times 0.01$<br>$\text{bar} = \text{psi} \times 0.06895$ |
| TEMPERATURE: | $^{\circ}\text{F}$ - "degrees Fahrenheit"; ( $^{\circ}\text{C}$ - "degrees Celsius")<br>$^{\circ}\text{C} = (\text{F} - 32) \times 0.556$  |

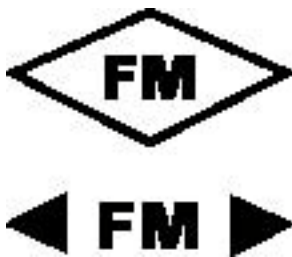
## APPENDIX B FM Approvals Certification Marks

FM Approvals certifications marks are to be used only in conjunction with products or services that have been Approved by FM Approvals and in adherence with usage guidelines.



### FM APPROVED mark:

Authorized by FM Approvals as a certification mark for any product that has been FM Approved. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.



### Cast-On FM Approvals marks:

Where reproduction of the FM Approved mark described above is impossible because of production restrictions, use these modified versions of the FM Approved mark. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable.



### FM Approved Mark with “C” only:

Authorized by FM Approvals as a certification mark for any product that has been evaluated by FM Approvals in accordance with Canadian codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.



### FM Approved mark with “C” and “US”:

Authorized by FM Approvals as a certification mark for any product that has been evaluated by FM Approvals in accordance with US and Canadian codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.

## FM Approvals Certification Marks

All FM Approvals certification marks are the sole property of FM Approvals LLC (“FM Approvals”) and are registered or the subject of applications for registration in the United States and many other countries. They are for use only according to these guidelines.

FM Approvals certification marks may be used only on FM Approved products and related product packaging, in advertising material, catalogs and news releases. Use of FM Approvals certification marks on such material is not a substitute for use of the complete FM Approvals certification mark on FM Approved products and/or product packaging.

No FM Approvals certification mark or aspect thereof may be incorporated as part of a business name, Internet domain name, or brand name/trademark for products/product lines. This includes both design aspects (the FM Approvals “diamond,” etc.) and word aspects (“FM,” “Approved,” etc.). The use of any FM Approvals certification mark as a trademark is strictly prohibited.

The Approval Standard number or class number may not be incorporated as part of a business name, Internet domain name, or brand name/trademark for products/product lines. For example, a company may not say “ABC Company’s 4100 Fire Door is FM Approved”; the proper terminology is, “ABC Company’s Fire Door is FM Approved per Approval Standard 4100.”

FM Approvals certification marks, except for the FM Approvals Quality System Registration mark, may not be used on business stationery/cards/signage because this could mischaracterize the relationship with FM Approvals. Additionally, these items should not reference any FM Approvals certification mark.

Products or services may not be marketed under any mark or name similar to “FM Global,” “FM Approvals” or any of the FM Approvals certification marks. Further, products or services may not be marketed to imply a relationship beyond the scope of any Approval made by FM Approvals.

When an FM Approvals certification mark is used in advertising material or on product packaging, all material must reflect the specific circumstances under which the product was FM Approved. The material must clearly differentiate between products that are FM Approved and those that are not, and may not, in any way, imply a more substantial relationship with FM Approvals.

A company may not reference the intent to submit a product for Approval or the expectation that a company will have a certain product FM Approved in the future. For example, a company may not state, “Approval by FM Approvals pending” or “Approval by FM Approvals applied for.”

FM Approvals certification marks should not be preceded or followed by a qualifier that indicates a degree of certification or acceptability. For example, “exceeds,” “first” or “only” may not be used to qualify any FM Approvals certification mark.

Only original artwork issued by FM Approvals should be used. The FM Approvals certification marks should not be altered in any way other than to resize the artwork proportionately. Unacceptable uses of the marks include, but are not limited to, adding/deleting wording or artwork, reducing the artwork to an illegible size, animation or distortion.

The text of the FM Approvals certification marks may not be translated into any language other than English.

FM Approvals certification marks must appear in a size and location that is readily identifiable, but less prominent than the name of the owner of the certification or the manufacturer/seller/distributor of the certified products.

