

МИНИСТЕРСТВО ОБРАЗОВАНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ

**УЧРЕЖДЕНИЕ ОБРАЗОВАНИЯ
«БРЕСТСКИЙ ГОСУДАРСТВЕННЫЙ ТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ»**

КАФЕДРА ЭКОНОМИЧЕСКОЙ ТЕОРИИ И ЛОГИСТИКИ

КОНСПЕКТ ЛЕКЦИЙ
по дисциплине «Логистика складирования»
на английском языке

Брест 2021

УДК 338.2

Методические указания предназначены для студентов экономического факультета БрГТУ и студентов заочной формы обучения специальности «Логистика». Целью методических указаний является оказание помощи студентам в процессе работы на практических и лабораторных занятиях и повышения эффективности самостоятельного изучения дисциплины «Логистика складирования» на английском языке.

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ПРЕДИСЛОВИЕ

Конспект лекций по дисциплине «Логистика складирования» направлен на углубление понимания теоретических положений дисциплины и выработку практических навыков в обеспечении оптимального функционирования логистической инфраструктуры применительно к складу.

Настоящий конспект предназначен для студентов экономического факультета и студентов заочной формы обучения специальности «Логистика». Целью методических указаний является оказание помощи студентам в процессе работы на практических и лабораторных занятиях и повышения эффективности самостоятельного изучения курса на английском языке.

Курс «Логистика складирования» изучается в соответствии с учебным планом и утвержденной программой, как одна из базовых дисциплин специальности «Логистика».

Конспект лекций ориентирует студентов на глубокое изучение дисциплины «Логистика складирования», на выработку навыков самостоятельного анализа логистических процессов на складе и принятие решений, способствующих повышению эффективности функционирования склада.

Конспект включает материал по ключевым темам дисциплины.

TOPIC 1: THE ROLE OF THE WAREHOUSE IN SUPPLY CHAIN

1. Definition of Warehousing

Warehousing is the process of storing goods which are to be distributed later. A warehouse is defined as any place which is used in the accumulation of goods.

Warehousing is important for businesses that import, export, transport and manufacture goods. Having a central location for your products gives you control over your products and helps you ensure that your customers receive their orders on time. Keeping everything organized in one place can also save you money and boost your productivity. Let's take a look at some of the things that warehousing can do for your inventory process

Warehousing enables you to store, ship, and distribute your goods from one single location. This makes it easy for you to track and manage your inventory efficiently. It can additionally reduce your transportation costs, increase your flexibility and reduce your staffing needs.

Warehousing allows for timely delivery and distribution of your products, thereby increasing labor productivity and customer satisfaction. Warehousing helps reduce errors, damage to your goods and prevents it from getting lost or stolen during your order fulfillment process helping you deliver your goods on time and increasing your brand value in your customers' perception.

Warehousing is an insured process, which means if your products get damaged or stolen, you will receive compensation to help you replenish your stock. Storing goods in a temperature-controlled warehouse protects them from spoilage and prevents unwanted changes in color or texture.

Warehousing logistics is at the core of any business that sells physical goods. A few of the most important elements of warehousing include warehouse management, warehousing operations, and warehouse management systems.

1. Warehouse management

Warehouse management is the strategic day-to-day running of operations in a warehouse to promote, improve, and ensure operational excellence. Managing a warehouse means overseeing all staff, training, inventory, equipment, safety and security, relationships with shipping carriers, and other moving pieces.

Responsibilities include:

- Forecasting and managing projected volume and labor
- Ensuring the proper safety gear is used and best safety practices are followed at all times
- Obtaining the proper licenses and certifications for anyone operating equipment
- Maintaining compliance and requirements for regulatory agencies
- Continuously planning and managing operations as the business grows and becomes more complex
- Keeping goods secure and accessible and performing warehouse audits as needed
- Providing clear instructions on how to receive, unpack, retrieve, pack, and ship inventory
- Setting up bins and other storage spots in optimal places to minimize the effort required to move between destinations

- Recording all inbound and outbound shipments and collecting the proper documentation

2. Warehouse operations

Warehousing operations refers to the processes that take place in a warehouse revolving around the movement of goods and tracking inventory.

Principles of warehousing include functions such as receiving inventory, then placing each SKU into a separate dedicated storage location (e.g., in a shelf, bin, or on a pallet), and sending product to its next destination.

Efficient warehousing operations help keep:

- Costs low
- Inventory received and shipped on time
- Staff productive
- Sufficient quantities of product on hand
- Space below capacity
- Storage optimized and aisles clear
- Equipment used effectively
- Customers happy

3. Warehouse management systems

A warehouse management system (WMS) is a type of software that provides the tools necessary to manage warehouse operations and inventory movement to save time and eliminate manual processes. Warehouse management systems help optimize inventory storage and tracking, warehousing operations, workload distribution, and shipping.

2. Warehousing benefits

Warehousing is just one part of an effective logistics management system for businesses, but without it, businesses are likely to face all sorts of problems.

A warehouse's value is sometimes exactly what you think – for sorting goods and keeping them safe and secure.

But equally, there are some less obvious social and economic benefits to having a warehouse, so they have a bigger role than you think in the logistics of a business.

1. Inventory control

By having a warehouse, it is much easier for businesses to manage a large amount of inventory. Warehouses can help when a company needs to match supply with demand in a fast-changing environment.

So if you're trying to get more organised and improve the success of your UK logistics, warehousing is a great place to start.

2. For economic reasons

Because of their efficient operations, warehouses offer many economic benefits to businesses, which is a key reason to invest in one.

Costs such as transportation, outbound delivery and shipping are massively reduced with a warehouse. Also, by building up products in a warehouse, as mentioned above, you have a buffer in the supply and demand of these goods, which can only be a good thing for the profit of your business.

3. Centralising the products

With all its products in one place, a business will have a much easier time of receiving, storing and distributing its goods.

