Guidelines for the Assessment and Repair or Replacement of Damaged Rack – Version 2.0

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Preface

Rack Manufacturers Institute (RMI)

The Rack Manufacturers Institute (RMI), formed in 1958, is an independent incorporated trade association affiliated with MHI. The membership of RMI is made up of companies which produce the preponderance of industrial steel storage racks, welded wire rack decking, and related structural systems used in the USA.

RMI maintains a public website at www.mhi.org/rmi that contains information about storage racks and the RMI members including ordering information for literature and a section for frequently asked questions.

For over 35 years, RMI has initiated extensive product testing and research and development programs, which have resulted in most of the technical advances made within the U.S. codes and standards community pertaining to rack systems. RMI representatives also maintain seats on several code and fire safety bodies to further assist in advancing the state of the art in rack design and application.

RMI members prepare and conduct extensive educational materials and programs to create additional value for users of industrial storage racks and related products.

RMI members are committed to the principals of continuous improvement in both product design and application and in the highest professional and ethical standards of performance as embodied in the mission and work conducted within RMI.

All RMI members are seated on the RMI Engineering Committee, whose primary mission is to develop and maintain standards and other guidance documents that provide guidance for the design, installation, and use of rack systems. RMI, in conjunction with MHI, an ANSI-Accredited Standards Developer, is responsible for the publication of the following American National Standards:

- ANSI MH16.1-2012(R2019), Specification for the Design, Testing, and Utilization of Industrial Steel Storage Racks;
- ANSI MH16.3-2016, Specification for the Design, Testing and Utilization of Industrial Steel Cantilevered Storage Racks, and
- ANSI MH26.2-2017, Design, Fabrication, Testing, and Utilization of Welded-Wire Rack Decking.

All inquiries concerning this document or the RMI standards should be submitted to the MHI Director of Standards, c/o RMI Engineering Committee, 8720 Red Oak Boulevard, Suite 201, Charlotte, NC 28217, standards@mhi.org.

MHI

MHI is the largest material handling, logistics, and supply chain association in the United States. MHI offers education, networking and solution sourcing for members, their customers, and the industry through programming and events.

MHI is an Accredited Standards Developer with the American National Standards Institute (ANSI) and works with MHI members and industry groups to develop American National Standards for material handling equipment and applications.

MHI provides RMI with certain services and, in connection with this document and RMI standards, arranges for its production and distribution. Neither MHI, nor its officers, directors, or employees have any other participation in the development and preparation of the technical information contained in the standards or in this document.

Guidelines for the Assessment and Repair or Replacement of Damaged Rack

Information contained in this document is intended to be informative. Voluntary compliance to the guidance in this document is within the control and discretion of the user and is not intended to, and does not in any way limit the ingenuity, responsibility or prerogative of individual manufacturers to design or produce industrial steel storage racks that do not comply with these guidelines. The RMI has no legal authority to require or enforce compliance with these considerations. This document includes technical information to the user for their specific application. Following these guidelines does not assure compliance with applicable federal, state, or local regulations and codes. These considerations are not binding on any person and do not have the effect of law.

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In the interest of safety, all users of storage racks are advised to regularly inspect and properly maintain the structural integrity of their storage rack systems by assuring proper operational, housekeeping and maintenance procedures.

Users of industrial pallet rack systems rely on competent guidance to specify, test, design storage rack systems for their application. These considerations are offered as assistance to the storage rack planner and user. If a user refers to, or otherwise employs, all or any part of this document, the user is agreeing to follow the terms of indemnity, warranty disclaimer, and disclaimer of liability.

Disclaimer

FOREWORD. This Guideline was developed by RMI, an Industry Group of MHI and represents suggested practices and considerations for repairing or replacing damaged racks. It is intended to provide useful information and guidance for owners, users, designers, purchasers and/or specifiers of repairs to racks and rack systems. It is advisory only and should only be regarded as a simple tool that its intended audience may or may not choose to follow, adopt, modify, or reject. The following information does not constitute a comprehensive safety program, cannot guard against pitfalls in operating, selecting, and purchasing such a system, its repair or its replacement, and should not be relied upon as such. However, such a safety program should be developed, and an independent adviser should be consulted in doing so.

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1 Scope and Introduction

The Rack Manufacturers Institute (RMI) has developed this document to provide a reference for owners and operators of industrial pallet rack systems to define the proper steps for:

- conducting assessments and surveys of rack damage;
- reporting and record keeping of damage surveys and repairs on an on-going basis;
- evaluating a damaged rack system and developing engineering solutions for its repair or replacement; and
- installing solutions for repairs or replacements.

This document highlights the importance of industrial pallet rack safety and certain risks, if poor practices are followed, and addresses frequent questions that may arise during rack repair projects. This document expands upon information that is contained in ANSI MH16.1-2012(R2019), "*Specifications for the Design, Testing, and Utilization of Industrial Steel Storage Racks."* This document also references the RMI document, *"Considerations for the Planning and Use of Industrial Steel Storage Racks."* These documents are available from the RMI website: http://www.mhi.org/rmi.

