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Rack Design: Resources & Frequently Asked Questions

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RMI
RACK MANUFACTURERS INSTITUTE

MAKE YOUR BUSINESS
FUTUREPROOF.

About RMI

- Not-For-Profit Trade Association
- Founded in 1958
- Members are manufacturers of industrial steel storage racks and structural rack decking products
- Accredited Developer of American National Standards
- R&D programs for over 55 years resulting in virtually all advancements to the state of the art
- R-Mark Certification Program for both the storage rack and the wire decks
- Extensive National and International Liaison Programs
- Wide array of education and research programs

Special Note – RMI has available an extensive planning and use document and guidelines for rack repair.

Racks As Part Of The Operational System

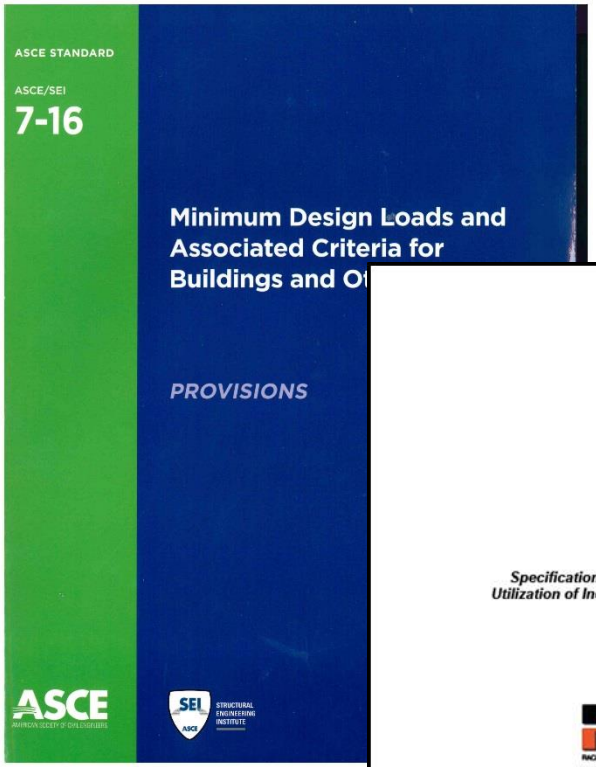
Rack structures are actually a sub-system that, to perform as intended, must operate as part of a fully integrated operational system. System components will generally include, but, certainly not be limited to:

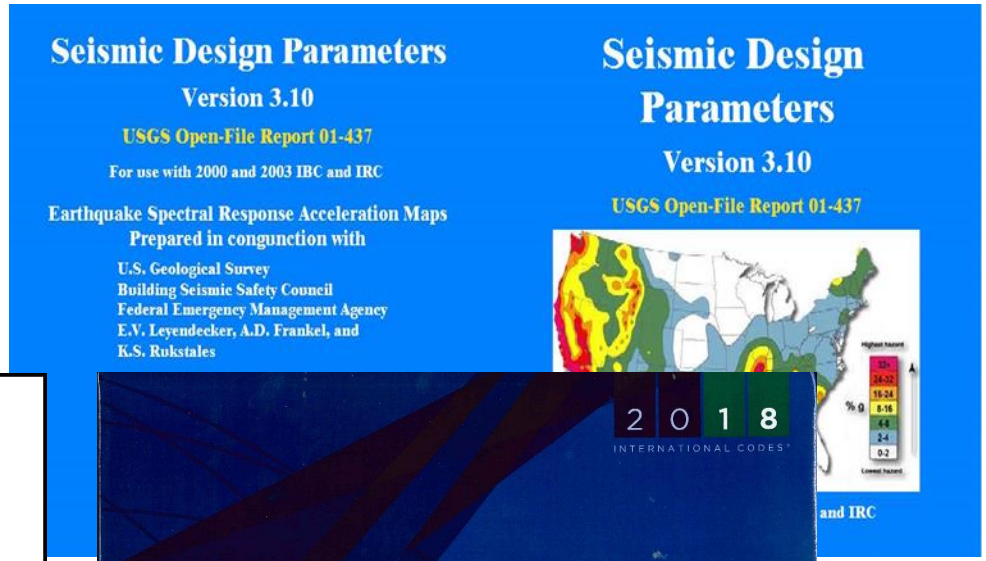
- The building
- The flooring and sub-soil
- The racking
- Anchorage
- The load platform (pallets, etc.)
- Decking, load support and fall protection
- Handling equipment

