Storage Rack Safety Standards
Maintenance and Inspection

Flexible Packaging Association
Safety Conference - February 10, 2010
Tony Mulholland P.E.
Primary Standard
International Building Code 2006

IBC is the predominant building code in the United States

Section 2208 – Steel Storage Racks
The design of storage racks shall be in accordance with the ANSI MH16.1. Where required, the seismic design of storage racks shall be in accordance with the provisions of Section 15.5.3 of ASCE 7.

ANSI MH16.1 is also know as the “specification for industrial steel storage racks”, produced by the Rack Manufacturers Association (RMI)
Key Requirements of Rack Standard
ANSI – MH16.1-2008

- Scope – does not apply to all types of rack, for example drive in and cantilever racks are excluded in the scope

- 1.4.1-The owner shall regularly inspect for damage. If damage is found, immediately unload the affected area and replace or repair damaged components

- 1.4.4 - Load application and rack configuration drawings shall be furnished with each rack installation
  - Comment – you will have to ask for this

- 1.4.2 The owner is responsible for displaying a load limit plaque that is not less than 50 square inches.
  - Comment – not always practical (will discuss later)
**Key Requirements of Rack Standard**

**ANSI – MH16.1-2008**

1.4.8 - you are exempt from having Load Configuration Drawings if less than **12 feet** in height and a floor area **less than 3,000 square feet**, and having a maximum unit load of **2,500 pounds**.

2.6.1 - Where customer specifications require or **local building codes dictate** that provisions be made for earthquake effects, the racks **shall be designed to resist seismic forces if they are more than 8 ft** in height to the top load shelf.
   - **Comment** – you will have to ask for this, rack is still sold as an off the shelf item, no drawings with basic capacities.
   - **Comment** – despite clause 2208 in IBC, for the most part rack goes up without permits, except in specific regions.

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**Storage Rack Safety Standards, Maintenance and Inspection**
Other Standards and Specifications

1. **CSA - A344** – issued by Canadian Standards Association in 2005 (also covers the **use & specification** of rack, and they offer a training on inspection and maintenance)

2. **FEM 10.2** – European series of specifications that govern design, testing & use

3. **Internal Standard Operating Procedures**
   - Routine rack inspections; 3rd party rack inspections
   - Staff training — rack inspection
   - Responding to damage

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**Storage Rack Safety Standards, Maintenance and Inspection**
Rack Manufacturers Institute (RMI) 
Draft User Guide

Inspection

- It is necessary to inspect all components of the rack system periodically.
- Select an inspection period. The more prone the rack are to being damaged, the more often they should be inspected.
  - Racks with **high damage potential** should be inspected at least once a month.
  - Racks with a **medium potential** for damage should be inspected at least **twice a year**.
  - All other racks should be inspected **at least yearly**.

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*Storage Rack Safety Standards, Maintenance and Inspection*
CSA A344.1 is a user guide and it requires the following:

8.1.1 – a **Systematic** rack inspection program be established

8.1.4 – the inspection should be **formally recorded**

8.1.5 – the inspection **frequency shall vary** depending on nature of facility
OSHA Voluntary Protection Programs (VPP)

Suggested Compliance Plan

- Internal monthly inspections
- Annual 3rd party inspection of entire facility
Notable Accidents

- OSHA statistics for fatalities related to “cases, cabinets, racks, and shelves” for 1992 to 2002 average 5.2 fatalities per year (typically the US has statistics 10 times that of Canada)

  - Racks collapsed and the 45 gallon metal drums fell onto the forklift operator, **killing** the operator.

- Direct Distribution Centres, Calgary, April 2008
  - The employee had been using a forklift when the racking collapsed and **killed** the employee

- VersaCold Canada, Brampton, August 2004
  - Worker was crushed to **death** by collapsed rack. Racking collapse was the result of a lift truck impact onto freezer rack.
Versacold Coroners Inquest

- Significant repair be engineered and certified by a Professional Engineer after being done

To: ALL MANUFACTURERS OF RACKS, MINISTRY OF LABOUR, AND THE PROFESSIONAL ENGINEERS OF ONTARIO:

1. That the design, installation, and significant repair or modification of a storage rack system be required to be engineered and certified by a professional engineer on a post-installation basis.

Rationale: Evidence presented revealed that there is a need for more clarity and understanding specific to each rack design. Designers of racks need to provide instruction on:
- Tolerances during installation
- Techniques on installation
- Rack maintenance requirements
- Inspection on racks
- Acceptable levels of damage

Storage Rack Safety Standards, Maintenance and Inspection
Why do Racks Collapse?