This also reduces transport costs associated with the business as staff at the warehouse can organise the goods straight from the premises, including identifying, sorting and dispatching.

4. An emergency buffer

Warehouses have an unusual role in maintaining the integrity of a business. Why? Because if an emergency strikes, such as faulty products or delays to transportation, the business has spare goods in stock to turn to.

5. Adding value

Warehousing is just one part of an efficient logistics system. All goods are kept together in one place, available to access whenever the time is right. They are there, ready, for other necessary activities to take place, such as order consolidation and mixing products. They are also a key part of the packing and shipment stages of logistics.

6. Keeping goods safe

This is a pretty obvious one, but a warehouse's role is also to protect a business's goods. Warehouses have both security personnel and excellent security technology to ensure sites can't be accessed without permission.

3. Classification of Modern Warehousing Complexes

There are several types of classification systems on the warehousing property market. The one most commonly used is the classification developed by Knight Frank Co. This classification divides all warehousing facilities into four main classes: A (divided into subclasses A+ and A), B (divided into subclasses B+ and B), C and D.

Class A+

1. A modern one-storey warehousing facility of light metal structures and sandwich panels, preferably rectangular in shape, without pillars, or with at least 12 m space between pillars, and bay space of at least 24 m.
2. Area covered by buildings – 40-45%.
3. Flat concrete floors with anti-dust coating, and carrying capacity of at least 5 tons/sq. m, raised 1.2 m above ground.
4. Ceilings at least 13 m high, allowing installation of multi-level rack equipment.
5. Adjustable thermal mode.
6. A fire alarm system and an automatic fire-fighting system.
7. A ventilation system.
8. Security alarm and video surveillance systems.
9. Stand-alone electric power plant and heating unit.
10. Sufficient number of automatic dock shelters, with adjustable dock levelers.
11. Areas for longtime heavy vehicle parking and a car parking lot.
12. Sufficient space for heavy vehicles to maneuver.
13. Office rooms available in the warehouse building.
14. Utility rooms available in the warehouse building (such as lavatories, shower rooms, backrooms, changing rooms for personnel).
15. Personnel check-in and check-out system.
16. Fiber optical telecommunications.
17. Developed premises, well-lit, fenced off and patrolled round the clock.
18. Location close to the central highways.
19. Professional management system.
20. Experienced developer.

Desirable, but not mandatory conditions:

1. Railway line.

Class A

1. A modern one-storey warehousing facility preferably rectangular in shape, without pillars, or with at least 12 m space between pillars, and bay space of at least 24 m.
2. Area covered by buildings – 45–55 %.
3. Smooth concrete floors with anti-dust coating, and carrying capacity of at least 5 tons/sq. m, raised 1.2 m above ground.
4. Ceilings at least 10 m high, allowing to install multi-level rack equipment.
5. Adjustable thermal mode.
6. A ventilation system.
7. A fire alarm system and an automatic fire-fighting system.
8. Security alarm and video surveillance systems.
9. Sufficient number of automatic dock shelters, with adjustable dock levelers.
10. Areas for longtime heavy vehicle parking and a car parking lot.
11. Sufficient space for heavy vehicles to maneuver.
12. Office rooms available in the warehouse building.
13. Utility rooms available in the warehouse building (such as lavatories, shower rooms, backrooms, changing rooms for personnel).
14. Fiber optical telecommunications.
15. Developed premises, well-lit, fenced off and patrolled round the clock.
16. Location close to the central highways.
17. Professional management system.

Desirable, but not mandatory conditions:

1. Railway line.
2. Experienced developer.
3. Personnel check-in and check-out system.
4. Stand-alone electric power plant and heating unit.

Class B+

1. A one-storey warehousing facility, preferably rectangular in shape, newly built or reconstructed.
2. Area covered by buildings – 45-55%.
3. Flat concrete floors with anti-dust coating, and carrying capacity of at least 5 tons/sq. m, raised 1.2 m above ground.
4. Ceilings at least 8 m high.
5. Adjustable thermal mode.
6. A fire alarm system and an automatic fire-fighting system.
7. Sufficient number of automatic dock shelters, with adjustable dock levelers.
8. Security alarm and video surveillance systems.
9. A ventilation system.
10. Areas for longtime heavy vehicle parking and a car parking lot.
11. Office rooms available in the warehouse building.
12. Utility rooms available in the warehouse building (such as lavatories, shower rooms, backrooms, changing rooms for personnel).
13. Fiber optical telecommunications.
14. Developed premises, well-lit, fenced off and patrolled round the clock.
15. Location close to the central highways.

Desirable, but not mandatory conditions:

1. Professional management system.
2. Experienced developer.
3. Personnel check-in and check-out system.
4. Stand-alone electric power plant and heating unit.
5. Railway line.

Class B

1. A one- or multi-storey warehousing facility, preferably rectangular in shape, newly built or reconstructed.
2. In case of two or more storeys, enough freight lifts/hoists with at least 3 tons lifting capacity must be provided for.
3. Ceilings at least 6 m high.
4. Floors: asphalt or concrete, no coating.
5. Heating system.
6. A fire alarm system and a fire-fighting system.
7. A ramp to unload vehicles.
8. Areas for heavy vehicle parking and maneuvering.
9. Security around the premises.
10. Telecommunication.
11. Security alarm and video surveillance systems.
12. Utility rooms available in the warehouse building.

Desirable, but not mandatory conditions:

1. A ventilation system.
2. Office rooms available in the warehouse building.
3. Personnel check-in and check-out system.
4. Stand-alone electric power plant and heating unit.
5. Railway line.

Class C

1. Permanent industrial building, or an insulated hangar.
2. Ceilings at least 4 m high.
3. Floors of asphalt or concrete slabs, no coating.