Codes and Standards

- International Building Code (IBC – 2018)
  - Note: Model Building Codes (formerly ICBO, BOCAI, SBCCI)
- ASCE7 - 16 (minimum design loads)
- RMI/ANSI MH16.1-2012 Pallet Rack,
  RMI/ANSI MH16.3-2016 Cantilever Rack
  MH26.2-2007 Wire Mesh Decking
- AISI (Spec. for Design of Cold-Formed Steel Structures)
- AISC (like AISI, except for structural steel shapes)
- AWS (welding)
- ACI 318 (concrete flooring)
- NFPA 5000 (building construction and safety)
- NFPA 13 (sprinkler systems) FEMA 460 (Guidelines and seismic considerations for racking accessible to the public)
- NEHRP Recommended Provisions (Seismic)

Codes and Standards





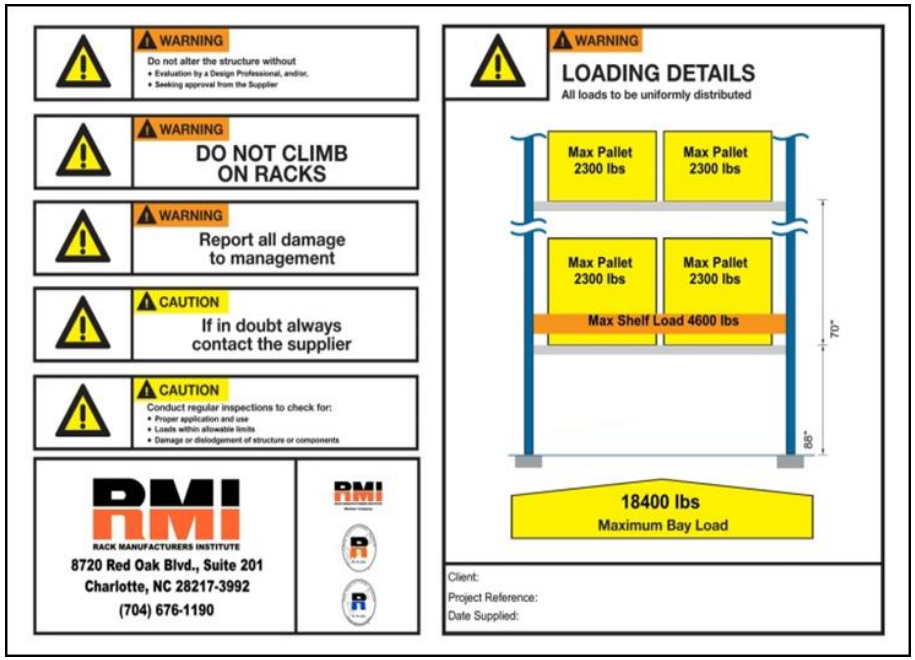
Highlights:
RMI/ANSI MH16.1-2012 & MH26.2-2007

While a design guide, this American National Standard incorporates provisions that end users will find important in developing operational protocols on many levels. Among the provisions are:

- A detailing of owner responsibilities
- Floor loading
- Pick-module design
- Stair design
- Handrail and guardrail design
- Discussion of product fall protection