## APPENDIX C Damage-Limiting Construction Venting Areas and Pressures

### C-1 Introduction

- C-1.1 This Appendix is intended to provide guidance to manufacturers in determining the area of damage-limiting construction venting panels that are required as well as the panel release and wall resistant pressures. This Appendix is based on FM Global Loss Prevention Data Sheet 1-44, *Damage-Limiting Construction*, as well as extensive research and an engineering analysis.
- C-1.2 FM Global Loss Prevention Data Sheet 1-44 provides guidance on designing damage-limiting construction for buildings that have been identified as having a deflagration hazard. A deflagration in a building that is not specifically designed for this hazard will experience extensive damage to or destruction of a building, its framing or equipment. By incorporating construction features that will relieve pressure or resist pressure resulting from such an event, the overpressures can be dissipated and dispersed in a controlled manner without jeopardizing the structural integrity of the building. While some damage is expected, this also helps reduce the extent of the damage by confining the damage to exterior panels or similar low cost components that can be quickly replaced. It also keeps the damaging effects from propagating to adjacent interior spaces.
- C-1.3 Additional research has shown that certain types of small buildings, such as metal framed construction typically found in storage buildings that house ignitable liquids or flammable gases, can withstand pressures much greater than the tables currently used in FM Global Loss Prevention Data Sheet 1-44. In addition, these metal buildings are usually free standing structures placed away from the main building.
- C-1.4 By incorporating damage-limiting construction, repairs and clean-up efforts to the main structure are minimized and use of the building can usually be restored in a timely and cost effective manner. This is not the case with detached metal storage buildings. Metal storage buildings are relatively low cost structures. If a deflagration were to occur, it would be more cost effective to replace the entire structure rather than attempt to repair or reclaim the structure. As a result, the focus of the damage-limiting construction for this type of structure can be confined to preventing flying objects from causing injury or harm to people, buildings and other items of value that may be located in or near the vicinity where the blast occurs.
- C-1.5 Since the intent is not to reclaim use of the building, an allowance can be made for a limited amount of damage, such as deformation of the walls and ceiling, provided that the deformation does not exceed that which will result in the formation of debris flying through the air. Based on this and an engineering evaluation of the existing data, it was concluded that the range of venting pressures shown in Tables 3 and 4 of FM Global Loss Prevention Data Sheet 1-44 can be safely extended up to pressure levels of 454 lbs/ft<sup>2</sup> (21.8 kPa) and 539 lbs/ft<sup>2</sup> (25.9 kPa) respectively. This assumes that the scaling of the reduced pressure is inversely proportional to the vent size for any given enclosure.

## C-2 Nomenclature

The following terminology will be used in this Appendix:

|       |  |
|-------|--|
| $A_E$ | the cross-sectional area of the elongated enclosure, ft <sup>2</sup> (m <sup>2</sup> ) |
| $A_S$ | the enclosure surface area, ft <sup>2</sup> (m <sup>2</sup> )                          |
| $A_V$ | the vent area, ft <sup>2</sup> (m <sup>2</sup> )                                       |
| H     | the height of the building, ft (m)   |
| L     | the length of the building, ft (m)   |
| $L_3$ | the largest dimension of the building, ft (m)  |
| P     | the perimeter of the elongated cross-section ft (m)                                    |
| $P_r$ | the design pressure for resistant walls, lbs/ft <sup>2</sup> (kPa)                     |
| $P_v$ | the vent release pressure, lbs/ft <sup>2</sup> (kPa)                                   |
| W     | the width of the building, ft (m)  |

## C-3 Determining Explosion Venting Areas and Pressures

C-3.1 When designing for damage-limiting construction, Tables C-1 and C-2 of this Appendix shall be used to determine the minimum design pressure for the pressure resistant walls which is based on the ratio of enclosure surface area to vent area. The design shall meet the following criteria:

- The ratio of  $A_S/A_V \leq 35$  (Table C-1) or  $A_S/A_V \leq 19$  (Table C-2)
- The minimum  $P_r = P_v + 50 \text{ lbs/ft}^2$  (2.4 kPa)

C-3.2  $A_S$  shall be taken as  $2 \times [(L \times W) + (L \times H) + (W \times H)]$ . When surfaces are curved or sloped, the actual surface area can be used instead of the projected surface area.

C-3.3 The static venting pressure shall be a minimum of 20 lbs/ft<sup>2</sup> (0.96 kPa) and a maximum of 40 lbs/ft<sup>2</sup> (1.92 kPa).

C-3.4 Pressure relieving panels should be designed to release at the lowest possible pressure that will provide adequate wind resistance.

C-3.5 The tables in FM Global Loss Prevention Data Sheet 1-44 are established based on the various types of fuel that is creating the deflagration hazard.

C-3.5.1 Table C-1 of this Appendix is designed to be used with the majority of fuels that are likely to be encountered. The specific fuels that are to be used with Table C-1 of this Appendix are shown in FM Global Loss Prevention Data Sheet 1-44, Table 1 (use this table for the liquids shown in the list for Tables 2 and 3).

