1. Reliability
2. Parts availability
3. Consistent servicing
4. Life expectancy of the truck
5. Price
6. Servicing intervals
7. Fuel source
8. Appearance of the truck
9. Brand name of the manufacturer.

RACKING/SHELVING

This equipment is used for storing products and goods. To illustrate the main aspects to be considered, we shall examine the common application for the storage of pallets. The principles involved here can then be applied to all other products requiring alternative forms of racking and shelving.

If pallet racking is not being used, then an alternative is block stacking of pallets, where each pallet is placed on top of others. Clearly there can be issues here on product crushing/damage and on access where, for example, in a large block stack of different products, the pallets in the middle of the block stack cannot be readily accessed.

Selecting racking

The following will have to be considered:

- Pallet (or for the product being stored):
  - size
  - type
  - construction
  - capacity
  - security
  - stability.

- Handling equipment:
  - type
  - maximum lifting height
  - dimensions/aisle width.

- Storage area:
  - dimensions
  - type and construction
  - floor loading, capacity
  - obstructions, exits, stairs, etc.
  - floor fixing facilities.

- Goods:
  - type
  - frequency of movement and access.

- Safety:
  - fire protection requirements
  - fire exits.

- Specialist requirements:
  - equipment
  - accessories
  - protective.

There are many different types of racking available, and the key features are given below and in Table 5.3.

Adjustable pallet racking (APR) is the most common type of racking. It is adjustable with the horizontal beams between the vertical uprights, the uprights being fixed securely to the floor. Accordingly, with APR, different pallet heights can be accommodated, but different length/width dimensions cannot be covered by adjustments to the beams as the length/width is determined by the floor area fixed upright positioning. Adjustments to the beams are not easily made, however, as the beams are solid structures held securely by pins that need to be manually moved and repositioned. Clearly the beams/racking must be empty while this is being done.

Table 5.3 Different types of racking available: key features

Feature	Adjustable pallet racking APR	Drive in racking DIR	Live racking and powered mobile racking PMR	High bay
Floor storage space utilisation: This can be critical as it reflects the use of the floor area/square metres, which is often a basis for charging of the warehouse structure	30–40%	80%	70%	70–90% (High bay warehouses can be built higher than other warehouses; subject to planning permissions)
Speed: Time is often a critical factor and the ease of access is involved here	Very good	Good (one way)	Very good (one way) but PMR can be slow due to time in moving the racks	Very good
Stock rotation	Easy	Very good (one way)	Very good (one way)	Easy
Stock visibility	Easy	Limited	Limited	Easy
Order picking access	Very good	Limited	Good	Very good
Mechanical handling equipment type: These are needed to access the racking	Standard	Standard	Specialised or bespoke	Bespoke

As stated above, with APR the floor space utilisation is low as APR needs relatively wider aisles to allow product access. This can be overcome by using *drive in racking* (DIR), which effectively can be thought of as block stacking with racking. DIR is a 'solution' for getting good floor space utilisation with no product crushing, but can still create problems for product access, as the product is 'in' the racking. The product has to be placed in/out of the racking by fork-lift trucks and a skilled positioning is needed as there are no wide aisle space tolerances.

One way to help to overcome this can be with *live racking* (so called as pallets move in the racking). After pallets are positioned at the end of the racking by, for example, a fork-lift truck, the movement in the racking is facilitated by having a structure that permits movement horizontally down the racking by incorporating rollers on which the pallet slides. The movement can be with gravity with, say, a 4% slope, or the pallets can be moved by powered rollers. The choice depends on individual company requirements and on safety requirements at a maximum speed of 0.3 metre per second. Live racking can be used to 'automatically' position pallets on a First in–First out basis and also position pallets in another part of the warehouse.

The following case study illustrates usage of live racking.

CASE STUDY 5.1: LIVE RACKING AT BMW

Pallet live, carton live and mobile line side live-storage are all features of the investment that will help the plant to achieve a 39 second cycle time for engines to support the BMW group's production network. The production of the engine requires a supply of 400 000 varied components to assembly lines every day.

Hams Hall is a pristine, state-of-the-art manufacturing and assembly facility for BMW's 1.6 1.8 and 2 litre, four-cylinder 'Valuetronic' petrol engines, with highly automated operations that adhere to the principles of lean, JIT production.

'Our storage and component delivery systems have to support a truly 21st-century enterprise,' says Hughes of BMW, 'a floor plan was devised for our "small container supermarket" comprising nine

aisles of pallet live storage, providing 110 pallet pick locations, each with a reserve pallet location and a single tier carton live storage, above the empty pallet return system services each bay for efficient pallet return, safety and minimal congestion at the pick face.'