Desirable, but not mandatory options:

1. In case of two or more storeys, freight lifts/hoists must be provided for.
2. Gate at elevation zero.
3. Areas for heavy vehicles parking and maneuvering.
4. A ventilation system.
5. A heating system.
6. Office rooms available in the warehouse building.
7. A fire alarm system and a fire-fighting system.
8. A ramp to unload vehicles.
9. Security around the premises.
10. Telecommunication.
11. Utility rooms available in the warehouse building.
12. Railway line

Class D

1. Basement premises or civil defense facilities, cold industrial premises or hangars.

Desirable, but not mandatory conditions:

1. Areas for heavy vehicle parking and maneuvering.

2. A fire alarm system and a fire-fighting system.
3. A ventilation system.
4. Telecommunication.
5. Security around the premises.
6. Railway line.

TOPIC 2: THE MATERIAL FLOW AND PACKAGING

1. Packaging

Product packaging has a significant impact on the sustainability of the supply chain as a whole.

There are three main types of packaging:

Primary (sales) packaging. This is the packaging around a product at the point of purchase by the user/consumer. Examples include bottles, tins, plastic covers or wrapping.

Secondary (grouped) packaging. This packaging groups a number of items together until the point of sale. Examples include an inner or outer box and strapping which binds a number of items together.

Tertiary (transport) packaging. This packaging allows handling and transportation of a number of grouped items as a single unit load. Over recent years the mainstays of returnable transit packaging (RTP), the wooden pallet and the metal stillage, have been joined by many other forms of RTP. These include plastic pallets, tote boxes and metal cages.

There are many reasons for reducing packaging costs. These include:

Lower packaging costs mean higher profits.

Waste minimization benefits your own company and the environment. By carefully segregating its waste into cardboard, plastics and general waste, one food contract packaging company reduced its waste removal costs by

45 % and is now recovering approximately 30 % of its packaging. It is possible to significantly reduce packaging costs and cut waste levels by implementing relatively simple measures, many with low or no associated costs; or, if there is a cost, payback is relatively quick.

Taking action on waste packaging will:

- increase overall profitability;
- increase staff awareness of environmental and cost-saving issues;
- develop closer relationships with suppliers and customers through shared benefits and cost savings;
- reduce the use of finite resources;
- reduce the volume of waste going to landfill;
- reduce product damage;
- enhance environmental performance;
- promote a better company image;
- meet current and future obligations under packaging waste regulations at least possible cost.

Packaging design

Although the majority of waste initiatives begin at the design stage and are mainly the concern of the production department, the warehouse can have a significant influence on the amount of packaging used.

When designing product packaging there needs to be an input from the warehouse operation. For example, secondary packaging needs to fit the actual pallet dimensions. Any overhang on the pallet can lead to packaging damage, an increase in the amount of stretch wrap required and potential issues when the product is put away in the racking.

Pallets

Although the mainstay of transit packaging over many years, the pallet can be replaced or at least augmented by other forms of tertiary packaging. For example, an alternative to the use of pallets where the products are lightweight in design include slip sheets and corrugated trays. Not only do they reduce the use of wooden pallets but they are lighter, take up less space in a container, for example, and are significantly cheaper, especially in circumstances where pallets are not returned.

However, if your operation necessitates the use of pallets there needs to be a process in place to track and recover pallets. A current client is spending in excess of €800,000 on wooden stillages that are left at customer premises. In such cases alternative methods of encasing and transporting the product need to be evaluated. These can include collapsible metal stillages which, although more expensive to produce initially, can be returned for reuse without significantly reducing the back-loading abilities of the delivery vehicles.

Utilizing recycled pallets can have a number of advantages over new pallets. They are likely to be cheaper and potentially stronger as a result of seasoning, which increases the strength of the wood. They are also exempt from packaging waste regulations.

Plastic pallets which are recyclable are also a potential alternative albeit they take more energy to produce, are more expensive at the outset and will require a robust system to track their whereabouts.

Stretch wrap

Suppliers can end up using excessive stretch wrap to stabilize product on a pallet. Alternatives include banding. Although a capital purchase, stretch-wrap machines can reduce the usage of wrap and make the unit load more stable.

Cartons

As with many of the topics we have discussed in relation to the warehouse operation, packaging again results in trade-offs.

A significant trade-off is the strength of the packaging and potentially less damage versus the additional cost of the packaging. A current client is having to replace packaging received from the Far East on a regular basis as a result of substandard cardboard.

When picking individual items from secondary packaging there is going to be a surplus of cartons. Where possible, cartons should be reused.

The replacement of cardboard packaging with plastic totes is possible. However, a robust system of tracking and tracing the equipment needs to be in place. Some companies are now embedding RFID chips into their reusable packaging.

Labelling

When labelling product in the warehouse it is advisable not to use paper labels that cannot be easily removed. Some plastic re-processors will not accept plastics contaminated with paper.

2. Warehouse material flows and flow charts

Warehouse material flows and flowcharts respond to one of its basic characteristics, since products stay temporarily inside a warehouse and everything that enters the installation must exit. This flow in a warehouse can be simple or complex, depending on each company, the degree of automated systems, the in-house operations carried out with the goods, the quantity there is of it and the way it is moved. The different material flows can be illustrated through simple flowcharts or flow diagrams.

Types of flows

Flows are the movements of the units as they enter the warehouse, move around it, and finally exit.

Simple flows: To understand how these movements work, we can examine the simplest possible flow, which takes place when units sent by the supplier are used, without dividing these up.