Highlights:
RMI/ANSI MH16.1-2012 & MH26.2-2007

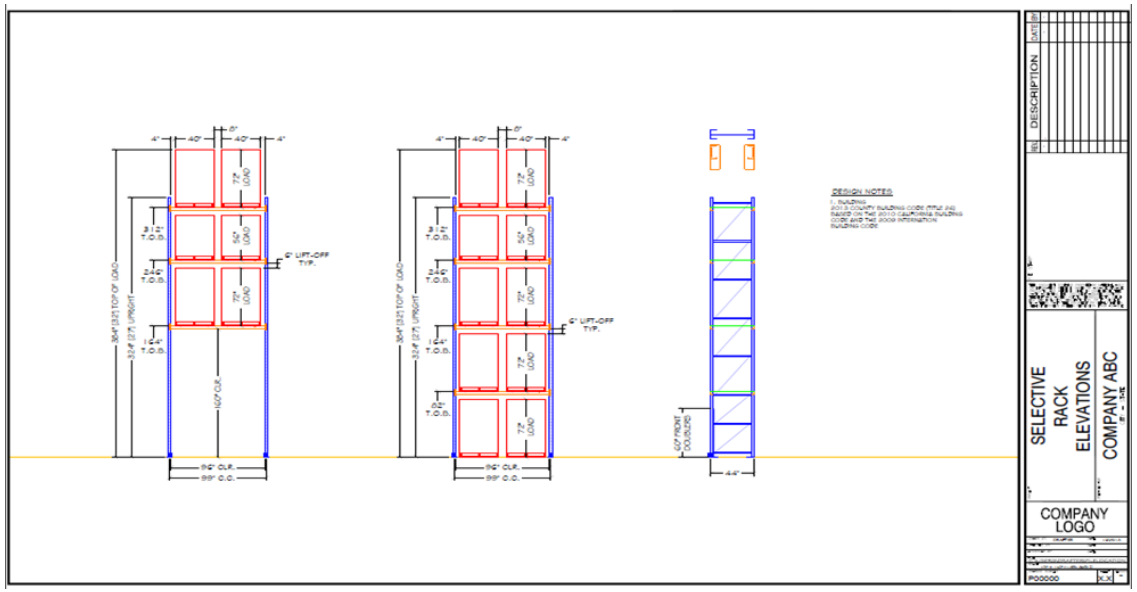
Load Notices (Plaques) – Load Generalities



Highlights:
RMI/ANSI MH16.1-2012 & MH26.2-2007

Load Application and Rack Configuration Drawings

Configuration Specifics



Highlights:
RMI/ANSI MH16.1-2012 & MH26.2-2007

- Loads on racks
- Load combinations
- Details of base-plates and shimming
- Performance of shelf-connection locking device
- Shelf-beam deflection limits
- System plumb and straight requirements
- Requirements for cross-aisle tying and anchoring
- Seismic design requirements

And many more…

RMI/ANSI MH16.3-2016 - *Specification for the Design, Testing and Utilization of Industrial Steel Cantilevered Storage Racks*

This American National Standard is published by the Rack Manufacturers Institute of MHI and is the industry design guide for cantilevered storage rack. It was approved as an ANSI standard on October 8, 2015. It will be referenced in the 2016 ASCE7 standard and the 2018 IBC. Development of this standard started over 15 years ago and input was received from industry engineers, outside consultants, and other interested parties knowledgeable in the design of cantilevered storage racks. The standard is the result of RMI's recognition of the need to standardize performance and design criteria for the proper utilization of cantilevered storage racks.

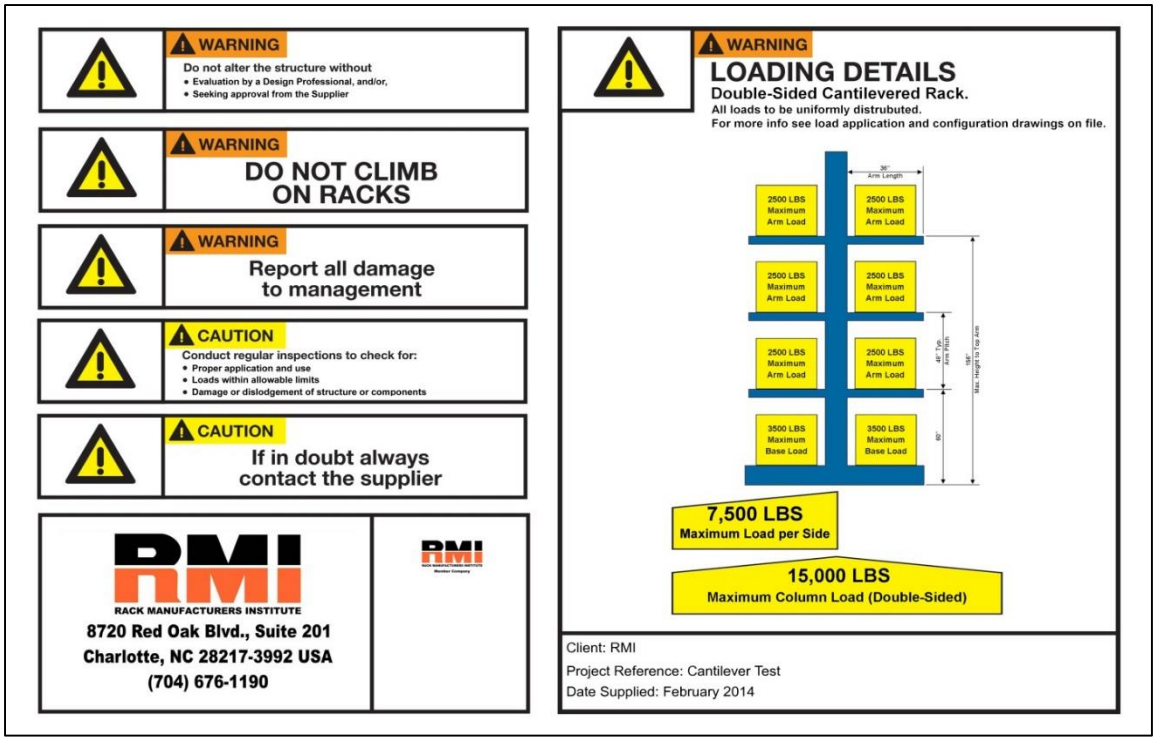
RMI/ANSI MH16.3-2016 - *Specification for the Design, Testing and Utilization of Industrial Steel Cantilevered Storage Racks*

