Code Loading Requirements For Rooftop Pipe Systems and Supports

Learning Objectives

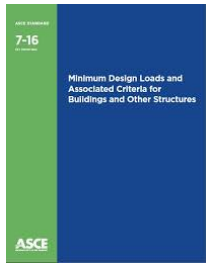
During this session, participants will learn:

- Learning Objective #1:
  - Building Code Purpose
- Learning Objective #2:
  - Code Adoption and Enforcement
- Learning Objective #3:
  - Applicable Loading to Consider on Ammonia Piping Systems
  - How the loading is applied

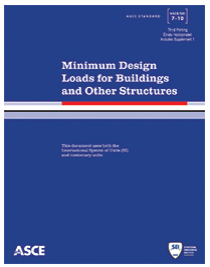
Building Code Purpose and History

OSHA® Occupational Safety and Health Administration
Employee Safety

2018 IBC



ASCE 7-16



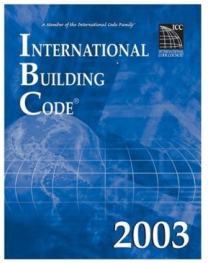
2015 & 2012 IBC

ASCE 7-10

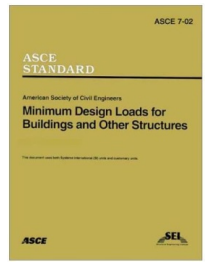
ICC INTERNATIONAL CODE COUNCIL

2009 & 2006 IBC

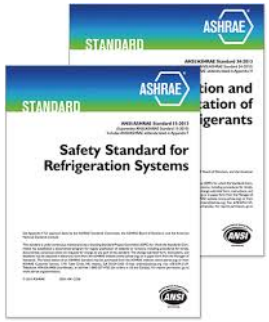
ASCE 7-05



2003 IBC



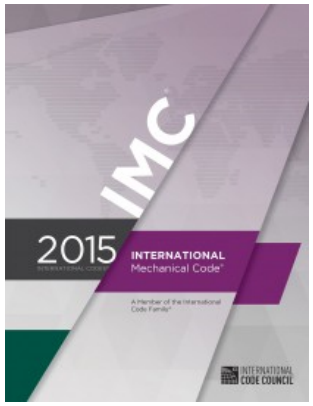
ASCE 7-02



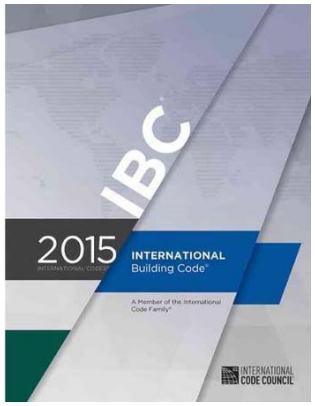
Industry Standards

What are Building Codes?

- Regulations governing the design, construction, alteration and maintenance of structures and systems.
- Minimum requirements to safeguard the health, safety and welfare of building occupants.



2015 IMC



2015 IBC

ASCE 7-10

Purpose of Building Codes

"The purpose of this code is to establish **minimum** standards to provide a **reasonable** level of safety, health, property protection and public welfare by regulating and controlling the design, construction, installation, quality of materials, location, operation and maintenance or use of mechanical systems." *2015 International Mechanical Code, Section [A] 101.3 Intent.*

"The purpose of this code is to establish the **minimum** requirements to provide a **reasonable** level of safety, public health and general welfare through structural strength, means of egress facilities, stability, sanitation, adequate light and ventilation, energy conservation, and safety to live and property from fire and other hazards attributed to the built environment and to provide a **reasonable** level of safety to fire fighters and emergency responders during emergency operations." *2015 International Building Code, Section [A] 101.3 Intent.*

Why are Codes Important?

- Building Codes:
  - Save lives
  - Improve disaster resilience
  - Enhance building stock
  - Reduce insurance premiums
- "Minimum" Codes are for life safety protection not loss prevention
- Everyone benefits when money is saved and losses are avoided.