C-3.5.2 Table C-2 of this Appendix is designed to be used with more volatile liquids and more reactive gases. The specific materials that are to be used with Table C-2 of this Appendix are shown in FM Global Loss Prevention Data Sheet 1-44, Table 1 (use this table for the liquids shown in the list for Table 4).

$P_r$  in lbs/ft<sup>2</sup>

| $P_v$<br>psf | $A_s/A_v$ |    |    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|--------------|-----------|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|              | 3*        | 5  | 7  | 9   | 11  | 13  | 15  | 17  | 19  | 21  | 23  | 25  | 27  | 29  | 31  | 33  | 35  |
| 20*          | 70        | 80 | 93 | 106 | 119 | 131 | 145 | 158 | 170 | 183 | 196 | 232 | 270 | 312 | 356 | 403 | 454 |
| 25           | 75        | 80 | 93 | 106 | 119 | 131 | 145 | 158 | 170 | 183 | 196 | 232 | 270 | 312 | 356 | 403 | 454 |
| 30           | 80        | 80 | 93 | 106 | 119 | 131 | 145 | 158 | 170 | 183 | 196 | 232 | 270 | 312 | 356 | 403 | 454 |
| 35           | 85        | 85 | 93 | 106 | 119 | 131 | 145 | 158 | 170 | 183 | 196 | 232 | 270 | 312 | 356 | 403 | 454 |
| 40           | 90        | 90 | 93 | 106 | 119 | 131 | 145 | 158 | 170 | 183 | 196 | 232 | 270 | 312 | 356 | 403 | 454 |

Table C-1

\*Or less

Linear interpolation is acceptable.

No extrapolation beyond table limits should be made.

Min  $P_r = P_v + 50$  psf

$P_r$  in lbs/ft<sup>2</sup>

| $P_v$<br>psf | $A_s/A_v$ |    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|--------------|-----------|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|              | 3*        | 4  | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  |
| 20*          | 70        | 84 | 100 | 117 | 134 | 150 | 166 | 181 | 199 | 215 | 252 | 293 | 336 | 382 | 431 | 484 | 539 |
| 25           | 75        | 84 | 100 | 117 | 134 | 150 | 166 | 181 | 199 | 215 | 252 | 293 | 336 | 382 | 431 | 484 | 539 |
| 30           | 80        | 84 | 100 | 117 | 134 | 150 | 166 | 181 | 199 | 215 | 252 | 293 | 336 | 382 | 431 | 484 | 539 |
| 35           | 85        | 85 | 100 | 117 | 134 | 150 | 166 | 181 | 199 | 215 | 252 | 293 | 336 | 382 | 431 | 484 | 539 |
| 40           | 90        | 90 | 100 | 117 | 134 | 150 | 166 | 181 | 199 | 215 | 252 | 293 | 336 | 382 | 431 | 484 | 539 |

Table C-2

\*Or less

Linear interpolation is acceptable.

No extrapolation beyond table limits should be made.

Min  $P_r = P_v + 50$  psf

**C-4 Special Design Considerations**

C-4.1 Vent panels shall be as evenly distributed and centrally located as possible,

C-4.1.1 Venting only one end of an elongated enclosure shall be permitted when the following criteria is met:

$$L_3 \leq 12A_e/P$$

C-4.2 The weight of pressure relieving panels should be kept to a minimum and should not exceed 4 lbs/ft<sup>2</sup> (19.5 kg/m<sup>2</sup>).

C-4.3 Damage-limiting construction relief panels shall not be placed in the roof for locations that are subject to snow accumulation.



- C-4.4 Venting panels shall be tethered or hinged, connected at the top or bottom only and shall not be connected along more than one edge.
- C-4.5 Doors located within venting walls shall be arranged to open outward but their area shall not be considered as part of the design vent area. They are not required to be pressure resistant.
- C-4.6 When FM Approved venting fasteners and latches are used, no additional testing of the panels shall be required.
- C-4.7 In lieu of the tables shown in this Appendix, the required vent area shall be permitted to be designed in accordance with FM Global Loss Prevention Data Sheet 1-44.

### C-5 Design Examples

- C-5.1 A building is 20 ft long  $\times$  12 ft wide  $\times$  10 ft high and needs to be designed for damage-limiting construction. Assume that the pressure resistant walls are designed to 110 lbs/ft<sup>2</sup>. The building is to be designed in accordance with Table C-1. How much venting area is needed?