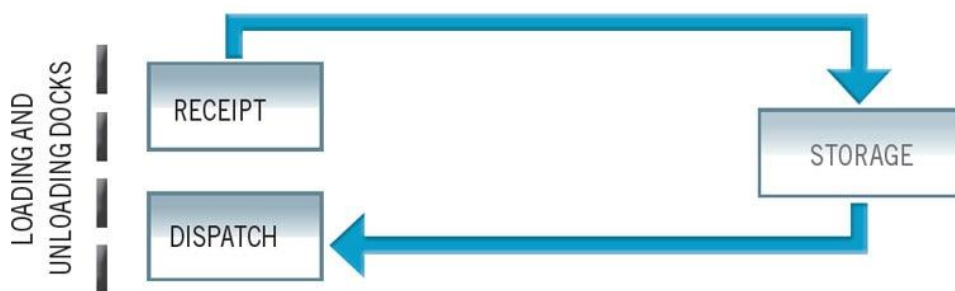


Figure 1 Simple flows

Medium flows: Movements start to become more complex with this type of flow. It is normally found in warehouses with single or combined picking operations, generally with the supply of full pallets.

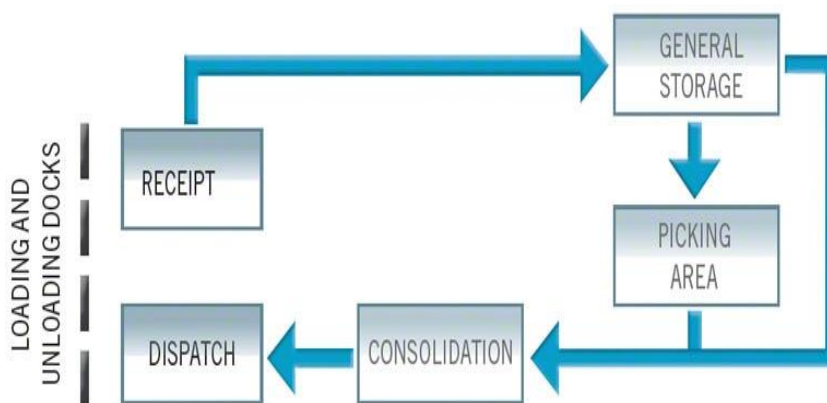


Figure 2 Medium flows

Complex flows: There are warehouses with different working areas, depending on the types of product and their consumption. They normally have intermediate handling areas and can require various operations that in turn need flows of a certain (and at times great) complexity. This diagram shows an example of this type of facility and the loading movements that occur there.

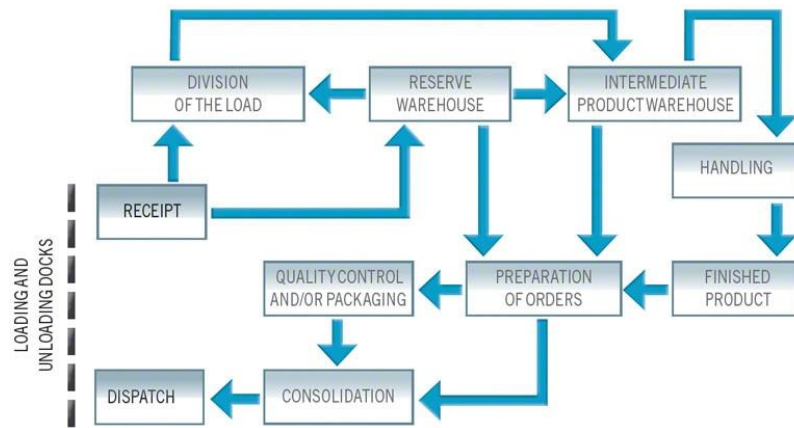


Figure 3 Complex flows

Each flow added to the working system represents an additional cost when it comes to calculating the overall cost of the process within the warehouse. The greater the division of the unit loads, the greater the impact on costs. Picking operations account for the largest proportion of the total warehouse costs (up to more than 60 %). This is why the design of these areas is of such importance.

In addition, the larger the warehouse, the further the handling machines and personnel have to travel and the greater the final cost of the operation. In centers with a great deal of movement, it is worth analyzing the possibility of introducing automation, so the product goes to the person rather than the person going to the product.

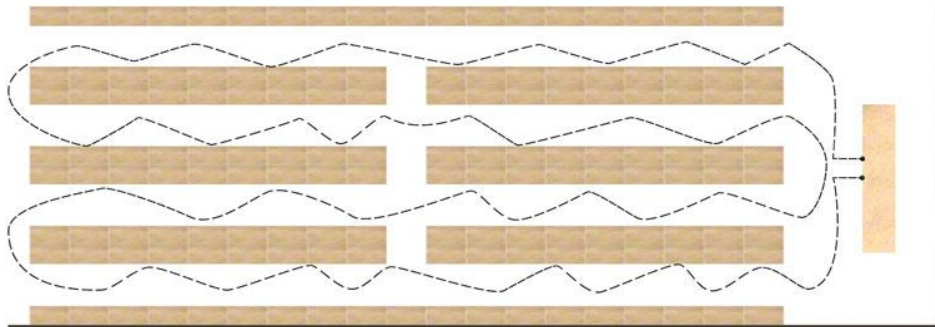


Figure 4 Picking installation with person-to-product operations.

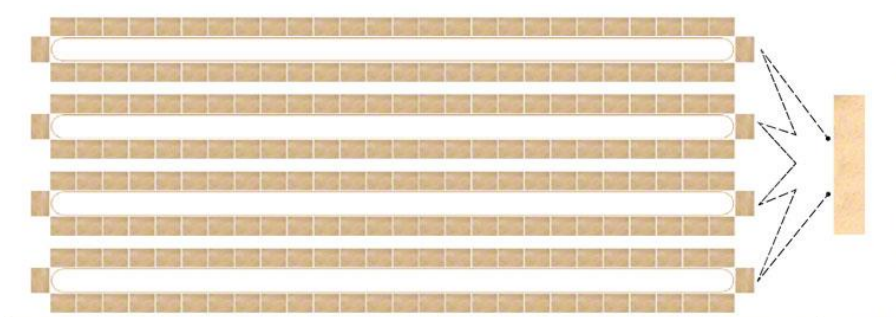


Figure 5 Picking installation with product-to-person operations.