History of U.S. Building Codes

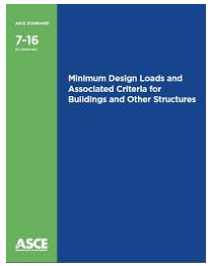
- Building Codes evolved over time largely in reaction to disasters and perceived threats (natural & man-made) to lives and property
- Earliest building regulations addressed problems associated with dense urban construction (improved substandard housing and control rapid spread of fire)
- Building regulation in the U.S. date to the 17th century
  - Boston, Massachusetts (1872), Fire – wooden chimneys and thatched roofs outlawed.
- Three model building code organizations formed between 1915 and 1940
- Each of these Building Codes was adopted largely in separate regions of the United States:
  - Building Officials and Code Administration (BOCA) – National Building Code
  - International Congress of Building Officials (ICBO) – Uniform Building Code
  - Southern Building Code Congress International (SBCCI) – Standard Building Code

- BOCA, ICBO and SBCCI formed the International Code Council (ICC) in 1994
  - Developed one set of uniform standards to be applied throughout the United States
  - Referred to as the I-Codes
  - IBC-2000 was the first Building Code from the International Code Council
  - Most current I-Codes are the 2015 Editions
- ICC International Codes have a 3-year update cycle
  - Updates are a result of research and experience
  - Changes go through democratic consensus process
- Open process that allows code change proposal submittals from any individual
- Balloting of proposed code changes is done by ICC members.
- Code Development, The Internationals Code Council (ICC) develops codes in collaboration with:
  - Federal Emergency Management Agency (FEMA)
  - Other Federal, state, local and private authorities
  - Professional organizations

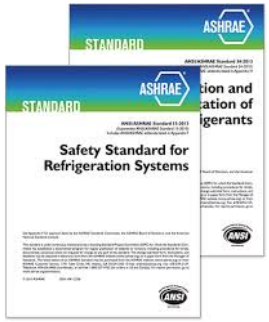
Code Adoption and Enforcement

OSHA® Occupational Safety and Health Administration
Employee Safety

2018 IBC

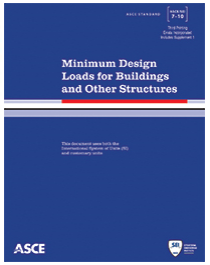


ASCE 7-16



Industry Standards

2015 & 2012 IBC

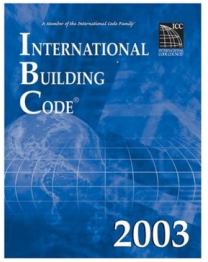


ASCE 7-10

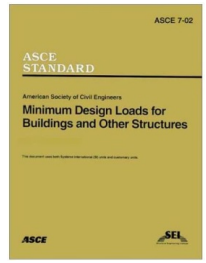
ICC INTERNATIONAL CODE COUNCIL

2009 & 2006 IBC

ASCE 7-05



2003 IBC



ASCE 7-02

Code Adoption

- Many states and local jurisdictions have chosen to adopt the model building codes maintained by the International Code Council (ICC)
- States and local jurisdictions do not always adopt the most current code every 3 years
  - Some jurisdictions still have the 2003 IBC as their adopted code
- State and local jurisdictions can adopt parts of the code and amend the codes to meet local needs.
  - California Building Code (Stricter Seismic Design Requirements)
  - Florida Building Code (Stricter Wind Design Requirements)
- The ICC Web Site keeps a fairly up to date list of State and Local Codes
  - http://shop.iccsafe.org/state-and-local-codes.html

Code Enforcement

- Adoption of building codes requires ongoing training of administration, enforcement, design, install, maintenance and enforcement to meet code objectives.
- Code enforcement is typically the responsibility of local government officials who review design plans, inspect construction, and issue building and occupancy permits.
  - Building officials, plan reviews and Inspectors must be familiar with and properly trained on code requirements.
- Design professionals must remain current and up to date on building code requirements to ensure compliance and to limit risk/liability in their designs.
- Contractors/Installers must ensure that construction proceeds in accordance with the approved plans.
- **Communication between professions and trades is essential!**

Applicable Loading to Consider on Mechanical Equipment and Distribution Lines (above grade)

- Dead Loads
- Service Loads
  - Start-up
  - Thermal Expansion/Contraction
  - Hammer
  - Component Stresses
- Location Loading
  - **Wind loading (Lateral and Uplift)**
  - **Seismic Loading**
  - Snow Loading
  - Ice Loading
  - Live Loading*

2015 International Mechanical Code

Loading specifically addressed in the IMC:

Section 301 - General

- **301.1 Scope.** This chapter governs the approval and installation of all equipment and appliances that comprise parts of the building mechanical systems regulated by this code in accordance with Section 101.2.
- **301.15 Wind resistance.** Mechanical equipment, appliances and supports that are exposed to wind shall be designed and installed to resist the wind pressures determined in accordance with the International Building Code.
- **301.19 Seismic resistance.** Where earthquake loads are applicable in accordance with the International Building Code, mechanical system supports shall be designed and installed for the seismic forces in accordance with the International Building Code.

Section 302 – Protection of Structure

- **302.1 Structural Safety.** The building or structure shall not be weakened by the installation of mechanical systems. Where Floors, walls, ceilings or any other portion of the building or structure are required to be altered or replaced in the process of installing or repairing any system, the building or structure shall be left in a safe structural condition in accordance with the International Building Code.