It is the intent of this document to focus on the section(s) of the rack system that could be affected by damaged components or connections being repaired or replaced, and not to require that an entire system be evaluated in every circumstance.

Industrial pallet rack systems are highly engineered, high performance structures that are often exposed to product loads more than ten times the weight of the pallet rack system itself. Each component should have been designed, tested, manufactured, and subjected to rigorous quality controls to assure that it will safely withstand those demands. RMI recommends that owners install rack systems designed and installed in accordance with ANSI MH16.1-2012(R2019) and that owners following the guidance in the *"Considerations for the Planning and Use of Industrial Steel Storage Racks"* document when planning to install or utilize industrial pallet rack systems.

ANSI MH16.1-2012(R2019) contemplates certain factors of safety but does not include requirements that could be imposed as a result of post-manufacture damage. It is important that racks be regularly inspected and correctly maintained to retain the system's design capacity and factors of safety.

Owners of industrial pallet rack systems need short-term and long-term strategies for damage assessments, executing repairs, and recordkeeping.

Recordkeeping is a key consideration in ensuring a rack system's compliance to ANSI MH16.1-2012(R2019). When engineering design and repair records are maintained by the owner, they can be used by the rack repair provider to identify feasible repair options.

ANSI MH16.1-2012(R2019), Sections 1.4.2 and 1.4.4, state that rack installations require load application and rack configuration (LARC) drawings and plaques. Local building codes may also impose additional requirements.

Repair, replacement, or reconfiguration of rack systems could void manufacturer's warranties or guarantees because original equipment manufacturers (OEM) lack control over repair or replacement processes. Such a situation involving subsequent modifications could shift responsibilities for product liability from the rack system OEM to the rack repair provider or the owner.

A priority of any rack repair needs to be that when the repair is complete, the industrial pallet rack system complies with the requirements set forth in ANSI MH16.1-2012(R2019) to contribute to a safe working environment for personnel working near or in the system.

2 Definitions and Responsibilities:

rack repair – encompasses the process of returning a damaged rack system to its required design capacity and integrity. Repair work can include repairing or replacing the damaged rack components, as needed.

replacement – the act of substituting damaged rack system components with similar or identical components approved by the OEM during a rack repair activity.

component – a finished part consisting of members. For example, an upright frame is considered a component, while the pieces that are used to build the frame are considered members.

Load Application and Rack Configuration (LARC) drawings – drawings that show appropriate details of the rack structure and repair solution encompassing the section of the rack system that is affected by the repair.

owner – the party that is responsible for managing and maintaining the rack system, and whose responsibilities include:

- maintaining a safe pallet rack system;
- maintaining up-to-date drawings and engineering documentation;
- maintaining load capacity plaques;
- conducting regular inspections, as outlined in the *"Considerations for the Planning and Use of Industrial Steel Storage Racks"* document; and
- selecting a supervising engineer and rack repair provider if rack repairs are needed.

supervising engineer – a person who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated an ability to solve or resolve problems relating to the subject matter, the work, or the project., and whose responsibilities include:

- identifying the original manufacturer of the rack system and whether the system is ANSI MH16.1-2012(R2019) compliant, as applicable;
- reviewing system documentation to validate the capacity rating for the section(s) of the rack that is being repaired or replaced;
- developing an assessment protocol to identify and grade damaged conditions that should identify overloading or damaged conditions, that could render the system unsafe and that could require unloading;
- overseeing the scope and thoroughness of the assessment of damage repairs or replacement;
- designing and approving the repair protocol to address all conditions identified by the field assessor; and
- developing repair solutions that address the loads imparted on the damaged components (static, seismic, etc.), not just the strength of individual members being repaired. All work must comply with applicable state laws and building codes.

field assessor – a person who works under the direction of the supervising engineer capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them, with responsibilities that include:

- identifying the manufacturer of a rack system (where possible) and obtaining the system's documentation, if available;
- documenting a rack system's as-built fabrication if original engineering documentation is not available or if the rack system has been modified;
- reviewing the system's configuration and comparing it to the system's drawings (beam levels, loads, etc.).
- noting any variances from system drawings;

- identifying all areas of damage and recording the location of damaged components, based on instructions from the supervising engineer; and
- performing post-repair or replacement inspections and reporting the results, as required by the supervising engineer.

OEM – is the original equipment manufacturer of the racking system.

rack repair provider – is the responsible party for assessing and/or repairing the rack system or components including:

- reviewing drawings and repair solutions that the supervising engineer recommends;
- implementing the repair or replacement solution, as directed by the supervising engineer; and
- providing updated LARC drawings to the owner that incorporate proposed repairs or replacements, as directed by the supervising engineer.

3 Rack repair and replacement principles

The responsibilities of owners include:

- maintaining appropriate documents that reflect the design and engineering of the rack system;
- consulting with an appropriate rack design professional or engineer when moving, reconfiguring, replacing, or repairing rack systems; and
- maintaining a regular program for inspecting and maintaining racks as outlined in the *"Considerations for the Planning and Use of Industrial Steel Storage Racks"* document.