Conclusion

- A rack collapse is most likely the result of an operator error and can happen at any time.
- Be prepared, making sure you are compliant (inspected, in good repair, capacity is known, required documentation is current).
Racks Failure Videos (Progressive Collapse)

- Building products store:
  www.youtube.com/watch?v=H0Xbmfais1E&feature=fvsr

- Vodka distribution warehouse:
  www.youtube.com/watch?v=V8ZmOgMlyRE&NR=1

Storage Rack Safety Standards, Maintenance and Inspection
Selective Pallet Rack

- Most common type of pallet rack and subject of ANSI – MH16.1
- Rack is arranged in one or a series of rows such that every pallet loaded on the rack faces an aisle
- Damage: front post, in the lower 5’
- Collapse: rare except for single rows

Storage Rack Safety Standards, Maintenance and Inspection
Drive In Rack

- Not in scope of ANSI-MH16.1
- Tunnel use for passage of lift truck to place pallets on rails
- Rails run the length of the tunnel on both sides
- Damage: rear frames and lower 8’ of all uprights
- Collapse: prone, especially if no transverse bracing

Storage Rack Safety Standards, Maintenance and Inspection
Push Back Racks

- Similar to selective rack except beam levels support system of tracks and carts allowing pallets to be moved to the rear (structure covered by ANSI MH16.1)
- Damage: usually only to the lower front post
- Collapse: rare
- Carts can hang up if not maintained
- Floor loading can be high — can warrant checking
Cantilever Racks

- Not covered by ANSI MH16.1
- Rack that usually consists of column with perpendicular arms used to support long items
- Damage: arms by dropping loads
- Prone to failure when constructed in-house
- Collapse: rare

Storage Rack Safety Standards, Maintenance and Inspection
Criterion for Needing Formal Review (ignoring IBC & MH16.1 rules)

Start

A

Is failure of the structure unlikely to cause serious injury or death?

Yes

B

Are installation requirements known (installers used) or are assembly instructions available?

Yes

C

Can the structural adequacy be easily determined by a layperson?

Yes

No

Structural Review Required

Storage Rack Safety Standards, Maintenance and Inspection
Conducting a Rack Inspection

- Checklist **must** be in your head
- Walk aisles slowly looking up and down
- Most damage is on the lower 5 feet of front post
- Don’t think “damage only”, also look for bad practices or root of problem
- Make sure documentation supports the configurations being inspected
Recording Your Findings

Clipboard and Worksheet Method

INSPECTION REPORT – STANDARD RACK

Area or Location:  

Date:  

Inspection By & Signature:  

<table>
<thead>
<tr>
<th>Location</th>
<th>Deficiency</th>
<th>Severity 1-10</th>
<th>Photo Number</th>
<th>Unload Year/No</th>
<th>Comments/Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

Inspectors Summary & Comments:

<table>
<thead>
<tr>
<th>Frame</th>
<th>Beam</th>
<th>Anchor Beam</th>
<th>Post</th>
<th>Screw</th>
<th>Nuts</th>
<th>Bolts</th>
<th>Caps</th>
<th>Inspect</th>
<th>User</th>
</tr>
</thead>
<tbody>
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</table>

Storage Rack Safety Standards, Maintenance and Inspection
Use of Inspection Sheet

Standard information on inspection

INSPECTION REPORT – STANDARD RACK

<table>
<thead>
<tr>
<th>Area or Location</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection By &amp; signature:</td>
<td></td>
</tr>
</tbody>
</table>

Try to use standard terms for describing items

Storage Rack Safety Standards, Maintenance and Inspection
### Use of Inspection Sheet

<table>
<thead>
<tr>
<th>Location/Slot</th>
<th>Deficiency</th>
<th>Severity 1-10</th>
<th>Photo Number</th>
<th>Unload Yes/No</th>
<th>Comments/Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
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**Inspectors Summary & Comments:**

- Photo if you think it will help
- Severity 10 is the worst case
- Use short form if easier
- Closest to the inspection item

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**Storage Rack Safety Standards, Maintenance and Inspection**
**Use of Inspection Sheet Abbreviations (optional)**

First digit is for primary classification of defect

<table>
<thead>
<tr>
<th>Frame</th>
<th>Beam</th>
<th>Assembly</th>
<th>Improper Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>damaged post/ column</td>
<td>damaged brace</td>
<td>damaged brace</td>
<td>damaged brace</td>
</tr>
</tbody>
</table>
Severity of Damage

- European (FEM) Method – generally **not** recommended (overly simplified)
- recommend you the evaluate structural affect of damage and assign a "severity index"

### European Damage Classification

<table>
<thead>
<tr>
<th>Tag Colour</th>
<th>Dimension 1</th>
<th>Dimension 2</th>
<th>Dimension 3</th>
<th>Action</th>
<th>Severity Index</th>
<th>CSA A344 Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>green</td>
<td>&lt;3 mm</td>
<td>&lt;5 mm</td>
<td>&lt;10 mm</td>
<td>requires monitoring</td>
<td>1 to 3</td>
<td>minor damage - requires repair</td>
</tr>
<tr>
<td>yellow</td>
<td>3 to 6 mm</td>
<td>5 to 10 mm</td>
<td>10 to 20 mm</td>
<td>requires quick response</td>
<td>4 to 6</td>
<td>not applicable</td>
</tr>
<tr>
<td>red</td>
<td>&gt;6 mm</td>
<td>&gt;10 mm</td>
<td>&gt;20 mm</td>
<td>requires immediate response</td>
<td>7 to 10</td>
<td>unsafe - immediately unload and put out of</td>
</tr>
</tbody>
</table>
10 Factors Influencing Severity Assessment