Among the provisions are:

- Loads on racks including seismic and wind and snow when located outside
- Load combinations
- Design requirements for both cold-formed and hot-rolled steel members
  - Column Design
  - Arm design
  - Column-to-base connection design
  - Column base and base plates

RMI/ANSI MH16.3-2016 - *Specification for the Design, Testing and Utilization of Industrial Steel Cantilevered Storage Racks*

Load Notices (Plaques) –



Frequently Asked Questions

What is a uniformly distributed load (UDL) vs. a point load? Why is this important?

The definition of UDL: Any static load which is evenly distributed over the entire surface on the rack deck. (Ref MH26.2). This means that the product being stored on the deck must cover the entire deck from side to side and front to back. General capacity ratings are based upon a UDL stored on the deck.

Point Load - any static load that is concentrated to particular points on the deck. (i.e. A container with four small feet (point load) versus a container with two runner bars running the entire length of the container (concentrated load).

Why should racks be anchored?

The ANSI/RMI Specification requires that all rack columns should be anchored. This means that both the aisle column and the interior or rear columns must be anchored on all frames according to the instructions from the manufacturer and applies to all rack frames all the time. If there is a specific application where the racks can't be anchored, the user should get permission from the manufacturer's engineer to waive the requirement. Anchors are required to resist many forces at the base of the columns and to maintain the position of the rack column.

There are two holes in the footplate, why? Does that mean I need two anchors per footplate?

Not necessarily. Racks must always be anchored to the floor as shown on the Load Application and Rack Configuration drawings. The RMI Specification requires at least one anchor per column. The rack manufacturer will often provide extra holes in the base plate as alternate holes that can be used in case floor reinforcing interference is encountered when drilling the floor.

How far out of plumb can your racks be?

The ANSI/RMI Specification permits the maximum out-of-plumb ratio for a loaded rack column to be 1/2” per 10 feet of height. Columns whose out-of-plumb ratio exceeds this limit must be unloaded and re-plumbed. Any damaged parts must be repaired or replaced. This ratio could be used for straightness also. In other words, the out-of-straightness limit between any two points on a column should not exceed 0.05” per foot of length (1/2” per 10 feet).

An out-of-plumb or out-of-straight condition will reduce the capacity of a rack column. The reduction can be significant. A rack that is out-of-plumb from top to bottom or a rack column that is not straight is likely to become further out-of-plumb or out-of-straight when it is loaded.

The out-of-straight limit is given to prevent excessive “bows” or “dogleg” conditions that may exist in a rack column. A column could be plumb from top to bottom but have an unacceptable bow at mid-height (see figure (a)), or a 20 ft. high column could be out 1” from top to bottom, which could be acceptable using a simple top-to-bottom out-of-plumb measurement, but the entire out-of-plumb could be between the floor and the 5 ft. level (see figure (b)). This dogleg condition would be very harmful. This condition could be caused by fork truck impact. The column could have a sine wave shape and be out of straight as shown in figure(c). A column could also become bent and exceed this limit (see figure (d)). As re-written the specification now prevents these situations from being acceptable if they exceed the 0.05" per foot out of straight limit.

How far out of plumb can your racks be?