ANSI MH16.1-2012(R2019) can provide the technical framework that guides the design of rack repair solutions.

The repair process (assessment, design, and installation) should be overseen by a qualified rack design engineer (supervising engineer).

The assessment and design of rack repairs should address all loads that can be imparted on damaged members (static, seismic, etc.), not just on the specific members being repaired.

Rack systems are subject to applicable building codes. Rack systems lacking original engineering documentation must be evaluated in accordance with applicable building codes. If stamped and sealed calculations of the original installation are needed, but not available, the system must be evaluated in accordance with applicable building codes.

4 Risks of ignoring damage

Pallet rack systems which are properly designed, manufactured, installed, used, and maintained, can provide years of trouble-free, safe service. When properly used by careful, well trained forklift operators, rack should need little maintenance or repair.

When racks are damaged or improperly repaired, the load-carrying capacity of the structure may be reduced. Although a single instance of damage to the rack may not result in failure, severe or accumulated damage will reduce the capacity of the system and may ultimately lead to its collapse.

The cost of rack collapses may far exceed the value of the entire rack structure and could lead to:

- injury or loss of life;
- loss of product;
- loss of business and business interruption;
- large cleanup and replacement expenses; or
- litigation.

As the cases in Table 1 show, inattention to rack safety or improper rack repair could result in failure of the rack system.

Table 1. Sample incident and cause summaries

Summary of incident	Cause of incident
• Location: A food industry company warehouse. • Consequences: A worker was fatally injured. • Summary: A temporary pallet rack collapsed, and the loads fell on the worker seated next to the pallet rack.	• Failure of a pallet rack upright frame following repair work involving the butt welding of two portions of a column. • The supplier did not establish any inspection procedure for the rack components before it was delivered and installed at the customer's premises. • Inadequate repair method that failed to consider the quality of the steel used and the racking manufacturer's recommendations. • Impact between the lift truck and the pallet rack.
• Location: A food industry wholesaler warehouse. • Consequences: A worker was fatally injured. • Summary: A pallet rack collapsed following an indirect impact between the lift truck and an upright frame column.	• An unprotected upright frame column was struck by a hand-operated truck that encroached on the main aisle. This rack was struck by the lift truck driven by the worker."

Examples of rack system collapses resulting from improper maintenance are shown in Figure 1.

Rack damage might not be noticed or might be ignored because the rack structure continues to remain standing. Examples of damaged rack where the rack system remained standing are shown in Figure 2. In each of these examples, the damaged rack systems should be assessed and repaired or replaced, as directed by a supervising engineer.

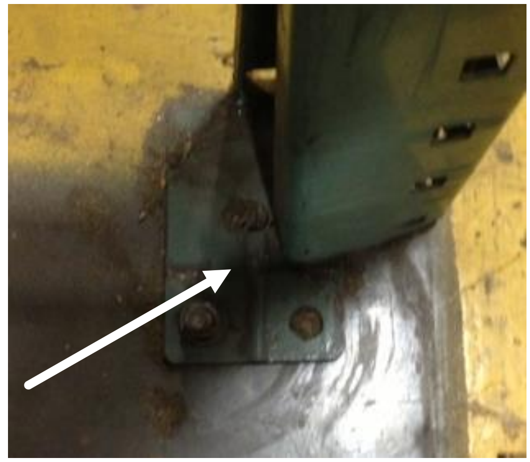
In some cases, repairs to damaged rack systems are attempted without consulting a supervising engineer. Owners should avoid attempts to repair rack despite possibly having personnel or resources in their facility to attempt repairs. Without proper engineering oversight, there is no proof or assurance that the repair is sound and will yield a safe operating system. Examples of attempts at repairs deemed to be unsafe are shown in Figure 3. In these instances, an attempt at a repair was made, but a supervising engineer subsequently inspecting the attempt at repair recognized that the repairs had not been properly designed, causing a potentially unsafe condition. The improper repairs were removed and properly repaired.

Rack damage was ignored

Rack collapse led to the surrounding building's collapse

Figure 1. Examples of collapses caused by rack damage

Missing diagonal



Sheared anchor; footplate separated from column

Damaged upright column

Damaged column with home-grown repair

Damaged beam

Damaged upright column

Figure 2. Examples of damaged rack where the rack system remained standing

Unsafe field welding repair

Defective field welding

Figure 3. Examples of ineffective attempts at repairs

5 Repair options

5.1 Replacement

Replacement of damaged rack components with identical parts approved by the OEM is recommended when the OEM can be identified and when original or revised engineering documentation is available.

When load-bearing components of a rack structure are replaced with components that are not identical, the owner should request an engineering evaluation to evaluate the loads on the replaced components.

5.2 Interchanging components

RMI recommends against interchanging components, such as uprights or beams with similar looking components from other OEMs because such components might not be compatible or interchangeable with the OEM rack system. If components from multiple manufacturers are used, appropriate testing would need to be performed to validate that the capacity of the industrial pallet rack system has not been affected. Replacement of load-bearing components is not recommended without first performing an engineering evaluation that incorporates the loads on the rack structure, including the components that have not been replaced.