- A) Determine  $A_E$        $A_E = 12 \text{ ft} \times 10 \text{ ft} = 120 \text{ ft}^2$   
 B) Determine P       $P = 2 \times (12 \text{ ft} + 10 \text{ ft}) = 44 \text{ ft}$   
 C) Check  $12A_E/P$        $12A_E/P = (12 \times 120 \text{ ft}^2)/44 \text{ ft} = 32.7 \text{ ft}$   
 D) Check  $L_3$        $L_3 = 20 \text{ ft} < 32.7 \text{ ft}$  therefore venting at only one end is allowed  
 E) Determine  $A_S$        $A_S = 2 \times [(20 \text{ ft} \times 12 \text{ ft}) + (20 \text{ ft} \times 10 \text{ ft}) + (10 \text{ ft} \times 12 \text{ ft})] = 1120 \text{ ft}^2$

- C-5.1.1 Based on Table C-1, the maximum  $A_S/A_V$  ratio for walls with a resistive pressure of 110 lbs/ft<sup>2</sup> is 9. (interpolation could have been used).

- C-5.1.2 The minimum venting area needed for walls with a resistive pressure of 110 lbs/ft<sup>2</sup> is  $A_S/9 = 1120 \text{ ft}^2/9 = 125 \text{ ft}^2$ .

- C-5.2 Assume the same building in C-5.1 above except that the height is 16 ft and that the pressure resistant walls are designed for a 270 lbs/ft<sup>2</sup>. How much vented area is needed?

- A) Determine  $A_E$        $A_E = 12 \text{ ft} \times 16 \text{ ft} = 192 \text{ ft}^2$   
 B) Determine P       $P = 2 \times (12 \text{ ft} + 16 \text{ ft}) = 56 \text{ ft}$   
 C) Check  $12A_E/P$        $12A_E/P = (12 \times 192 \text{ ft}^2)/56 \text{ ft} = 41.1 \text{ ft}$   
 D) Check  $L_3$        $L_3 = 20 \text{ ft} < 41.1 \text{ ft}$  therefore venting at only one end is allowed  
 E) Determine  $A_S$        $A_S = 2 \times [(20 \text{ ft} \times 12 \text{ ft}) + (20 \text{ ft} \times 16 \text{ ft}) + (16 \text{ ft} \times 12 \text{ ft})] = 1504 \text{ ft}^2$

- C-5.2.1 Based on Table C-1, the maximum  $A_S/A_V$  ratio for walls with a resistive pressure of 270 lbs/ft<sup>2</sup> is 27.

- C-5.2.2 The minimum venting area needed for walls with a resistive pressure of 270 lbs/ft<sup>2</sup> is  $A_S/27 = 1504 \text{ ft}^2/27 = 56 \text{ ft}^2$ .

C-5.3 Assume the same building in C-5.1 above except that the walls have been designed to resist a pressure of 400 lbs/ft<sup>2</sup>. How much vented area is needed?

- |                    |   |
|--------------------|---|
| A) Determine $A_e$ | $A_e = 12 \text{ ft} \times 10 \text{ ft} = 120 \text{ ft}^2$   |
| B) Determine P     | $P = 2 \times (12 \text{ ft} + 10 \text{ ft}) = 44 \text{ ft}$  |
| C) Check $12AE/P$  | $12AE/P = (12 \times 120 \text{ ft}^2) / 44 \text{ ft} = 32.7 \text{ ft}$   |
| D) Check $L_3$     | $L_3 = 20 \text{ ft} < 32.7 \text{ ft}$ therefore venting at only one end is allowed  |
| E) Determine $A_s$ | $A_s = 2 \times [(20 \text{ ft} \times 12 \text{ ft}) + (20 \text{ ft} \times 10 \text{ ft}) + (10 \text{ ft} \times 12 \text{ ft})] = 1120 \text{ ft}^2$ |

C-5.3.1 Based on Table C-1 the maximum  $A_s/A_v$  ratio for walls with a resistive pressure of 400 lbs/ft<sup>2</sup> is 33

C-5.3.2 The minimum venting area needed for walls with a resistive pressure of 400 lbs/ft<sup>2</sup> is  $A_s/33 = 1120 \text{ ft}^2/33 = 34 \text{ ft}^2$ .

C-5.4 Comparing the vent area needed for the examples shown in Paragraph C-5.1 and Paragraph C-5.3, increasing the pressure resistant wall strength from 110 lbs/ft<sup>2</sup> to 400 lbs/ft<sup>2</sup> reduces the required venting area from 125 ft<sup>2</sup> to 34 ft<sup>2</sup>.