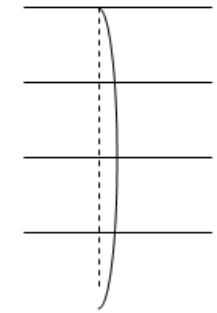


Figure (a)

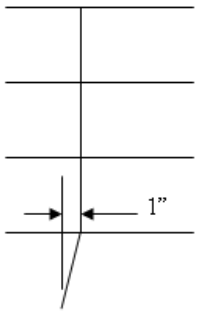


Figure (b)

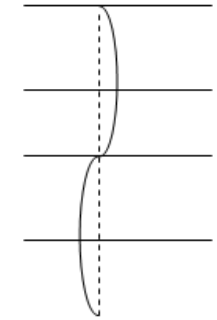
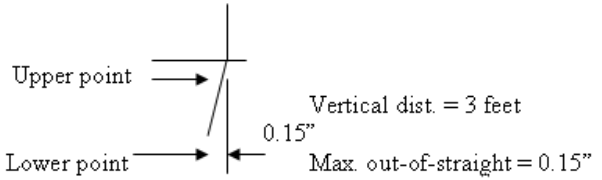


Figure (c)



Figure(d)

Can you tie racks to the building structure?

It is generally not a good idea to tie racks to the wall because forces from the building can be transferred to the racks and because forces from the racks can be transferred to the building, although wall ties are sometimes used in low seismic areas. If wall ties are used, there must be proper coordination between the building engineer and the rack engineer to ensure that the ties and any transmitted forces will not damage the rack or the building structures. The connection to the wall must be capable of transferring the required forces, and the connectors must be compatible with the wall material. The seismic analysis of the rack and the building being tied together is extremely complex, and the connection is best avoided. If the height to depth ratio is such that a single row needs extra stability, heavy-duty anchor patterns with larger base plates or cross aisle tie configurations could be used rather than wall ties.

What should you know about height-to-depth ratios?

The RMI defines the height-to-depth ratio for a single row of pallet rack to be the ratio of the distance from the floor to the top beam level divided by the depth of the frame. Normal anchoring as is used for double rows is usually adequate for racks whose ratio is 6 to 1 or less. If the height-to-depth ratio exceeds 6 to 1, the anchors and the base plates should be designed to resist overturning. The ANSI/RMI Specification in section 8.1 provides for the anchorage to resist an overturning force of 350# applied at the topmost shelf level (to an empty rack). If the LRFD method of design is used, this force should be treated as a live load and multiplied by 1.6.

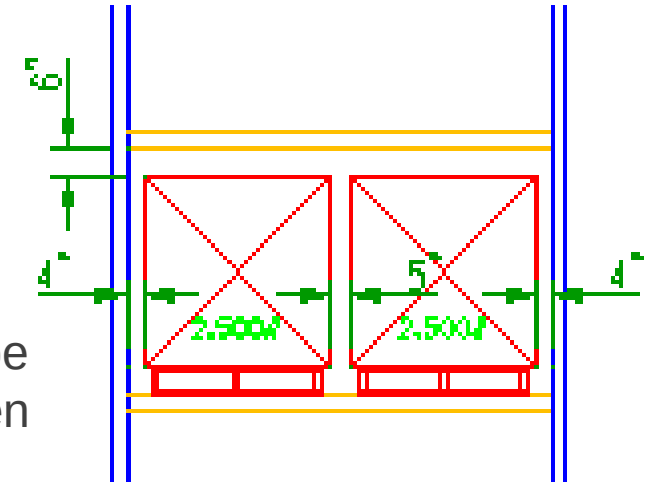
If the height-to-depth ratio exceeds 8 to 1, the racks should be stabilized using overhead ties. If anchoring is used for this extreme case, the design of the anchors must be certified by an engineer. All of these ratios and requirements are for a typical rack frame. If a set back leg or slope leg upright were to move the center of gravity from the frame's midpoint, these ratio limits do not apply, and a rack engineer should approve the configuration. Slope or setback legs should generally be avoided in single rows.

Are there recommended clearances between pallet loads?

In the storage rack system planning, clearance around the loads is second in importance only to the size and shape of the loads. Too little clearance will result in damage to both the loads and the storage racks. In an effort to minimize the damage operators will slow down the movement of the loads and greatly add to the operation cost of the warehouse. Too much clearance will waste space and increase the costs of construction, and, in some cases, the cost of the rack system.

Automated Storage and Retrieval Systems have tighter operating tolerances and, therefore, may be able to function with tighter clearances. The user of the installation is responsible for assuring that these operating clearances are conveyed to the rack designer.

Are there recommended clearances between pallet loads?