5.3 Repair kits

In some situations, it can be economical or advantageous to remove the damaged section of an upright and to replace it with a component from a pre-engineered rack repair kit.

Such kits are typically bolted or welded in place and anchored to the floor. When designing the kit, a supervising engineer needs to evaluate the configuration and loading of the existing rack at the location of the damage, considering the loads imparted on the damaged component, and not just on the particular member being repaired. Each load configuration needs to be evaluated separately. The repair kits need to be engineered to meet applicable building codes.

5.4 Component straightening

Component straightening should not be considered as a repair technique unless it is expressly approved by the supervising engineer. If a repair solution requires bending or straightening damaged components, the straightening process needs to be conducted in a manner that ensures that the appropriate load-carrying properties of the steel, including the effects of residual stresses, are maintained in the repaired member.

5.5 Welded field repair

Where replacement or repair kits are not an option, the owner could choose to perform a welded field repair on a rack system. Any field repairs should be supervised by a supervising engineer and welding should be performed by a certified welder so that the work is performed in accordance with applicable American Welding Society (AWS) standards. (Refer to Annex A for additional risks associated with field welding.)

6 Repair assessment

6.1 General

ANSI MH16.1-2012(R2019) requires that all damaged rack be isolated and evaluated by a supervising engineer prior to repair or replacement of the damaged components.

A major challenge in developing an effective repair program for racks is to ensure that the repairs or replacements are performed to a uniform, engineering-driven standard with supporting documentation that establishes that good practices were followed. Because of the long lifecycle of rack systems, such documentation can pose special challenges for owners because many rack systems are moved, reconfigured, repurposed or changed in some way from what was originally designed and installed.

Performing a proper assessment of damage can be more complicated than simply fixing the worst damage. Any process of assessing damage to a rack system needs to be conducted under the direction of a supervising engineer. This does not mean that the supervising engineer has to perform the assessment; however, the supervising engineer should approve the assessment process and protocol and should communicate regularly with the field assessor to ensure that the appropriate information is sufficiently documented for a complete evaluation of the repair.

Repair programs can be constrained by budgets or the temptation to repair only the worst damage. All damage that the supervising engineer concludes should be repaired ought to be implemented to assure the rack system is brought back into compliance with ANSI MH16.1-2012(R2019).

6.2 Best practices

6.2.1 Projects with original engineering drawings and documentation

For projects with original engineering drawings and documentation:

- validate that the rack is in the location identified in the engineering documentation; and
- validate that the rack system has not been reconfigured from the original drawings.

If there is no change from original drawings: If there is no change to the rack system, the field assessor can readily document all instances of damage and can present the results of the survey to the supervising engineer, who can develop appropriate repair solutions. Appropriate steps for inspection are included in Section 6 of the *"Considerations for the Planning and Use of Industrial Steel Storage Racks"* document.

If stamped and sealed calculations are required: If stamped and sealed calculations are not available from the original project, the system would need to be evaluated under current standard and Building Code requirements (as required by law) and new stamped and sealed calculations would need to be created.

If the rack system's configuration has changed, but documentation has not been updated and the system has not been relocated to a new facility: The supervising engineer could calculate the capacity of the system based upon codes that were in effect when the system was installed.

6.2.2 Projects with missing or no documentation:

Efforts should be made to locate documentation and calculations, because this is normally the easiest way to demonstrate compliance with the standard.

If the original documentation is not available, a supervising engineer should be selected to develop an assessment process, to supervise the preparation of the engineering package, and to approve the engineering packaging when the assessment is complete. The assessment process encompasses collecting all relevant information needed by the supervising engineer including, but not limited to:

- the identity of the rack system manufacturer;
- the number of affected parts;
- rack construction;
- the sizes of affected members;
- the properties of materials;
- gauges;
- spacing;
- elevations;
- loads;
- anchoring; and
- slab.