Loading specifically addressed in the IMC (continued):

Section 305 Piping Support

- **305.1 General.** Mechanical system piping shall be supported in accordance with this section.
- **305.2 Materials.** Adequate strength and compatible materials.
- **305.3 Structural attachment.** Hangers and anchors shall be attached to the building construction in an *approved* manner.
- **305.4 Interval of support.** Piping shall be supported at distances not exceeding the spacing specified in table 305.4 or in accordance with ANSI/MSS SP-58.
  - Steel pipe – Max horizontal spacing: 12 ft
  - Max vertical spacing: 15 ft
- **305.5 Protection against physical damage.**

Section 306 Access and Service Space

- **306.1 Access.** Appliances, controls devices, heat exchangers and HVAC system components that utilize energy shall be accessible for inspection, service, repair and replacement…..

- **306.5 Equipment and appliances on roofs or elevated structures.** Where *equipment* requiring access or appliances are located on an elevated structure or the roof of a building such that personnel will have to climb higher than 16 feet above grade to access such equipment or appliances, an interior or exterior means of access shall be provided. **Such access shall not require climbing over obstructions greater than 30 inches in height** or walking on roofs having a slope greater than 4 units vertical in 12 units horizontal (33% slope). Such access **shall not require the use of portable ladders**. Where access involves climbing over parapet walls, the height shall be measured to the top of the parapet wall.

OSHA 1910 Subpart D – Walking Working Surfaces

Loading specifically addressed in the IMC (continued):

Section 1101 General

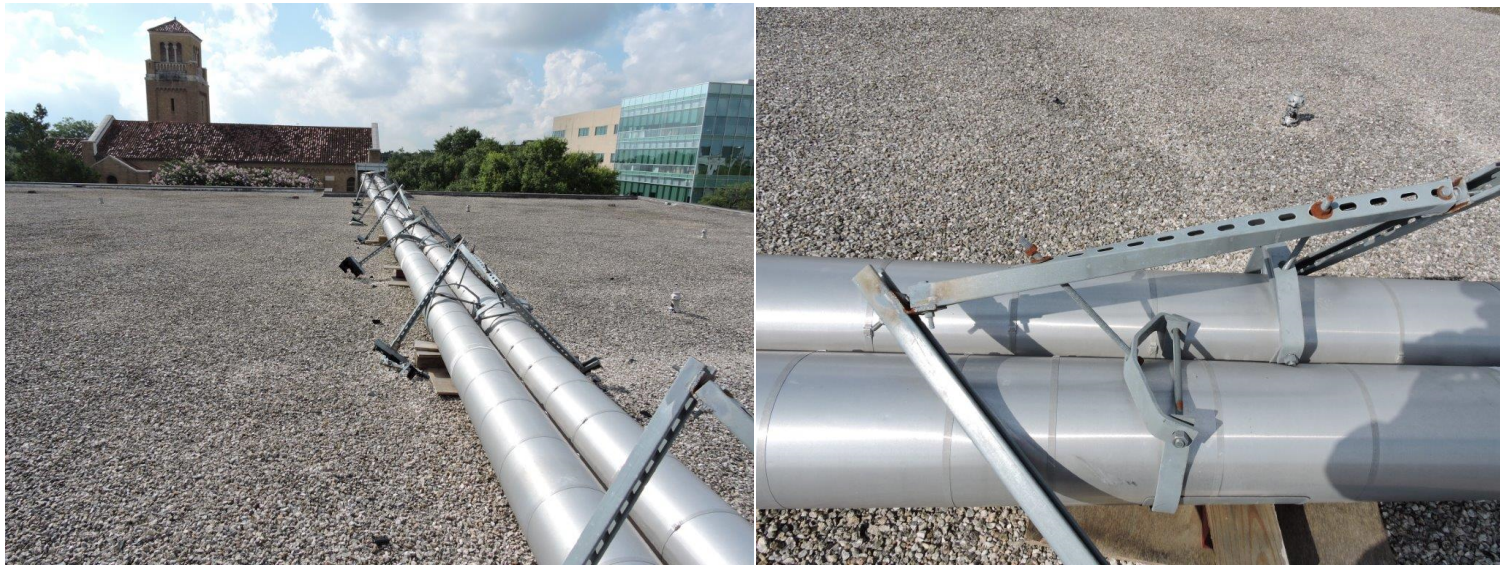
- **1101.1 Scope.** This chapter shall govern the design, installation, construction and repair of refrigeration systems that vaporize and liquefy a fluid during the refrigerating cycle. Refrigerant piping design and installation, including pressure vessels and pressure relief devices, shall conform to this code. Permanently installed refrigerant storage systems and other components shall be considered as part of the refrigeration system to which they are attached.