As is to be expected, the location of items depending on their consumption and volume is basic. The closer the high demand or large goods are to the loading and unloading docks, the lower the handling costs.

A good example is a warehouse where loose units are directly prepared. As explained in the discussion on unit loads, a single pallet can contain hundreds of sales units. Therefore, by moving these in a single operation it is possible to avoid the hundreds of movements that would otherwise be required to prepare each individual loose item.

All operations need a person, a machine, or both, to be performed. Therefore, it is vital to ensure that a single operator performs the greatest number of actions in a given time, or what boils down to, taking the shortest possible time for each operation. This applies to all activities in the warehouse. However, applying this principle is particularly important for picking, since this involves more movements than any other operation.

Product rotation: A-B-C

Another decisive factor that influences the speed and cost of operations is demand for the product or good. This is why items in most demand must be close to the loading and unloading docks. To this end, the concept of rotation is used. Products are classified as described below, according to their consumption:

A. High rotation: Units enter and exit continuously. These items are in high demand.

B. Medium rotation: Units enter and exit in smaller volumes than in A.

C. Low rotation: These are the items that spend the most time in the warehouse, and are in low demand.

In most warehouses, the 80/20 rule or Pareto Chart applies. According to this rule, 80% of sales can be attributed to 20 % of the products, while the remaining 20 % of sales come from the remaining 80 % of products.

Obviously, the flow of materials has to be treated differently according to the rotation in question (A, B, or C). Below it illustrates two examples of possible criteria to apply:

In the first example, the “A” products have been positioned closest to the loading and unloading area.

In the second example, the “A” products have been positioned in the most ergonomic part of the rack.

To arrange a warehouse in the most logical manner, each individual case must be analyzed. There must also be an awareness that things may not be that simple, given that there are probably existing factors to be taken into account.

At times, to make the best possible use of the available space, it will be advisable to position products according to the storage systems used. However, in other situations, speed and the shortest possible time spent on operations will take precedence. Where feasible, a combination of both factors will be sought.

One example that demonstrates this is the standard combination of selective and drive-in pallet racking in a warehouse, where the drive-in system is used for high rotation products.

Conclusions about flows and rotation

Handling costs can be reduced and, therefore, the warehouse made more profitable, if products are arranged in the correct manner according to their consumption, with appropriate handling, the correct order of flows, and if intermediate process points are correctly located.

To ensure that a warehouse is optimized, it is essential to choose the appropriate storage equipment, both in terms of the type of system and forklift trucks or handling equipment used.

The various storage systems (selective, drive-in, flow racks, etc.), explained in other articles, have different features which make them ideal in different situations. Having a good warehouse management system (WMS) is vital for achieving the objectives set out in this section.

3. Packing Shipping Supplies

Pallets are flat structures that provide a foundation for storing or transporting goods. They are made from a variety of materials including wood, metal and plastic.

Typically, pallets are flat and horizontal, which make them easier to stack, move and load. Often, the goods placed on these pallets are much heavier, which requires the use of machinery to move the pallets like forklifts and pallet jacks. The following is a list of the different types of pallets including the pros and cons of each.

When it comes to categorizing and distinguishing pallets, it can be done in a variety of ways. We break up each distinction below by style (entry points), design (block vs. stringer pallets) and by material.

./ Pallet styles by Entry Points and decking.

One significant way to distinguish pallets is by the number of entry points for forklift forks. There are two-way and four-way entry points. Below is a detailed chart illustrating the differences.

Another noticeable difference is the deck/ Gap deck and solid wood deck pallets.

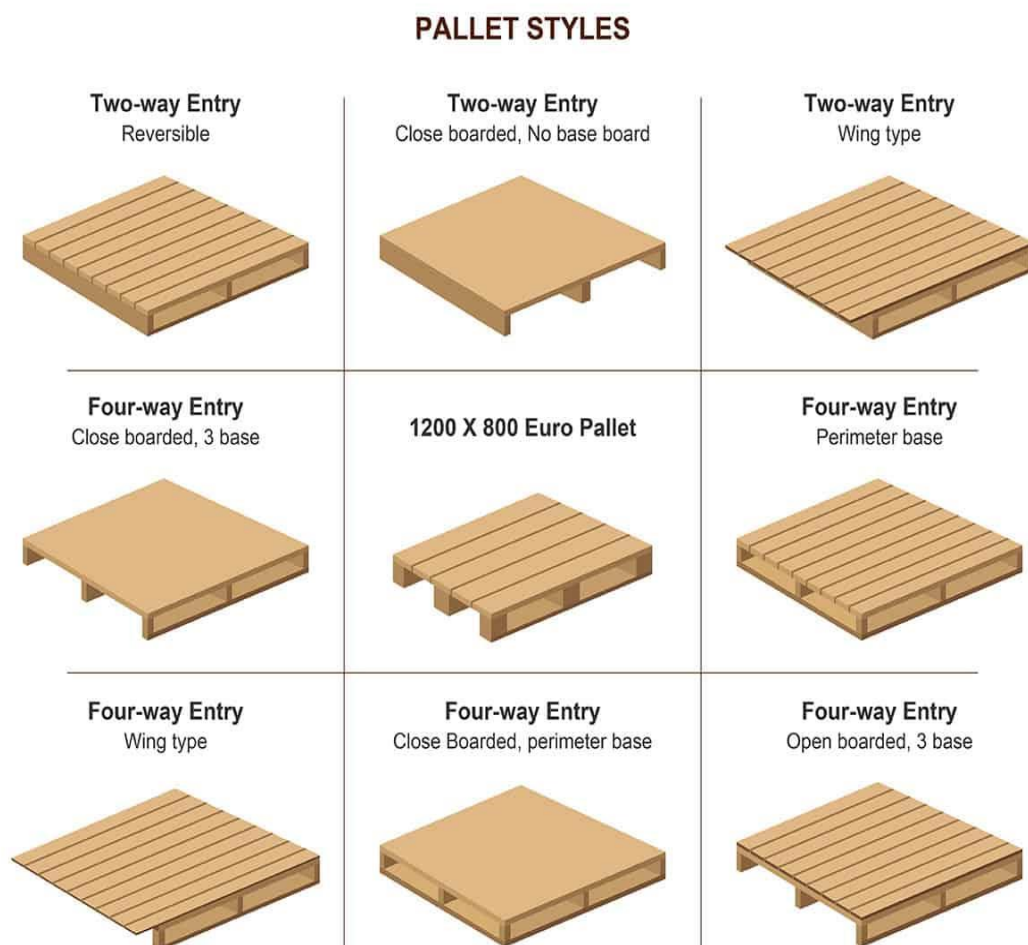


Figure 6 Pallets styles

1. Two-way entry

Two-way entry pallets have entry openings on two sides for the forklift forks.