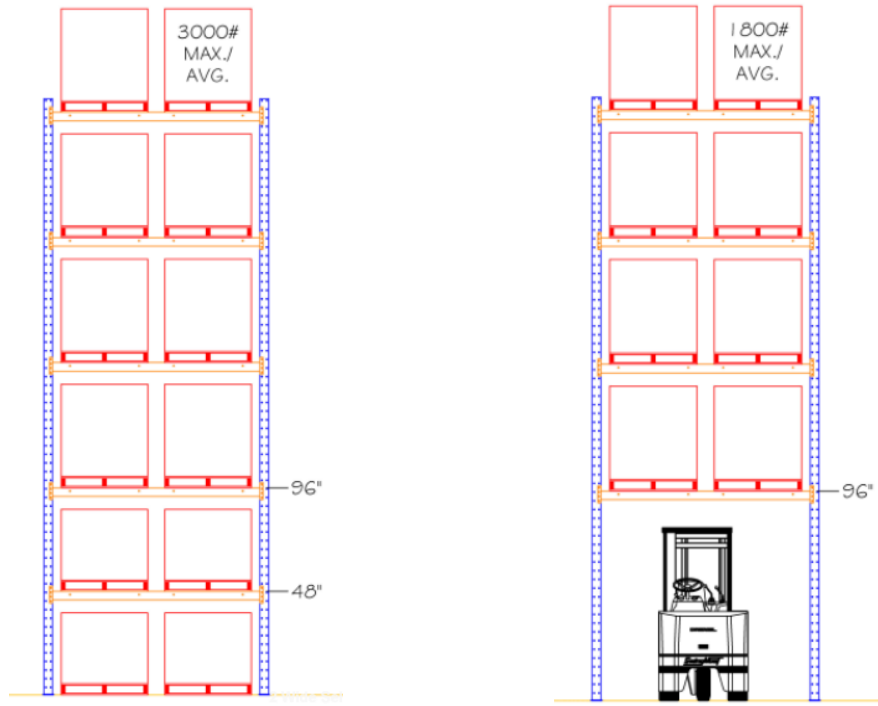
Based on the protocol that the supervising engineer develops, the field assessor should document all damage and present the results of their survey to the supervising engineer. The supervising engineer should develop repair solutions.

7 Repair of a rack system versus repair of a rack component

When repairing rack systems, the supervising engineer would need to evaluate the loads imparted on the damaged component, not just on the specific member being repaired. This evaluation is especially important with older systems that could have been moved or reconfigured during their lifetime.

The following example shows how a seemingly simple reconfiguration can dramatically reduce the load capacity of a system and can create a significant safety risk.

> *An owner reconfigured a rack without engineering oversight, as shown in Figure 4. The owner's maintenance department removed the lower level of a push-back rack system to allow for additional clearance for forklifts to drive under the rack to place floor-level pallets.*
>
> *The owner did not realize that this reconfiguration reduced the capacity of the rack system from 3,000 lbs. (1,360 kg) per pallet to 1,800 lbs. (820 kg) per pallet because the unsupported span of the uprights was increased. The owner continued to store 3,000 lb. (1,360 kg) pallets on the system, thereby exposing forklift operators driving under a system that was loaded 66% over its rated capacity.*



Original Configuration

3,000 lb. (1,360 kg) per pallet capacity

Modification

1,800 lb. (820 kg) per pallet capacity

Figure 4. Example of a rack system modification

An engineering review of the system conducted before the modification was implemented would have identified this capacity change. An engineering change could have been performed on the rack system to modify the system while maintaining the original load capacity.

Owners, manufacturers, and rack repair suppliers should not rely only on experience or history when planning or executing rack repair. It is critical to first ensure that the original system meets applicable codes and safety requirements before repairs are begun. If this step is ignored, the rack repair provider could repair or replace a damaged component but leave other parts of the rack system in a non-compliant if, for example, the system was overloaded. Careful review by a supervising engineer is imperative.