For normal load size, shape (and misshape) and weights a single-selective pallet storage rack might be configured with 4 inches (102 mm) clearance between the rack column and the load and 5 inches (127 mm) between two adjacent loads on a beam. In a single deep storage configuration 6 inches (152 mm) lift-off clearance might be typical. For a double deep storage configuration more clearance would be required. For push-back type pallet storage operations less clearance may be used for pallets resting on moving carts, but care must be used to assure that the pallets can get under all interior obstructions when accounting for the cart track slope.

How much beam/shelf deflection is acceptable?

At normal design working loads, beams are typically designed to accommodate vertical deflections that do not exceed 1/180 (or 0.55 percent) of the horizontal beam length as measured with respect to the ends of the beams. Some users may specify a lesser-deflection requirement for visual appearance or cosmetic purposes. Still other users with systems intended to use more precise automated storage and retrieval equipment may specify a lesser-deflection requirement. (See ANSI/RMI Specification section 5.3, Commentary section 5.3).

What does the load capacity on a Wire Deck really mean? How should it be applied to the real world?

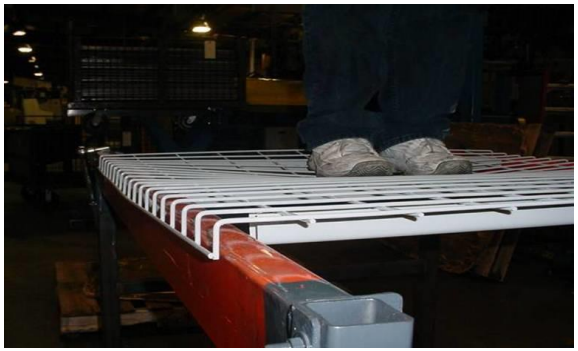
The load capacity assigned to a specific make and model of a wire deck is based on a testing protocol from MH26.2. This test is designed to evaluate the capacity (both strength and deflection) of the wire decking when the deck is subjected to a uniformly distributed load. The test protocol is designed to have the entire load weight supported by the decking components. The test does not allow any of the weight to be supported by the shelf beams or members other than the decking components.

This test protocol is intended to allow the end user to compare the load carrying capacities of dissimilar decking construction on an equal basis.

The actual loading of a rack deck may or may not be uniformly distributed. Evaluation of the specific loading and the deck's ability to safely carry that load should be evaluated by an engineer who is familiar with the design of storage rack decks.

Why should you not walk on a wire deck?

Wire decking is not designed to be walked or stood upon. Walking and/or standing on a wire deck creates both dynamic (moving and varying) and concentrated loads. Wire decking is designed and assigned a load carrying capacity based on carrying uniformly distributed, static loads. While there is a safety factor designed and built into wire decking, dynamic and concentrated loading as a result of standing or walking on a wire deck is a use which falls outside its intended purpose. In addition, the surface of a wire mesh deck is flexible and irregular and the open areas within the mesh may cause a person to trip. Furthermore, when subjected to lateral motion decks may slide upon the supporting rack beams or tip upward and become dislodged when loaded in a concentrated fashion on the outer extremities (beyond the outermost support members).



What should you know about used or repurposed racks?

Racks that do not conform to the ANSI/RMI Specifications may not be as safe as racks that conform to the specification. The Rack Manufacturer's Specification is the only recognized U.S. specification for the design, testing and utilization of industrial steel storage racks. If there should ever be an accident or other incident involving the storage racks, a responsible rack user may want to show that its racks have been designed to meet this recognized standard.

The RMI recommends purchasing racks that clearly meet the requirements of the ANSI/RMI Specification.

Pallet racks are originally designed for configurations requested by the owner. These configurations are shown on the Load Application and Rack Configuration Drawings supplied to the owner. Changing the racks to a configuration that was not considered in the design may create an unsafe condition. A qualified engineer should review any change to the bay configuration that is different from the original design configurations.

Additional Questions

Ongoing Resources – Highlights

- International Code Council – www.iccsafe.org
  - International Building Code (IBC)
- National Fire Protection Association – www.nfpa.org
  - NFPA 13
  - NFPA 5000
- Rack Manufacturers Institute – www.mhi.org/rmi
  - RMI/ANSI MH16.1-2012
  - RMI/ANSI MH16.3-2016
  - RMI/ANSI MH26.2-2007
  - FAQs
  - More comprehensive list of resources
- US Geological Survey – www.usgs.gov

- A more extensive list can be found at
- www.mhi.org/rmi

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