- **1101.3 Protection.** Any portion of a refrigeration system that is subject to physical damage shall be protected in an approved manner.

- **1101.6 General.** Refrigeration systems shall comply with the requirements of this code and, except as modified by this code, ASHRAE 15. Ammonia-Refrigerating systems shall comply with this code and, except as modified by this code, ASHRAE 15 and IIAR 2.

Failed Rooftop Equipment Supports

Of the industries that utilize the roof space for distribution lines and equipment, we have seen far fewer concerns with ammonia lines then with others.



Rooftop supports on a Texas Community College

Overturned supports

A 30’x10’x8’ 18,000 lb HVAC unit was attached to its curb with 16 straps (one screw per strap). Wind speeds were estimated to be only 85 to 95 mph (3-second peak just). Source – FEMA 489 “Mitigation Assessment Team report: Hurricane Ivan in Alabama and Florida” August 2005

Wind Screens?

Codes do not allow reductions in design wind loading due to apparent shielding from adjacent structures. Source - FEMA

Photovoltaic?

Ballasting to resist wind loading is not always the proper solution.

Excessive loading causes ponding or puncture of the roof membrane.

Resourceful

Sometimes you have to use what's available.

2015 International Building Code

Chapter 16 – Structural Design

Section 1601 - General

- **1601.1 Scope.** The provisions of this chapter shall govern the structural design of buildings, structures and portions thereof regulated by this code.

Section 1604 – General Design Requirements

- **1604.5 Risk Category.** Each building and structure shall be assigned a risk category (previously Occupancy Category) in accordance with Table 1604.5
  - Category I – Low hazard to human life
  - Category II – Building not assigned to Categories I, III or IV
  - Category III – Substantial hazard to human life
  - Category IV – Essential facilities

Section 1606 – Dead Loads

Chapter 16 – Structural Design (Continued)

Section 1607 – Live Loads

Section 1609 – Wind Loads

- **1609.1 Application.** Buildings, structures and parts thereof shall be designed to withstand the minimum wind loads prescribed herein. Decreases in wind loads shall not be made for the effect of shielding by other structures.
  - **1609.1.1 Determination of wind loads.** Wind loads on every building or structure shall be determined in accordance with Chapters 26 to 30 of ASCE 7 or provisions of the alternative all-heights method in Section 1609.6. ……. Wind shall be assumed to come from any horizontal direction and wind pressures shall assume to act normal to the surface considered. (Alternative all-heights method is not applicable to rooftop equipment or supports per 1609.6.1-5)
  - **Exceptions:** (Rooftop equipment and supports do not qualify for any of the exceptions listed in the code.)
  - The wind speeds in Figure 1609.3(1 – 3) are ultimate design wind speeds, V_{ult}. *(Conversion to nominal design wind speed, V_{asd},* is not applicable for rooftop equipment and supports.)

- **1609.6 Alternative all-heights method.** The alternative wind design provisions in this section are simplifications of the ASCE 7 Directional Procedure.
  - **1609.6.1 Scope.** As an alternative to ASCE 7 Chapters 27 and 30, the following provisions are permitted to be used to determine the wind effects on regularly shaped buildings that meet all of the following conditions:

    5. For open buildings, ……., and rooftop equipment, apply ASCE 7 provisions.

Chapter 16 – Structural Design (Continued)

Section 1609 – Wind Loads (Continued)

- ASCE 7 Chapters 26 to 30 must be used for determining wind loading on rooftop equipment.
- Wind design parameters are typically provided in the structural general notes of the project documents when a Structural Engineer is involved. If a structural engineer is not involved the parameters can be obtained for the project location via the ATC Windspeed By Location web page
  - http://windspeed.atcouncil.org/index.php?option=com_locationfinder&view=location&Itemid=10

Section 1613 – Earthquake Loads

1613.1 Scope. Every structure, and portion thereof, including nonstructural components that are permanently attached to structures and their supports and attachments, shall be designed and constructed to resist the effects of earthquake motions in accordance with ASCE 7, excluding Chapter 14 and Appendix 11A. The *seismic design category* for a structure is permitted to be determined in accordance with Section 1613 or ASCE 7.

