

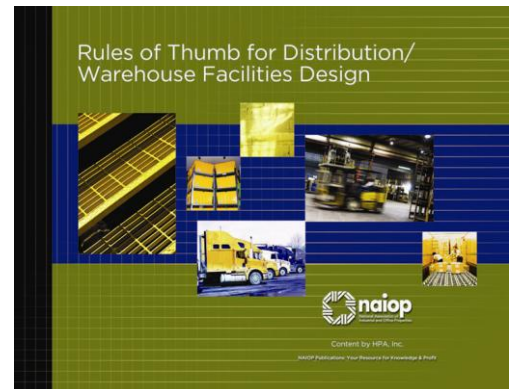
# HPA, Inc. White Paper

## Supersized Distribution Facilities

(Want fries with that?)

Perhaps it's the Darwinian forces of evolution, or maybe the marketing lure of 'supersizing', or even a discounting of the old adage "size doesn't matter". At any rate distribution facilities keep getting bigger; wider, longer, and taller.

HPA penned a book for the NAIOP in 2005 with the snappy title *Rules of Thumb for Distribution/Warehouse Facilities Design*. In it we discuss, among other things, the issues of structural bay spacing and clear height in relation to optimizing rack system layouts for different types of material handling equipment. While everything we said in 2005 is still relevant and for the most part accurate, our work with the increasing trend towards really large facilities with over a million square foot footprint has provided some new insights on the structural bay and clear height issues associated with these supersized buildings.



We want to look at three primary issues:

- Is there a significant capacity gain for a user by moving from 32' clear to 36' clear?
- What are the impacts of operating at 36' on fork lift equipment and racking layouts?
- What are the limitations in a 36' clear building regarding ESFR systems?

HPA has found that there are positive outcomes in these issues but also a few caveats. If it is desired to continue the trend to continued higher 'cube' utilization, 36' clear is a good target with some tradeoffs.

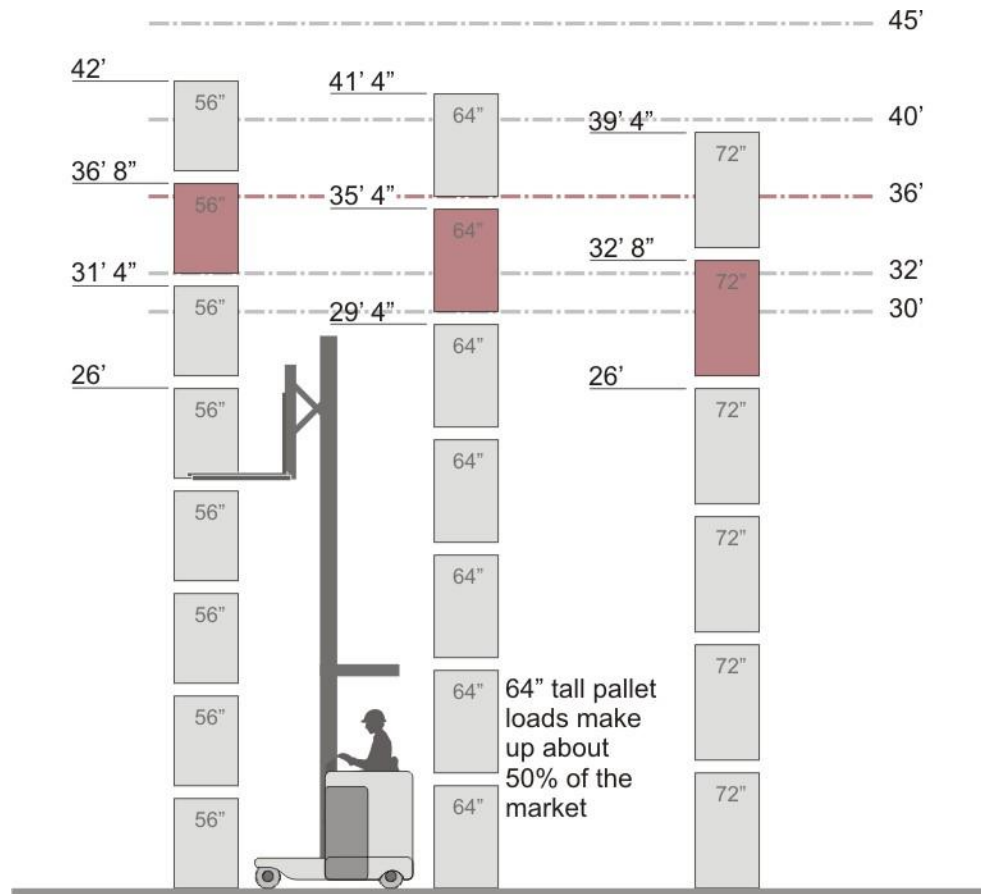
In the NAIOP publication we outlined the reasons why HPA has recommended a 52' or 54' structural bay to optimize potential racking layouts in distribution facilities. In this paper we would like to extend that discussion to show why we are now looking at a 56' structural bay and a 36' clear height for the supersize distribution buildings we are designing today. We also want to include an update to the fire suppression table published in the NAIOP book to include the current NFPA approved technologies.