The feed sides face on to wide aisles, replenished by electric fork-lift trucks operating from a conveyor feed from an auto store, while special commissioning vehicles operate in narrow aisles fronting the pick face.

'The components within the bays are positioned in such a way as to allow the components to be picked sequentially, exactly in the order that they will be required at the production line. There is no need for pick vehicles to back up or travel along the feed aisles,' says Hughes.

Inside the main assembly hall, engine sub-assemblies are delivered to work stations by AGV's (automated guided vehicles). At these stations, line side live units are an integral part of a pick-to-light system. Ergonomics are a key consideration and the minimal motion required of operators at each station is immediately noticeable.

'The main live storage installation services our slow moving components which on average draws between one and two boxes of a particular part number, per hour' explains Hughes. 'Fast moving components are delivered to the line by pallet-load.'

A consideration when specifying the project was that the storage system could keep pace with increasing complexity as various engine derivatives are introduced into the build schedule. The static carton live bays will eventually take many channels each and there is capacity to put at least 300 part numbers through the system, which should satisfy long-term projections for the plant.

Source: Industrial Handling and Storage, October/November 2001. Reproduced by permission of Quartz Publishing and Exhibitions.

Powered mobile racking (PMR) is racking that is fitted onto rails in the floor. A whole rack is then powered along the rails and opens up access down the now opened aisle into the, effectively, normal pallet-racked areas. Once access has been made, that aisle of racking is closed. The advantage here is that within a given space, more pallet spaces can be

fitted against the trade-off of a slower non-instant access to each aisle. There is also a cost impact as PMR requires an adequate power system with very precise installation.

The 'ultimate' racking is that found in *high bay* warehouses. Indeed, often the warehouse structure can be totally supported by the racking in a so-called 'rack-clad' structure. This form of high bay racking has fully automated access with automated fixed cranes. Effectively these are very sophisticated, narrow aisle multi-level riser/side movement fork-lift trucks which do not require any manual driver operation. Such operations are purposely designed and operate within tight tolerance clearances with bespoke equipment and ICT planning and controls.

Finally, a brief summary of the racking options available for palletised goods is given below. The main objective is to minimise pallet movement while maximising storage capacity.

For limited pallet access:

- Is block stacking feasible? (= low cost)
- Drive in/drive through racking?
- Live racking? (= higher cost)

For random access of pallets:

- APR? (= low cost)
- Powered mobile racking?
- High bay? (= higher cost)

Once the type of racking is determined, the next to be considered is the height and length of the row/run/racking. Consideration is given here to the lift heights of equipment, rack height limitations, building limitations and legislative aspects such as fire regulations and the health and safety requirements.

APR rack lengths of around 25 to 30 metres favour good flow movements with gaps as needed to give cross gangway access. Finally the direction of entry of fork-lift blades into pallets – the short side or the long side – will have to be agreed as this impacts on the turning circle in the aisles and, therefore, affects the aisle widths.

THE AISLE WIDTH DECISION

We noted earlier that fork trucks are restricted in the size of aisle widths in which they can operate. The minimum aisle widths for 1.2 metre pallets are given in Table 5.4. It is also important to check specific details as the table gives only 'typical' details and the minimum aisle widths assume the use of 1 × 1.2 meter pallets and short-side pallet handling by the fork-lift truck. Accordingly, if different sized pallets are being handled, then these need appropriate adjustments. The major problem with pallet sizes is where mixed pallet sizes are handled, for example, with Euro pallets of 1200 by 800 mm. Here the option taken is often one where the larger size of pallet being used will then determine the racking aisles width. Alternatively, separate areas for different sized pallets will be required. Should the UK ever fully adopt the Euro standard, then the vast majority of existing warehouse racking and equipment will need to be re-examined and potentially reconfigured.

With the space saving of narrow aisle/very narrow aisle (NA/VNA) equipment, it could be envisaged that all warehouses should have them. However, wider aisle options are still viable, especially in warehouses that require much movement. As the aisle widths narrow, then speed slows. Wide aisle trucks enable the picking of pallets from racking and loading to a trailer immediately, combined with fast travel speeds. They also operate at lower costs. So, wide aisles give more flexibility.

Moving to narrow aisles gives greater storage density. The varied capacities can be seen in the comparisons given in Table 5.5, which have been calculated using an identical normal rectangular open area sized warehouse with different internal racking types installed. These are figures for this specific warehouse only, but the principles are valid when assessing storage density.

Storage density

With narrower aisles, slower travel speeds with slower putways/pickup times are found. Additionally normal NA/VNA equipment cannot load trailers, although the hybrid articulated fork-lift trucks can. Additionally