2. Four-way entry

Four-way entry pallets have entry openings on all four sides of the pallet.

3. Open Deck Pallet

An open deck pallet is one with gaps between the deckboards which makes them lighter and less expensive. However, they cannot be used to ship smaller items because they'll slip through the cracks.

4. Solid Deck Pallet

As the name suggest, solid deck pallets are those that have a continuous single, large sheet of plastic, wood or metal without any gaps or spaces. Their most distinctive features or qualities are that they are very easy to clean and transport. These pallets are mainly used for the transportation of small objects. The fact that they are designed in a continuous flow minus any spaces makes them ideal for transporting small items which are likely to through the crack in the case of other types of pallets such as plastic and metal.

There are different types of solid deck pallets that are available, some of which are made of plastic while others with wood. The latter consists of non-porous surfaces which help ensure that there are no contaminants or other particles trapped within the surface of the pallet. This makes it really easy to clean them and also makes the solid deck pallets ideal for hygienic applications.

The former category, on the other hand, is the best of its kind because solid deck engineered wood pallets are super cost-effective since they come with an extended lifecycle. As compared to plastic and traditional wood deck pallets, these are relatively lightweight and sturdier than them. Furthermore, wooden solid deck pallets have been shown to sustain lesser damage overall than other types of pallets and they are also a lot easier to repair and use again. This makes them an excellent option to use for numerous purposes given the multiple benefits attached with solid deck pallets.

5. Double Face Pallet

Most pallets come with just the top deck. However, there are also those pallets that also have a bottom deck along with the top deck. The latter are called double-faced pallets and they can easily be used with any side or face up.

The addition of the bottom deck in these pallets provides it with increased strength and the ability to hold the unit's load with great ease and convenience. The bottom deck also evenly distributes the weight of the entire load.

A typical double face pallet has bottom and top deck boards that extend past the stringers. This makes the pallets appear as if they have wings on the side. These pallets are available in two main types; reversible and non-reversible. The latter only has one surface with planks that are densely packed while the former has items on both sides and can be flipped easily. Both these types are great for storing and packing different types of items.

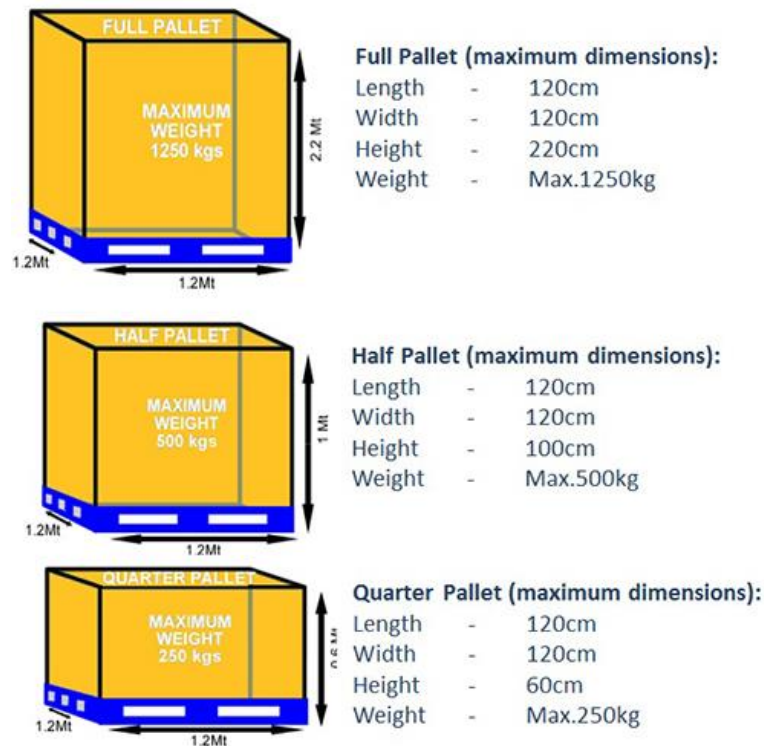


Figure 7 Double Face Pallet

Cargo label should have a few mandatory components which are crucial to ensure prompt delivery:

1. Clearly marked pick up or senders address. This is crucial because, in case of any returns or non-delivery, the cargo can be returned safely to the sender.
2. Sender's reference number. In order to identify the package, as the same sender could be sending various parcels to the same receiver but with different items.
3. Clearly marked delivery address. This should have the full style address including the zip/postal code to ensure that it gets to the right area as there could be cities and streets with the same name in different parts of the country, but zip/postal codes are unique.
4. Receiver's reference number. The receiver may be receiving parcels from same, or various senders and they can identify the contents/order quickly with the reference number.
5. If goods are hazardous, then the relevant hazardous labels must be affixed to the box.
6. If the goods are Fragile, it must be labeled with Fragile stickers or tape.
7. The label should have be clearly visible and have a big enough barcode for quick and reliable scanning.
8. The label should be at least A5 size or larger to accommodate all the above information.








You have to ensure that only the relevant markings are present on the outside of the package.