## Pallet stacking and clear height

How high is the right height?

Palletized storage is a pretty customized world when it comes to load heights. There are almost as many load heights in use as there are operators. Luckily for us however, putting pallet loads onto racks requires some standardization in the module of the racking itself. It turns out that almost half the racks currently manufactured for high pile palletized storage use a bar to bar vertical dimension of 72". They accommodate pallet load heights of up to 64". The two second most configured racks have 64" and 80" bar modules corresponding to 56" and 72" pallet loads.

We think that there are opportunities for maximizing the 'cube' of today's large scale distribution facilities by moving up to 36' clear over the currently popular 32' clear. Here is a diagram of pallet stack heights related to building clear heights.



This diagram and the following table summarize the three most utilized pallet rack configurations, showing how high the top of the last pallet load is for each. The diagram is to scale and shows a ten foot distance between the stacks which as we will see later is a preferred aisle width for swing reach trucks lifting to these heights.

***Pallet stacking heights table***

Pallet Load Height	56"	64"	72"
Rack vertical module	64"	72"	80"
Number of pallets in rack			
4	20'-8"	23'-4"	26'-0"
5	26'-0"	29'-4"	<b>32'-8"</b>
6	31'-4"	<b>35'-4"</b>	39'-4"
7	<b>36'-8"</b>	41'-4"	46'-0"

The middle column represents around half of the rack configurations currently manufactured. In a 32' clear building it shows you can stack 5 pallet loads high. If you are in a 36' clear building you can get an extra load and stack 6 high for a 20% increase in pallet positions.

The third column shows that with 72" pallet heights you can stack 4 high in a 32' clear building. Stacking 5 high is just a bit above 32', but you can argue that with normal roof slopes a significant portion of the building could be stacked 5 high. In fact a portion of that building could even be stacked 6 high. A 36' clear building ensures that all of the building could be stacked at least 5 high totaling 25% more pallet positions.

Back at the first column we see that with a 56" pallet load height you can stack 6 high in a 32' clear building. Stacking 7 high puts us just above 36', but as alluded to in column 3, you could likely stack a significant portion of a 36' clear building 7 high and achieve 12% more pallet positions.

**It appears that there is a clear opportunity for most users to increase the pallet capacity of a building footprint by 12% to 25% by going to a 36' clear height over a 32' clear height.**

## The structural bay spacing

How does the extra height impact aisle width and structural bay spacing?

The math we examined in the 2005 publication relating pallet loads, pallet racks, forklift configurations, and flue spaces remains pretty much the same. We continue to recommend 52' and 54' structural bays in most facilities but there are additional considerations as we get higher. In the following discussion we will be talking about clear aisle widths which are about 6" smaller than the steel to steel rack aisle itself.

The most prevalent current rack layout we see is a 3 aisle, 6 rack module generating minimum 8'6" aisles in the 52' bay and 9'-2" aisles in the 54' bay. There are millions of square feet of this type of rack layout in our buildings, but most of our buildings are 30' to 32' clear.

As we said in 2005, as you go over 30' clear and extend the racking height, operating lifts in the aisles takes a bit more room and the 54' spacing makes for quicker lift operation. This becomes even more of a consideration when going over 32' clear and we should look closely at lift truck operations in the aisles of 5, 6, and 7 high stacked pallet racks.

Most operations in a 36' clear building will be utilizing narrow aisle reach truck equipment. If you look at the spec sheets for Crown and Raymond, the two largest manufacturers of these lift trucks; you will see that the lifts are about 9 to 10 feet long tip to tail. An immediate question arises: How can a 9 foot long truck turn to pick up a pallet in an aisle 8'-6" wide?