- ASCE 7 Chapter 13 must be used for determining seismic loading on rooftop equipment.
- Seismic design parameters are typically provided in the structural general notes of the project documents when a Structural Engineer is involved. If a structural engineer is not involved the parameters can be obtained from the U.S. Geologic Survey Earthquake Hazards Program.
  - Earthquake.usgs.gov/designmaps/us/application.php

Equipment Support Deferred Submittals

3. Deferred Submittals
   a. Deferred Submittals include those portions of the project that are furnished by the Contractor and designed by someone other than the Engineer of Record and are submitted at the time of application. Deferred Submittals shall be submitted to the Building Official prior to fabrication and installation.
   b. Submittal documents for Deferred Submittals:
      i. Shall be included in the Contractor's scope of services and shall be sealed by an Engineer licensed in the project state. Design of Deferred Submittals shall be in accordance with the governing Building Code.
      ii. Shall be submitted to the registered design professional in responsible charge who shall review them and forward to the Building Official with a notation indicating the deferred submittal documents have been reviewed and that they have been found in general conformance with the design of the building. Deferred submittal items shall not be installed until the design and submittal documents have been approved by the Building Official.
   c. The following shall be considered Deferred Submittals:
      i. Temporary/Permanent Shoring and Underpinning
      ii. Steel Connections – See "Structural Steel" Section
      iii. Cold-Formed Exterior Steel Stud Framing
      iv. Roof Top Unit Anchorage
      v. Curtainwall/Window Wall Systems
      vi. Slotted Channel Strut Framing

Example Design

Design Criteria:

Adopted Building Code: 2015 International Building Code & ASCE 7-10

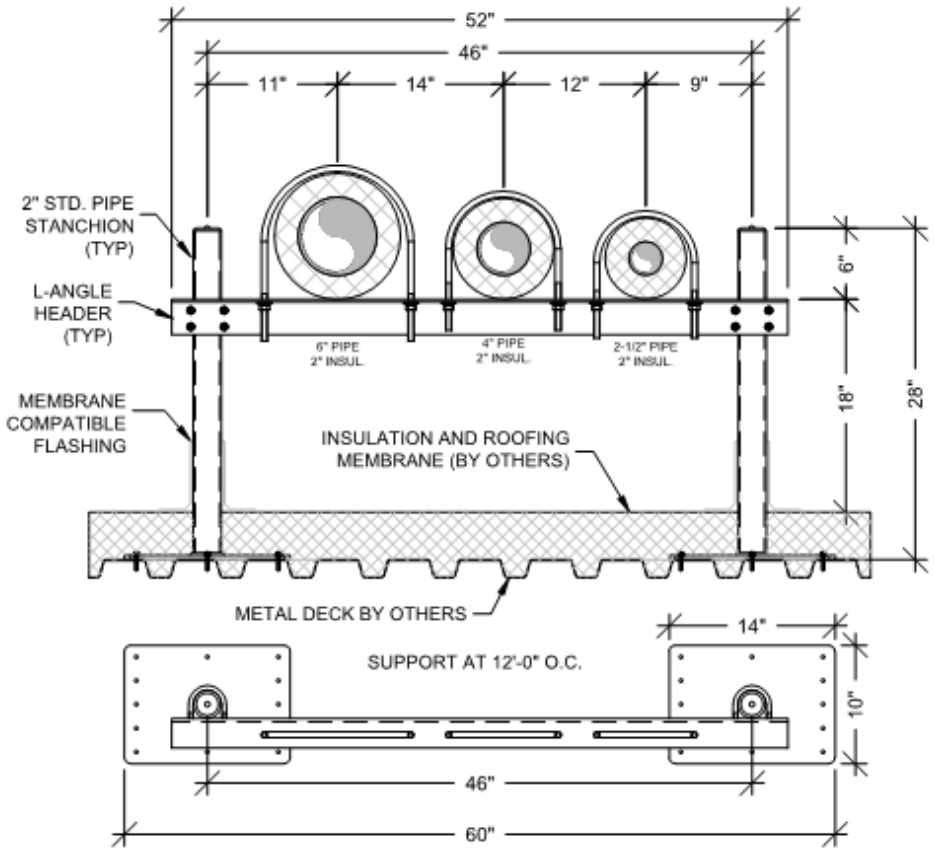
Risk Category: IV

Wind Design Criteria:

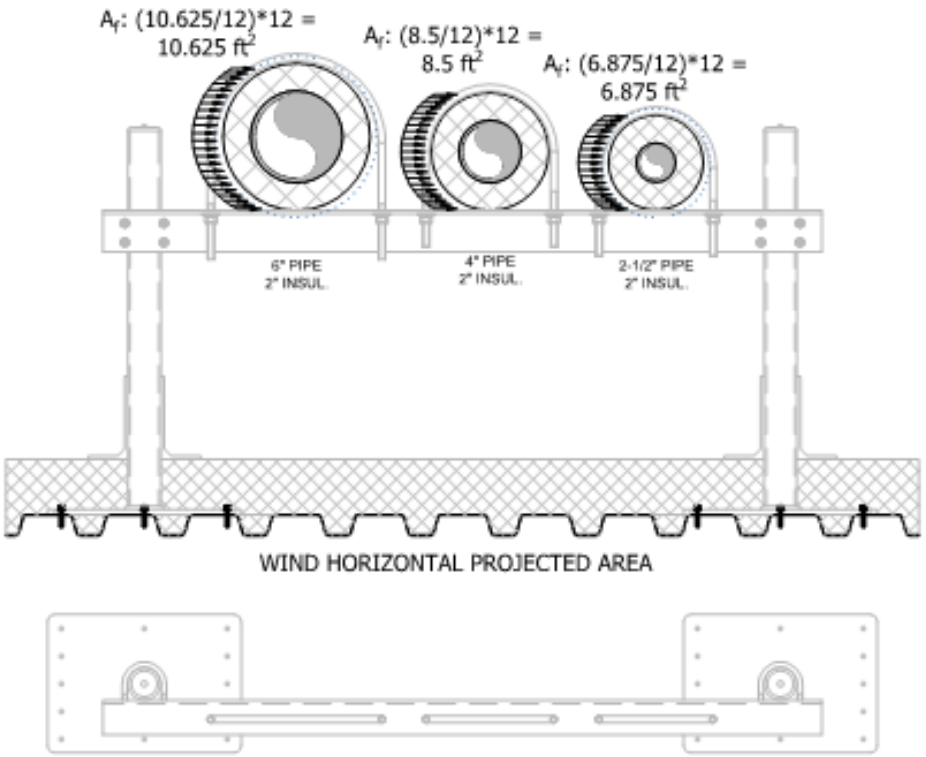
- Mean Roof Height: 40 Feet
- Basic Wind Speed, V: 120 mph – 3 sec gust
- Wind Exposure Category: C

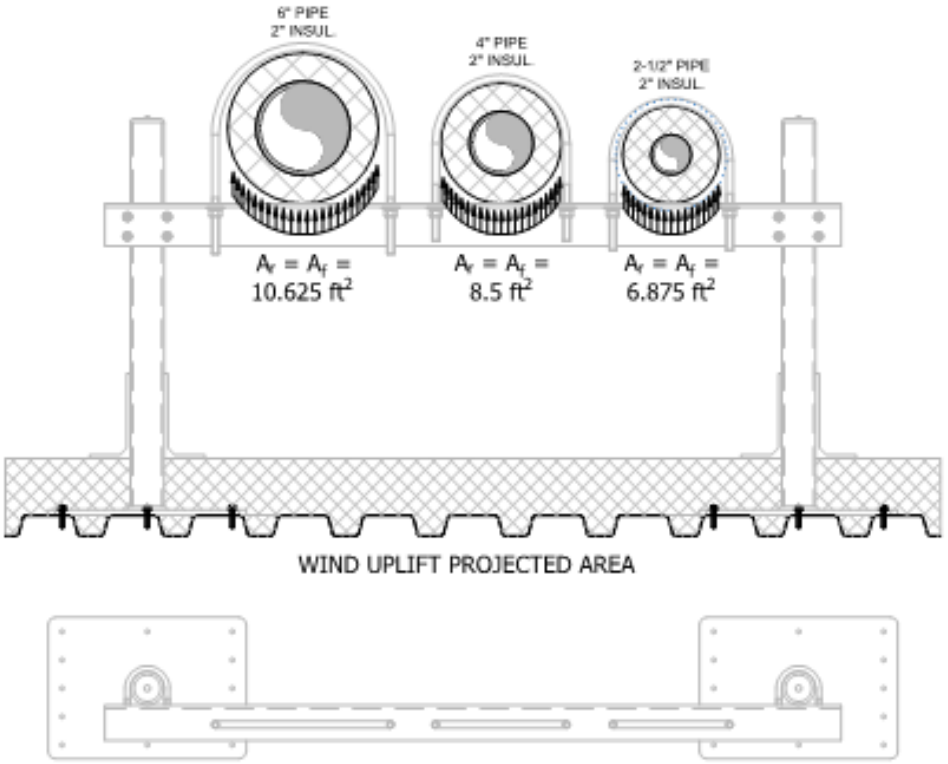
Seismic Design Criteria:

- Site Soil Classification: D (Assumed)
- Short Period Spectral Acceleration, S_{DS}: 1.643 g
- Seismic Design Category: D
- Seismic Component Importance Factor, I_p: 1.5
- Component Amplification Factor, a_p: 2.5
- Component Response Modification Factor, R_p: 12
  - For the seismic component amplification factor, a_p, and component response modification factor, R_p, from Table 13.6-1 of ASCE 7 we will assume the pipe is designed in accordance with ASME B31 with joints made by welding.