If there are markings on the label or box that are irrelevant to the shipment, that must be removed as it may cause confusion with regard to the delivery. The labels used must be hardy and be able to withstand the elements as in sun, rain, snow or any

other conditions they may be exposed to during the journey although it is unlikely that the goods can get wet during road transport. If you have more than one item in a consignment to the same receiver, it would be good to affix the labels in the same place on each item as it makes it easier for the goods to be scanned and sorted.

There are standard labels for package handling instructions which clearly indicate the nature of the contents of the packages so that everyone in the transportation chain knows what handling methods to be used like whether the package is sensitive to heat or moisture or which side is up and where the loading hooks may be used etc.

The symbols on the labels are based on an international standard ISO R/780 (International Organization for Standardization).

Designation	Symbol	Explanation
Fragile, Handle with care		The symbol should be applied to easily broken cargoes. Cargoes marked with this symbol should be handled carefully and should never be tipped over or slung.
Use no hooks		Any other kind of point load should also be avoided with cargoes marked with this symbol. The symbol does not automatically prohibit the use of the plate hooks used for handling bagged cargo.
Top		The package must always be transported, handled and stored in such a way that the arrows always point upwards. Rolling, swinging, severe tipping or tumbling or other such handling must be avoided. The cargo need not, however, be stored "on top".
Keep away from heat (solar radiation)		Compliance with the symbol is best achieved if the cargo is kept under the coolest possible conditions. In any event, it must be kept away from additional sources of heat. It may be appropriate to enquire whether prevailing or anticipated temperatures may be harmful. This label should also be used for goods, such as butter and chocolate, which anybody knows should not be exposed to heat, in order to prevent losses.
Protect from heat and radioactive sources		Stowage as for the preceding symbol. The cargo must additionally be protected from radioactivity.
Sling here		The symbol indicates merely where the cargo should be slung, but not the method of lifting. If the symbols are applied equidistant from the middle or center of gravity, the package will hang level if the slings are of identical length. If this is not the case, the slinging equipment must be shortened on one side.
Keep dry		Cargoes bearing this symbol must be protected from excessive humidity and must accordingly be stored under cover. If particularly large or bulky packages cannot be stored in warehouses or sheds, they must be carefully covered with tarpaulins.

Center of gravity		This symbol is intended to provide a clear indication of the position of the center of gravity. To be meaningful, this symbol should only be used where the center of gravity is not central. The meaning is unambiguous if the symbol is applied onto two upright surfaces at right angles to each other.
No hand truck here		The absence of this symbol on packages amounts to permission to use a hand truck on them.
Stacking limitation		The maximum stacking load must be stated as "... kg max.". Since such marking is sensible only on packages with little loading capacity, cargo bearing this symbol should be stowed in the uppermost layer.
Clamp here		Stating that the package may be clamped at the indicated point is logically equivalent to a prohibition of clamping anywhere else.
Temperature limitations		According to regulations, the symbol should either be provided with the suffix "...°C" for a specific temperature or, in the case of a temperature range, with an upper ("...°C max.") and lower ("...°C min.") temperature limit. The corresponding temperatures or temperature limits should also be noted on the consignment note.
Do not use forklift truck here		This symbol should only be applied to the sides where the forklift truck cannot be used. Absence of the symbol on other sides of the package amounts to permission to use forklift trucks on these sides.
Electrostatic sensitive device		Contact with packages bearing this symbol should be avoided at low levels of relative humidity, especially if insulating footwear is being worn or the ground/floor is nonconductive. Low levels of relative humidity must in particular be expected on hot, dry summer days and very cold winter days.
Do not destroy barrier		A barrier layer which is (virtually) impermeable to water vapor and contains desiccants for corrosion protection is located beneath the outer packaging. This protection will be ineffective if the barrier layer is damaged. Since the symbol has not yet been approved by the ISO, puncturing of the outer shell must in particular be avoided for any packages bearing the words "Packed with desiccants".
Tear off here		This symbol is intended only for the receiver.

TOPIC 3: WAREHOUSE AND EFFECTIVNECE

The cost of operating a warehouse can average between 1 and 5 per cent of total sales depending on the type of company and the value of its goods. For example, a pallet of laptops will take up the same amount of space and the same amount of handling as a pallet of baked beans, yet the value of goods will be significantly different. Hence the variation in the percentage cost of sales. Warehousing also makes up around 22 per cent of a company's total logistics costs with inventory carrying costs at a further 23 per cent. As a result, warehouse managers require a comprehensive knowledge of all costs and cost drivers within the warehouse as they are under significant pressure to reduce costs yet continue to produce optimum customer service with the added pressure of reduced inventory but increased numbers of SKU. Managers are also expected to contribute data to the company budget and continually reassess the resource and cost budget in line with the actual operation.

The costs typically associated with a warehouse operation are shown below:

Space costs:

- rent/leasing costs on building/land and building depreciation (depending on how the building and land has been acquired);

- insurance;

- rates or local government taxes;

- utility and telecoms costs;

- fixtures and fittings depreciation;

- racking depreciation;

- refrigeration plant depreciation;

- repairs and maintenance;

- cleaning, security, other building equipment depreciation;

- waste disposal. Direct labour costs (fixed): warehouse operators:

- wages including on-costs;

- personnel insurance;

- safety wear (PPE);

- welfare;

- training. Indirect labour costs (fixed): warehouse management including supervisors and administrators:

- wages including on-costs;

- insurance;

- safety wear (PPE);

- welfare;

- training. Labour costs (variable):

- overtime, bonuses. Equipment costs (fixed):

- depreciation/lease costs/rental costs.