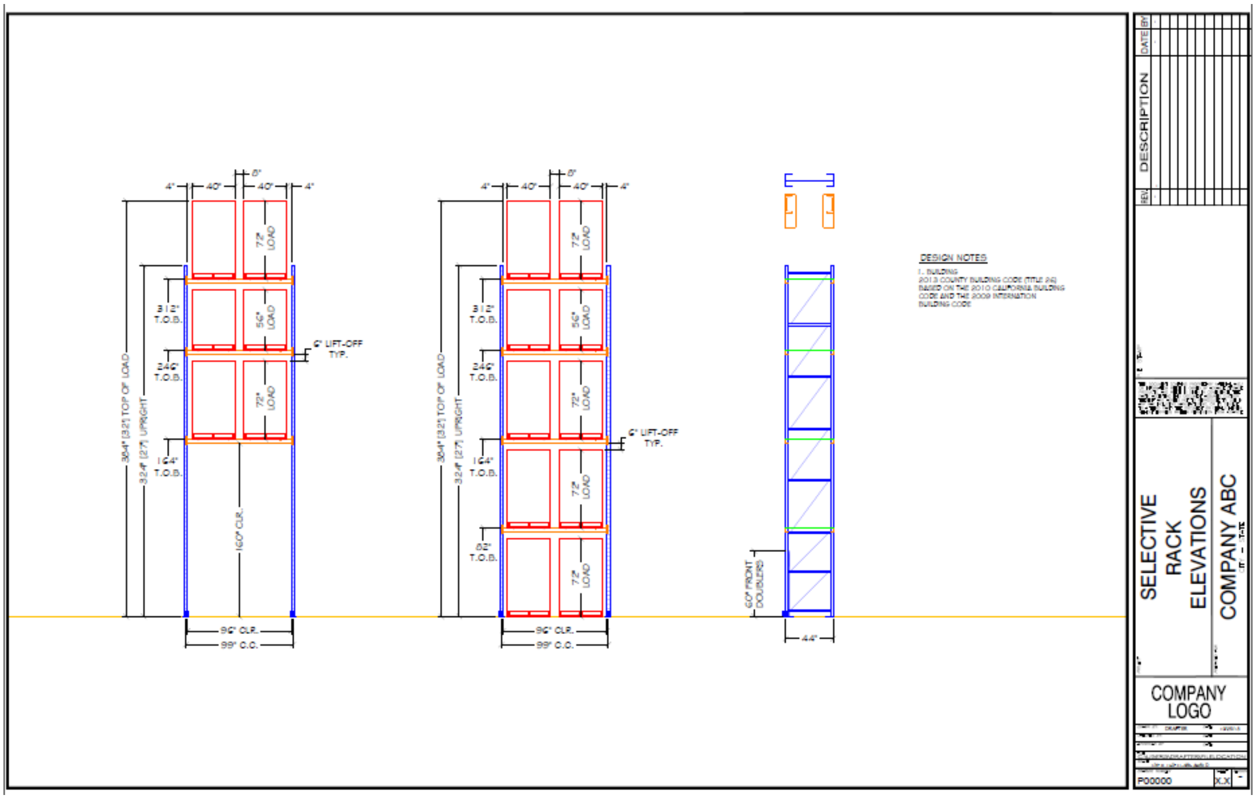
8 Engineering

8.1 Drawings and maintaining proper documentation:

8.1.1 LARC drawings

If the existing LARC drawings are not available, new LARC drawings showing the load capacity of the repaired system should be created, as shown in Figure 5. The supervising engineer should approve such drawings before repairs are begun. LARC drawings should provide clear information defining the repair or replacement, as well as, configurations of bays or sections affected by the repair or replacement.

Notice should be conspicuously depicted on LARC drawings showing that the supervising engineer is to evaluate any deviations from the drawings and that any deviation may impair the safety of the rack system. (reference: ANSI MH16.1-2012(R2019), Section 1.4.5).



*Note that design loads and beam elevations are clearly identified

Figure 5. Example LARC drawing

8.1.2 Load capacity plaque

As specified in ANSI MH16.1-2012(R2019), Section 1.4.2, the owner is responsible to ensure that load capacity plaques are conspicuously displayed in one or more prominent locations. If there are any modifications to the rack configuration, the capacity plaques need to be updated and reinstalled. Sample load plaques are shown in Figure 6.

8.2 Technical requirements

8.2.1 Load requirements

The supervising engineer shall review the maximum loading capabilities of the system with the owner. If appropriate, the supervising engineer should determine all external loading requirements of the rack structure, including product load, wind load, snow load, rain on snow surcharge, snow drifting, seismic load and dead and live load from structures supported by the storage rack and more. The necessary strength and stiffness of the members and connections shall be determined by structural analysis for the appropriate load combinations (ASD or LRFD, as required by ANSI MH16.1-2012(R2019) Section 2.1 or 2.2, respectively).

8.2.2 Component requirements

The components affected by the repair or replacement shall meet all the material and design requirements of ANSI MH16.1-2012(R2019), which details component design requirements. Sections 8.3 through 8.5 in this document cover components that are not mentioned in the ANSI MH16.1-2012(R2019) but are important and unique to the repair of storage racks.