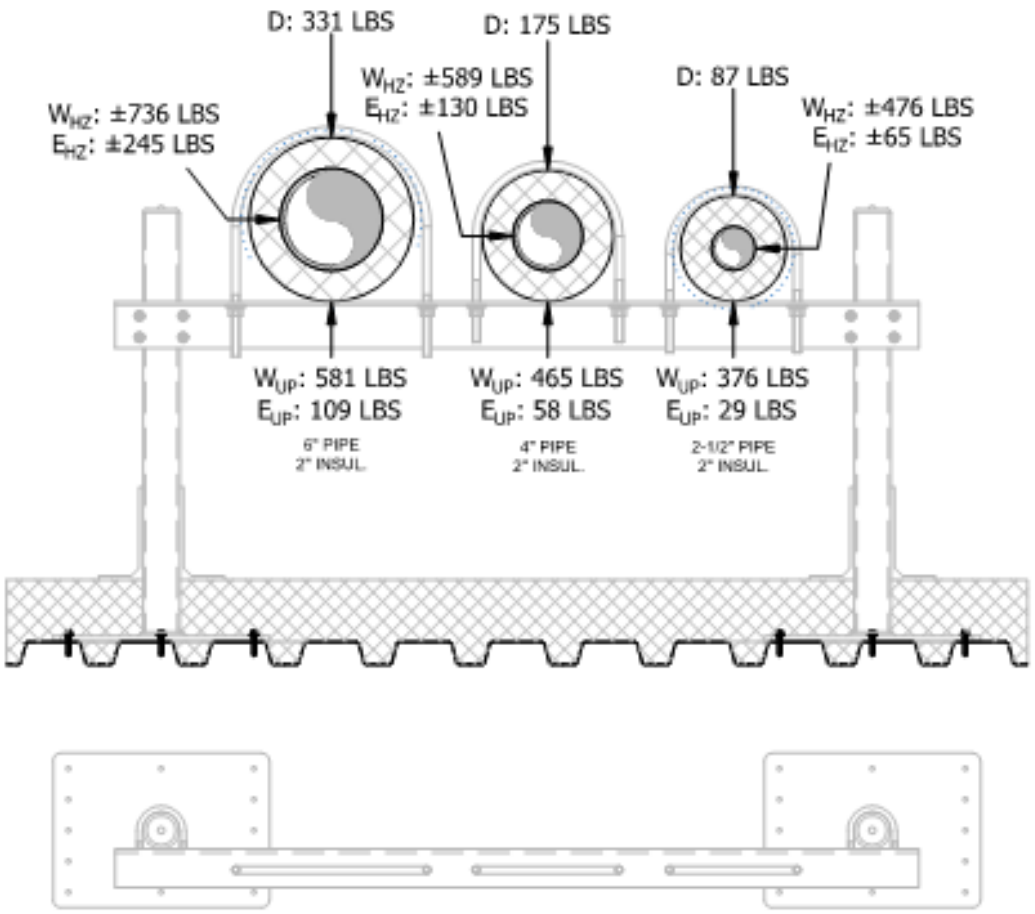


- Supports at 12’ O.C. (typ)





- Supports at 12’ O.C. (typ)


D: 331 LBS
D: 175 LBS
D: 87 LBS
W_{HZ}: ±736 LBS
E_{HZ}: ±245 LBS
W_{HZ}: ±589 LBS
E_{HZ}: ±130 LBS
W_{HZ}: ±476 LBS
E_{HZ}: ±65 LBS
W_{UP}: 581 LBS
E_{UP}: 109 LBS
6" PIPE
2" INSUL.
W_{UP}: 465 LBS
E_{UP}: 58 LBS
4" PIPE
2" INSUL.
W_{UP}: 376 LBS
E_{UP}: 29 LBS
2-1/2" PIPE
2" INSUL.

Other Loading factors included in ASCE 7 that may be applicable to exterior above ground applications

- Snow Loading – Contributes additional downward loading on the pipe in addition to gravity loading
- Ice Loading – Contributes additional downward loading on the pipe in addition to gravity loading. Ice buildup also increases the diameter of the pipe which will contribute to greater wind loading on the pipe. A load combination for Wind on Ice loading is provided in ASCE 7.