1. Reserve capacity of rack - overcapacity can affect ability to function while damaged
2. Severity of damage – how big is the dent or imperfection
3. Location on member or component – damage in specific location can severely weaken member
4. Failure mode – does damaged member continue to support the load
5. Structural redundancy – are there other members backing up member of concern
6. Load carrying function of member – does it carry load full time
7. Function of item damaged (e.g., for impact strength or sustain constant load)
8. Type of product stored – hazardous or high value
9. Seismic zone – are you in a high seismic zone
10. Location or use – near work stations or retail environment

Conclusion – assessing damage can be a difficult task and assigning severity will differ amongst users

Storage Rack Safety Standards, Maintenance and Inspection
Responding to Damage
Marking & Identifying

- Primary Item: circle item if applicable
- Optional field: initial of inspector or severity colour code
- Number indicating level or panel (optional)
- Location: Rear/Front/Left/Right

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Storage Rack Safety Standards, Maintenance and Inspection
Responding to Damage

!! Caution !!

Date Reported: 
Unload Levels: 

Report By: 
Description of Damage: 

Do Not Load Damaged Rack

– Wire tie signs at operator sight level work well

Storage Rack Safety Standards, Maintenance and Inspection
Structures 101: Rack Structures

**Columns (Posts)**

- Length of the column affects its buckling strength (increasing spacing lowers frame capacity)
- Moving a beam up reduces capacity
- Removal of a frame brace or strut greatly affects the frame capacity

Storage Rack Safety Standards, Maintenance and Inspection
Structures 101: Rack Structures

Beams

Beam Stress
- from single load is two times a uniformly distributed load
- is highest in middle of beam

Beam Deflection
- Maximum allowed is Length/180 i.e. 96”/180 = ½ ”

Storage Rack Safety Standards, Maintenance and Inspection
Structures 101: Rack

Bracing Function

- Diagonal braces convert sway forces into post loads
- Bottom brace is **most** critical
- Row spacer location improves structure performance

Storage Rack Safety Standards, Maintenance and Inspection
Structures 101: Rack
Single Rows Bracing

- Single rows tend to collapse at a rate that is 10 times that of double rows
- Bracing is especially critical in single rows
Row Spacers (not discussed in MH16.1)

- Recommended as they eliminate “single rows” that are susceptible to collapse

- Adjacent upright frame must be connected with row spacer (CSA A344.2, 11.4.1)

- Location addressed by (CSA A344.2, 11.4.1) – in a direct force line
Capacity Signage or Plaques

- Clause 1.4.2 of ANSI MH16.1 requires the user to display in one or more conspicuous locations a permanent plaque(s) stating the racks' capacity (minimum size 50 square inches).
- CSA A344.1 clause 7.3 is the equivalent and states “Owners institute training or procedures that will ensure the weight of loads placed in the racks do not exceed the load capacity.”
- Signs or a “plaque” are not effective unless they achieve the goal of ensuring racks are not overloaded.
Cross Aisle Ties and Anchorage

- H:D ratio exceeding 6:1 results in a 350 pound design force that results in the use of anchors.

- H:D ratio of 8:1 typically results in the use of cross aisle ties or an alternative engineered solution.

- Anchors still primarily resist shear from impact forces (except for high seismic zones).
Repairs and Corrective Action

- if repair is not relatively simple use replacement
- Liability is on the owner if repairs not approved by an engineer
- Complex repairs may be required in special circumstances
Repairs and Corrective Action Certification

- Versacold inquest primary recommendation was to have engineer approve major repairs
- Always have repairs individually certified

Storage Rack Safety Standards, Maintenance and Inspection
Planning Your Next Steps

- Set up rack inspection program to have staff conduct rack inspections at least monthly
- Ensure you have formal documents that establishes the capacity of your racks
- Arrange to have an annual rack inspection by a third party that has inspection experience and engineering support
- Make plans for having rack repaired (and certified) or damaged components replaced
- Consider the use of an annual certification cycle

Storage Rack Safety Standards, Maintenance and Inspection
Consider keeping your warehouse in compliance by using an annual cycle of events:

1st - validate capacity documentation
2nd - arrange a third party inspection
3rd - train staff to do monthly rack inspections
4th - repair or replace damaged components
5th - certify any rack repairs
Future concerns or questions can be emailed to:

tony@RNW.ca

Thank You!

Storage Rack Safety Standards, Maintenance and Inspection