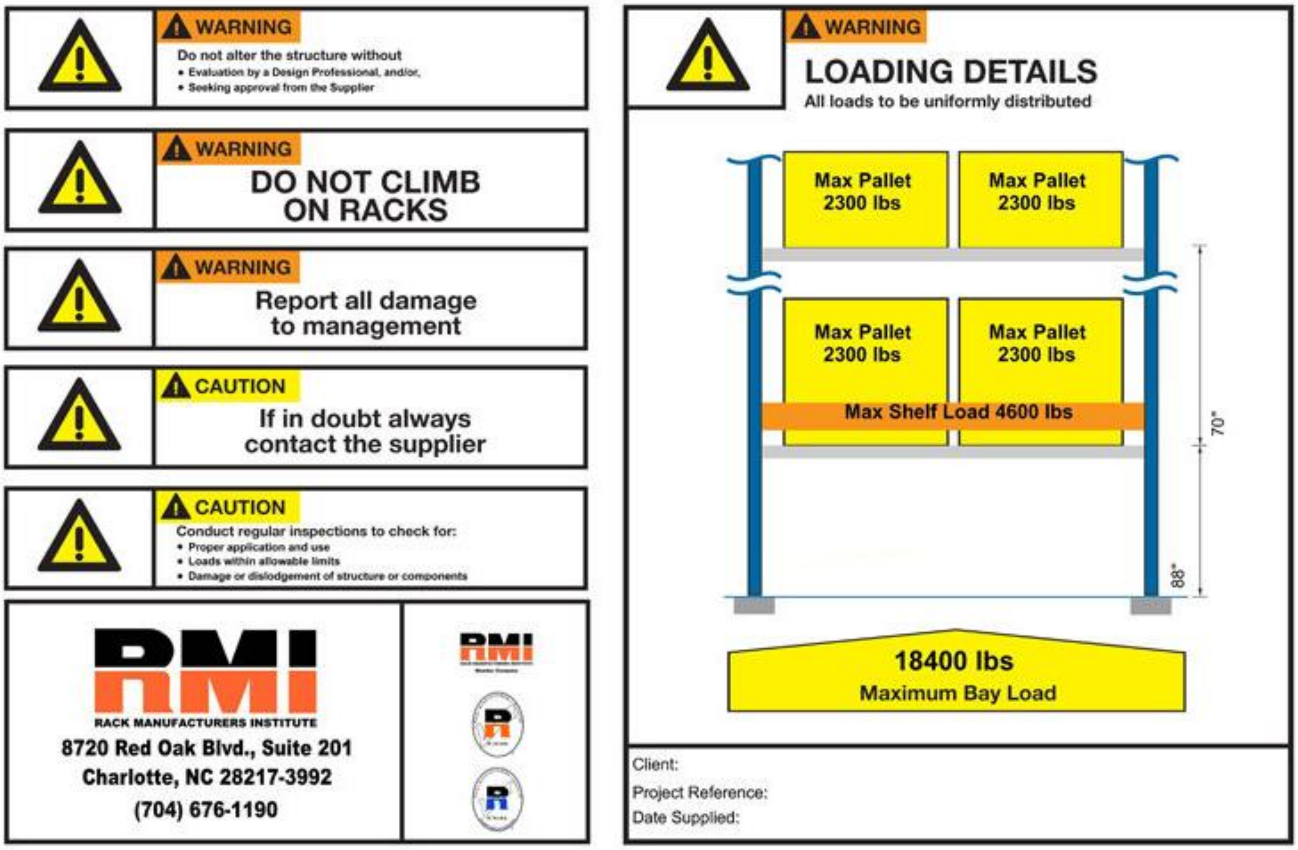


Figure 6. Sample load plaque

8.2.3 Testing requirements

When testing is deemed necessary, the supervising engineer will approve and oversee the test procedure. Tests should use components from the existing system, repaired components, and replacement components. The tested components from the existing system should be representative of the components being repaired. This testing can be done in any facility acceptable to the supervising engineer, and the testing records shall be maintained by the supervising engineer.

8.3 Column

8.3.1 Column splice

If it is necessary to repair a column segment with a new section, a splice may be used to join the two components. The continuity of the load path across this splice joint is critical to the structural integrity of the repair.

The column splice needs to meet the loading requirements of the applicable loading combinations in ANSI MH16.1-2012(R2019) Section 2.1 or Section 2.2. The splice connection shall be evaluated for the following factors including, but not limited to:

- column axial force;
- flexural buckling;
- torsional buckling;
- flexural-torsional buckling;
- column bending strength; and

- column bending stiffness.

The supervising engineer needs to determine whether the repair kit design requires full contact on the bearing horizontal surface to ensure continuity of load path across the splice joint. Refer to 9.3.

8.3.2 Column baseplate

A column baseplate might have to be replaced with a new plate, particularly if a column needs to be re-anchored and old hole locations are no longer accessible. The bending stiffness of the base joint could be critical to the success of the repair.

The column base plate needs to be shown to meet the loading requirements of the applicable loading combinations in ANSI MH16.1-2012(R2019) Section 2.1 or Section 2.2. The base connection shall be evaluated for the following factors including, but not limited to:

- the column downward axial force;
- the column uplift;
- the base joint bending strength; and
- the base joint bending stiffness.

If replacement anchors cannot be reinstalled in the same place relative to the column, a new location would need to be designed and evaluated. Replacement anchors shall be installed in the same hole or a new hole not less than 3 times the larger anchor diameter from existing anchor holes, whether the holes are empty or contain the remnants of old anchors. If existing anchor holes are filled with “dry-pack mortar” and the mortar has set for at least 7 days, replacement anchors may be placed not less than 1.5 times the diameter of the largest anchor from existing holes.

When welding new base plates onto existing frames, field welding risks discussed in Annex A should be addressed.

8.4 Bracing continuity

Original frame bracing generally provides a continuous load path to the supports. Repair of that bracing needs be shown to establish a satisfactory replacement of the original load path.

The design of the repaired bracing system with an evaluation of the repair kit and the existing structure needs to ensure that stability and force requirements meet ANSI MH16.1-2012(R2019), Section 2.4. Frame bracing and its connections to the column need to be shown to have the necessary strength and stiffness to support the column axial and bending load. All replaced or repaired frame bracing needs to be capable of carrying this load.

Consideration needs to be given to compression bracing members that have discontinuities or splices.

8.5 Shelf beams

8.5.1 Shelf connection

The shelf beam-to-column connector of conventional racking is the primary joint that stabilizes the storage rack columns in the down-aisle direction. These connections vary widely from manufacturer to manufacturer. Each original equipment manufacturer is required to test its connector with its column in to comply with ANSI MH16.1-2012(R2019).

If a shelf needs to be replaced, the supervising engineer shall obtain (or develop through testing) the beam-to-column test results that are for the specific combination being used and shall incorporate that data into the design of the repair solution.

