PALLET RACK SYSTEMS
DESIGN CRITERIA & SEISMIC CONSIDERATIONS

The design and implementation of pallet rack systems has become increasingly complex in recent years. This is due in large part to the advent of sophisticated handling equipment, such as very narrow aisle (VNA) turret trucks. Rack system specifications and tolerances are much more stringent when integrated with these advanced handling technologies. This is particularly true when high bay elevations and/or automation are employed.

Additionally, the options regarding rack configuration have been greatly expanded. Selective rack, drive-in rack, drive thru rack, push back rack, double deep rack, and pallet flow rack are among the many styles available.

Each rack design has inherent advantages and disadvantages. Your operational requirements will often mandate the use of a particular system type or combination (i.e.: selective rack offers unobstructed access to each pallet, however, the trade-off is a loss of storage density in comparison to other systems.) As a rule, there is an inverse relationship between density and selectivity. Some of the more dense storage systems are not well suited to first in/first out use (FIFO), while flow thru rack guarantees FIFO. A thorough analysis of your storage and retrieval requirements and operating constraints must be performed before you can seriously address rack system design criteria.

Decisions regarding rack construction also must be considered. There are two major categories of rack components; hot rolled structural steel or cold roll-formed types. The structural steel variety is much more resistant to damage as a result of lift truck impact, however, this added durability and safety are achieved at an incrementally higher cost (usually about 5-10%).

To further complicate these issues, many governing bodies throughout the country require that rack system design and installation comply with locally adopted building codes. As such, they must be engineered to withstand seismic activity (earthquakes). In many cases this means that a seismic analysis of the rack system design must be performed by a licensed engineer to meet the code requirements for your particular seismic zone. The United States is divided into seismic zones and many states have portions of several zones within their borders. The zones, which are numbered 0, 1, 2a, 2b, 3, and 4, are designations which indicate the likelihood of an earthquake occurring and its probable length and intensity, based on the area's proximity to fault lines. The higher the zone number, the greater the probability of seismic activity and the more stringent the engineering requirements for man - made structures (including rack systems, shelving, mezzanines, conveyors, etc.).

Not all pallet rack designs will meet seismic requirements. As a rule of thumb, seismically rated rack systems carry an increased cost of approximately 10-15% vs. non - conforming rack designs. Do not assume that newly manufactured rack, which may have been fabricated to R.M.I. (Rack Manufacturers Institute) or A.I.S.C. (American Institute of Steel Construction) standards, will be acceptable for the intended loading under seismic conditions. Simply described, seismically designed pallet rack (in addition to correctly sized members, bracing patterns, connections, welding, and anchoring methods) will have a period (pattern of motion) which is substantially different from the period of the earth's movement. This specifically designed period is intended to cancel (or counteract) seismic movement and allow the system to ride out the quake. A seismic study for rack systems should include down aisle and cross aisle calculations as well as column axial loads and bending

moments.

Why all this concern over earthquakes and the structural integrity of rack systems, particularly in areas of the nation that are not at high risk? Let's examine the facts. Warehousing and distribution centers have employed technological advances which yield greater storage density (primarily achieved by increased height and narrowed aisles). Over the past several years there has been a notable rise in the number of rack system collapses, although seismic activity is rarely the cause of such structural failure. It is much more likely that a series of pre-existing (man-made) conditions caused the rack structure to be inherently unstable.

Forensic engineers conclude that lift truck damage, overloading, or inadequately engineered systems account for nearly all rack failures. One or more of the above factors can cause the center of gravity to shift away from the center of the rack column and compromise structural integrity. As the center of gravity shifts further from the column center (at the baseplate), this “offset” subjects the column to a bending moment, which creates horizontal force on the column pushing it towards the load center. The column deforms and the load center continues to shift further away from the column center, creating an even greater moment. This cycle (called micro - shifting) continues until the rack structure becomes so unstable that a relatively minor impact may trigger a major collapse.

With this in mind, it may be prudent to take a good long look at your existing rack structures. Columns should not be deformed from impact and the loads should not cause a deflection of beams (bending) greater than 1/180th of the span (after unloading, the beam deflection should return to its normal position). As an example a 96" long beam should not deflect more than approximately 1/2". These two indicators of obviously dangerous conditions are visual. Many other potential problems that cannot be identified with the naked eye may still exist. If in doubt, secure the services of a professional to assess the structural integrity of your rack systems.

It is safe to assume, however, that government authorities responsible for establishing and enforcing building codes, have chosen to apply seismic requirements to rack structures simply as a preventive measure (perhaps driven by insurance underwriters) against catastrophic loss.

It is highly recommended that you investigate local requirements for pallet rack engineering in the early planning stages of your project. Even within a given state and county, there can be drastic differences in the interpretation of the building codes by individual municipalities. Your local building subcode official should be able to guide you in this respect. It is advisable to ask for all code requirements in writing to avoid future problems.

Additionally, depending on the commodity type, density, and elevations, in-rack fire suppression (sprinklers) and fire baffles may be necessary. Specialized systems such as high-bay very-narrow-aisle (VNA) turret truck designs may also require "superflat" (f100) concrete floors in order to insure proper operation. In a nutshell, now more than ever, careful research and planning is a prerequisite for a safe and productive design.

GROSS &ASSOCIATES