The trick is in the actual operation of reach trucks. They can pivot into selective rack installations and not have to square up 90 degrees before putting the forks into the load. As a result of this pivot movement, a reach truck operates efficiently in an aisle only 8'-6" wide. This generates a very efficient layout in a 52' column bay. If you like a little more elbow room a 54' bay will give you a 9'-4" aisle. A table at the end of this section compares different column bays for aisle widths and total aisles achievable in specific building lengths.

So, how do we determine an efficient width for aisles in a 36' clear building that has load pickup heights of up to 400"?

You get very detailed and examine the mast extension configurations and battery compartment dimensions of the equipment able to generate reasonable capacities to lift pallets almost 34' off the floor. These considerations begin to add up and an 8'6" aisle simply won't work if a user is stacking to the capacity of a 36' clear building.

**Working with Raymond and Crown we have determined that a minimum 10'-0" clear aisle is required to utilize reach truck equipment to operate at the maximum heights affordable in a 36' clear building.**

To generate these 10' aisles the bay spacing needs to grow from our previous recommendation of 52' and 54' to 56' or even 58'. The table below shows the aisle widths and total number of aisles in various building lengths for the 4 different structural bay sizes.

<b>Building length</b>	<b>structural bay size</b>			
	<b>52</b>	<b>54</b>	<b>56</b>	<b>58</b>
<b>500</b>	27	27	24	24
<b>800</b>	45	42	42	39
<b>1000</b>	57	54	51	51
<b>1200</b>	69	66	63	60
Aisle width'	8.67	9.33	10.00	10.67
Aisle width"	104	112	120	128

One of the caveats we have alluded to comes into play in the increased aisle widths as the reach truck equipment increases mast and battery compartment requirements to make the lifts at around 35'. Looking at the above table, you can see that there are theoretically 3 more 9'-4" aisles in a 1,000 foot long building than 10' aisles. In practice, a rack layout that spans the entire building with minimum aisles is very rare.

## Building height and ESFR systems

How does the extra height impact the design of an ESFR fire suppression system?

We put a table out lining the NFPA fire suppression requirements for high piled storage into the 2005 publication that is now somewhat obsolete. It essentially shows that conventional ESFR systems were limited to 35' storage heights. That is no longer true. NFPA section 13 now allows the following ESFR configurations.

### Required pressure at sprinkler head specified by NFPA 13 (2012)

For class I-IV and cartoned unexpanded plastics

40' deck height allows 35' maximum storage height, 45' deck is 40' maximum storage ht.

Max deck Ht	K-14.0 head	K-16.8 head	K-22.4 head	K-25.2 head
30	50 psi	35 psi	25 psi	15 psi
35	75 psi	52 psi	35 psi	20 psi
40	75 psi	52 psi	40 psi	25 psi
45	in rack required	in rack required	40 psi	40 psi

There are now two ESFR configurations using K-22.4 or K-25.2 heads at 40 psi that allow maximum storage heights of 40' under a maximum 45' high deck. These configurations are what would be used in a 36' clear height building.

There is, however, a caveat with this deck height and ESFR configuration. A small percentage of the users in distribution facilities have a commodity defined as exposed (uncartoned) unexpanded plastics. This commodity requires the additional protection of in-rack sprinklers to store higher than 6' in a building where the deck is 45' high. With the in-racks, this commodity can be stored up to 25' high. This is not a limitation in a building with a 40' deck where this commodity could be stored under the general ESFR system up to 25' high. So while a 36' clear building can accommodate exposed unexpanded plastics, the costs of doing so will exceed the costs of doing so in a 32' clear building.

## **The proposed 36' clear height building configuration**

We started off looking at the trend to larger distribution buildings and focused in on what clear height provided the most options for users to maximize capacity. We think that currently an optimal approach to a flexible super-sized distribution building is to design for 36' clear height, 56' structural bays and ESFR with K-22.4 heads at 40 psi. There is a caveat in that this proposed building would require in-rack sprinklers to store exposed unexpanded plastics at 25'.

- **A 36' clear building allows most users to achieve a 12% to 25% increase in pallet positions.**
- **ESFR configurations approved by the NFPA allow two different designs to accommodate storage heights to 40' and deck heights to 45' on the large majority of commodity types.**
- **Reach fork lift equipment configured for load picking heights of 34' require 10' aisles and we recommend 56' or 58' structural bays to correspond.**