Conclusion

- International Code Council's International Codes are the most widely adopted codes. States typically either adopt the code in it's entirety, or use the codes as their base and make modifications as applicable their circumstances.
- Adopted codes establish minimum requirements with the goal to safeguard the public health and safety in all communities, large and small.
- Industry standards like IIAR 2 or ASHRE 15 are recognized in the codes and can be used in the design of systems on the condition that the minimum requirements outlined in the International Codes are met.
- There are currently no exemptions from evaluating equipment that is exposed to wind.
- Seismic exemptions exist, but are subject to site specific and other general requirements.
- Where wind and seismic must both be considered, wind loading will typically govern the design.
- The design of rooftop equipment supports requires coordination between multiple trades, and professions.
- Rooftop equipment supports are typically handled as a deferred submittal in the project documents. If not addressed in the project schedule, the rooftop support submittal can lead to project delays.

Conclusion

- Evaluation of wind and seismic loading on rooftop equipment can be, and has been, overlooked by many industries, building officials and inspectors.
- A larger presence in the International Building Code and ASCE 7 will lead to stricter adherence and enforcement.
- Codes are always evolving and participation in code development can help ensure practical or realistic requirements are implemented.

Questions?

Thank you for your time!

Robb N. Davis, PE

MIRO Industries, Inc.

800-768-6978

Robb@miroind.com

References

- International Code Council
  - 2015 International Mechanical Code
  - 2015 International Building Code
- American society of Civil Engineers, ASCE 7-10 (2010), Minimum Design Loads for Buildings and Other Structures
- International Hurricane Research Center, Hurricane Loss Reduction for Housing in Florida: Rooftop Equipment Wind Load and its Mitigation for Buildings in Hurricane Prone Regions (Aug. 2007)
- Federal Emergency Management Agency (2005), "Summary Report on Building Performance: 2004 Hurricane Season," FEMA 490.
- Federal Emergency Management Agency (2006), "Mitigation assessment Team Report: Hurricane Katrina in the Gulf Coast," FEMA 549.
- Hosoya, N., Cermak, J. E., Steele C. (2001), "A Wind Tunnell Study of a Cubic Rooftop AC Unit on a Low Building," Americas Conference on Wind Engineering, American Association for Wind Engineering.
- National Institute of Standards and Technology (2006), "Performance of Physical Structures in Hurricane Katrina and Hurricane Rita: A Reconnaissance Report," NIST Technical Note 1476.
- Reinhold, T.A. (2006), "Wind Loads and Anchorage Requirements for Rooftop Equipment," ASHRAE Journal, Vol.48, No. 3, p. 36-43.
- United States Geological Survey (USGS), http://geohazards.usgs.gov/contact.php, U.S. Seismic Design Maps
- Applied Technology Council (ATC), http://www.atcouncil.org, Windspeed By Location.
- Michael J. Griffin, P.E. (2017) "Building Codes – Why They Matter", Developed under FEMA NETAP Program.


As of this date
FIREARMS WILL NOT BE ALLOWED
WITHIN THE CITY LIMITS OF
TOMBSTONE
ARIZONA TERR.
OCTOBER 30, 1880
Signed
Virgil W. Earp
City Marshal, Tombstone
BE IT KNOWN
REWARD
The "Wild Bunch"
Harry Longabaugh (Sundance Kid) - Robert Leroy Parker (Butch Cassidy) - Ben Kilpatrick - Will Carver - Harvey "Kid Curry" Logan
Wanted for Robbery of the BUTTE COUNTY BANK and the UNION PACIFIC EXPRESS
$7500 REWARD
Contact the nearest U.S. Marshal's Office
WANTED
MANAGERS! OPERATORS! TECHNICIANS!
Charged with learning to operate safely
LAST SEEN IN HERSHEY PENNSYVANIA
APPROACH WITH GREAT ENTHUSIASM
RETA 2018 National Conference
November 6-9, 2018
DALLAS • TEXAS
REWARD
PDH Credits Certification
Technical Program Social Events
Exhibition
www.reta-events.com
REWARD
($500.00)
Reward for the capture, dead or alive, of one Wm. Bonney better known as
"Billy the Kid"
Age, 18. Height, 5 ft. 7 inches. Weight, 125 lbs. Light hair, blue eyes and even features. He is the leader of the worst band of desperadoes the territory has ever had to deal with. The above reward will be paid for his capture or positive proof of his death.
PAT GARRETT, Sheriff
Lincoln County, N.M.T.
Pat Garrett Shoots Down
Billy the Kid!
On July 14, 1881, Lincoln County, New Mexico Sheriff Pat Garrett confronted and shot to death Billy the Kid at the ranch of Peter Maxwell in Fort Sumner. The Kid had been on the run after killing two guards and escaping jail on April 18, 1881 to avoid hanging.
Once friends with Billy, it is rumored that Peter Maxwell may have set the Kid up in revenge for a personal betrayal by Billy.
Billy the Kid was buried in the Fort Sumner cemetery on July 15, 1881.