8.5.2 Lateral bracing of beam

Beams (particularly open sections) that are bent about their major axis are subject to lateral buckling. If the replacement beams are open sections, the design shall account for this buckling, or adequately brace the compression flange. Long, tubular-type sections may also need lateral bracing to prevent spreading.

9 Installation

9.1 General

This Section addresses considerations that are unique to rack repair or to replacement installations. For general guidance, refer to ANSI MH16.1-2012(R2019) and the *"Considerations for the Planning and Use of Industrial Steel Storage Racks"* document.

9.2 Straight and plumb

The first factor to check is whether the loaded rack structure that is being repaired is plumb and within tolerances that are established by the supervising engineer. ANSI MH16.1-2012(R2019), Section 1.4.11 calls for a minimum plumbness and straightness (both cross and down aisle) of 0.5 in. per 10 ft of height. If the structure's plumbness or straightness is out of tolerance, it needs to be plumbed and straightened as part of the repair process. After completion of the repair work, the plumbness and straightness of the repaired rack when loaded needs to be verified as being within tolerance for the entire height of the frame (repaired section + original frame members).

9.3 Repair kit splice joint cut tolerances

In cases where a section of an existing rack structure is removed and replaced with a repair kit, the tolerances for the splice joint specified by the supervising engineer need to be maintained in the field. The kit design may require that the existing rack column rest directly on the horizontal surface of the repair kit to achieve full rated capacity. (In these cases, the connecting bolts might not have sufficient capacity to carry the load themselves). If there is a gap between the existing column and the repair kit, the gap needs to be shimmed as specified by the supervising engineer. When the repair kit does not require bearing on the horizontal surface, the bolted or welded connections need to be strong enough to transfer the load into the splice sleeve and back into the lower column member. In this case, the gap may not need to be filled.

9.4 Working on loaded rack

In some cases, it is possible to repair a damaged rack while it is still loaded by using a jack that is attached to the rack column above the damaged section. Such a jack would temporarily relieve the rack column of the load, allowing the repair work to be completed without having to unload the rack. When using such a jack to support the loaded rack, the jack and its attachment to the column needs to have a capacity capable of supporting the actual load on the rack structure. The lifting device needs to be designed and validated for such an application by a qualified engineer. Special considerations to address include:

- Floor conditions need to be considered when selecting a jacking method. For example, jacks that rely on friction to remain in place might not be appropriate for certain floor conditions.
- When a front column is supported by a jack and the existing bracing sections are removed to install a repair kit, the rear column's unsupported height could increase significantly, which could reduce its capacity. The Supervising Engineer would need to evaluate the load that the unbraced rear column will have to support during such a repair.

9.5 Anchoring repaired rack

The supervising engineer should consider the location of existing anchor holes and should design the kit for repair or replacement for proper anchoring. It is not acceptable to leave repaired rack unanchored.

9.6 Reuse of hardware

New fasteners are recommended in lieu of reusing existing fasteners. Fasteners shall be tightened in accordance with the requirements set forth in ANSI MH16.1-2012(R2019) or by the OEM.

Annex A – Field welding risks

Although field welding could seem to be a fast and economical option in repairing a damaged rack system, there are several risk factors that should be reviewed before moving forward.

Fire Risk:

The welding process will throw off sparks and embers into the area immediately surrounding the work, which may include flammable materials. This has often resulted in catastrophic fires and product damage. If field welding is the only option, the repair supplier needs to follow all appropriate fire safety procedures. Consult OSHA standard 29 CFR 1910.252(a) for more detail.

Weld Contamination:

As required in D1.1/D1.1M, Section 8.5.1, *Base-Metal Condition*, "..The portions of such surfaces which will be welded shall be thoroughly cleaned of all foreign matter including paint for at least 2 in [50 mm] from the root of the weld."

When racks are manufactured, the environment where welding is performed is controlled so that the welds meet engineered design requirements. In a field situation where a painted product is welded, the surface where welding is to take place needs to be cleaned to bare metal so that there is no contamination of the weld metal which could otherwise result in a weakened weld or hydrogen embrittlement, which could lead to a weld failure.

Operating Temperature:

Welding processes generally assume that the welds are made in relatively narrow operating temperatures. When a welded solution is necessary to pallet racks that are used in cooler or freezer environments, it is incumbent upon the repair provider to ensure that weld techniques for low temperature implementation including ensuring proper ventilation (heating of the material may be required) are followed. Welding in freezers is generally discouraged.

If field welding is necessary, the supervising engineer would need to provide a qualified or pre-qualified procedure for the weld joint that meets appropriate AWS standards.

Welder Certification:

Welder certifications are limited to specific skill sets that the welder has demonstrated and are often not transferrable. A welder who is certified for making a fillet weld in a flat position may not be certified (or have the skill) to make a fillet weld in a vertical or overhead position that may be necessary to affect a proper repair. A welder should present documentation of his certification to execute the welding procedure specified by the supervising engineer.