Equipment costs (variable):

- running costs, eg fuel, tyres, lubricants, batteries;

- packaging, pallets, stretch wrap. Overhead costs (management, finance, human resources, IT and administration):

- salaries and on-costs plus benefits in kind such as mobile phones, accommodation, etc;

- company cars and running costs;

- office equipment and furniture depreciation/lease/rental costs;
- information technology costs (hardware and software). Overhead costs (sales and marketing in 3PLs):
- salaries and on-costs plus benefits in kind such as mobile phones, accommodation, etc;
- company cars and running costs;
- marketing spend, eg advertising, exhibitions, brochures, etc. Miscellaneous costs:
- communication costs;
- postage;
- bank charges and interest payments;
- funding costs/cost of finance;
- insurance;
- legal and professional fees;
- audit f

As well as wages and salaries, total labour costs include employer’s social contributions (including national insurance contributions and other non-wage costs including sickness, maternity and paternity costs, vocational training costs and recruitment costs plus any benefits in kind which might apply. As can be seen in Figure 8, the costs can be built up to produce a total warehouse cost. Third-party logistics companies can add an element of profit in order to produce a costing model to charge clients.

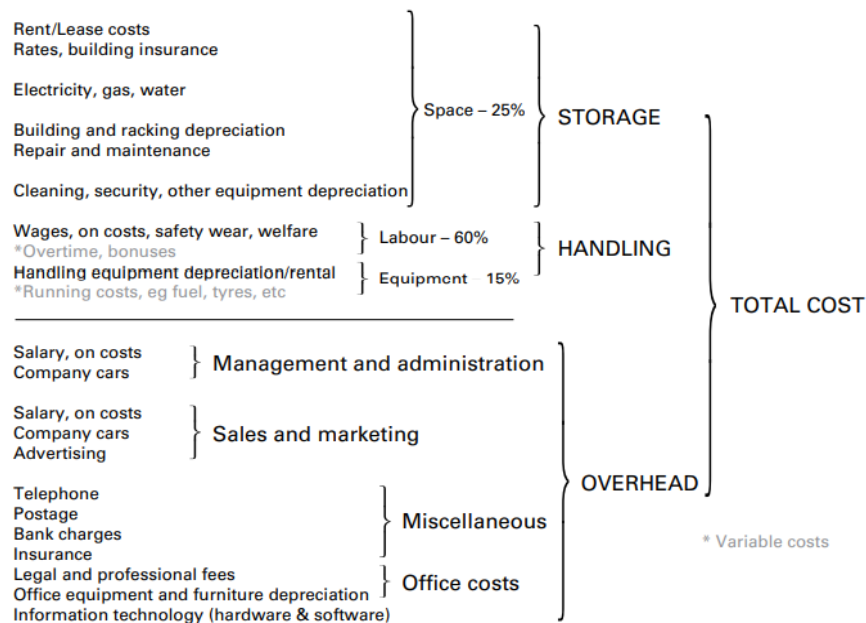


Figure 8 Simple warehouse cost tree

Return on investment (ROI)

This is a measure used to evaluate the efficiency of an investment or to compare a number of different investments. ROI is important to calculate because if an investment doesn’t have a positive ROI or if there are other opportunities with a higher ROI, then the investment should not be made. The calculation of ROI percentage is as follows:

$$(Gain\ from\ investment\ (or\ savings) - cost\ of\ investment) \div cost\ of\ investment \times 100$$

A similar calculation is the payback period. This basically measures how long an investment takes to pay for itself. It does have drawbacks, however, as it does not properly take into account finance cost and opportunity cost, the latter being what must be given up (the next best alternative) as a result of the decision. During a recent voice picking trial a client calculated that their ROI, by replacing barcode scan picking, was approximately 25.4 per cent in the first year with a payback period of nine and a half months.

TOPIC 4: WAREHOUSE SYSTEM

Although warehouses differ in terms of size, type, function, ownership and location the fundamental processes remain.

These processes include pre-receipt, receiving, put-away, storage, picking, replenishment, value-adding services and despatch.

Figure 9 shows each main warehouse activity as a percentage of cost, emphasizing the importance of the pick, pack and despatch operation. These figures will vary significantly depending on the type of operation.

For example, companies which are under pressure to speed up throughput are likely to use concepts such as cross docking, thus reducing the amount of time spent on put-away, picking and retrieval.

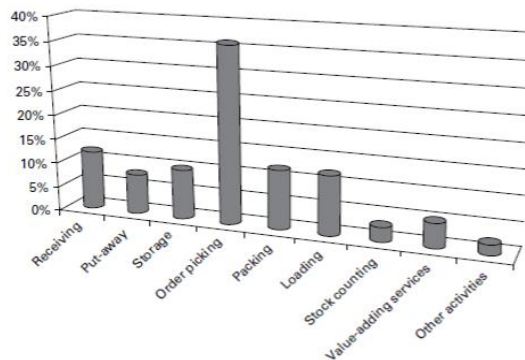


Figure 9 Warehouse activities as a percentage of total costs

The main activities mentioned above are shown in Figure 10 together with their relationships.

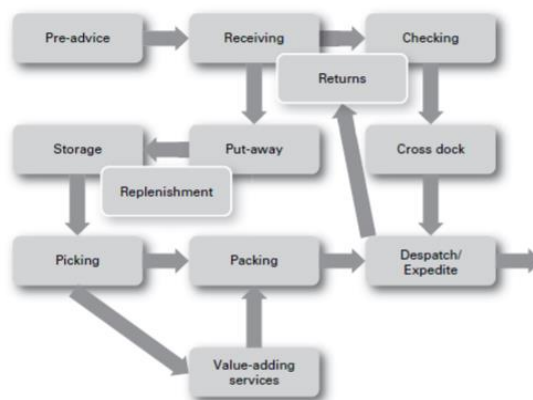


Figure 10 Warehouse process

Receiving

Receiving, goods-in or in-handling is a crucial process within the warehouse. Ensuring that the correct product has been received in the right quantity and in the right condition at the right time is one of the mainstays of the warehouse operation. These elements are often termed supplier compliance.

However, it is our contention that once goods have arrived at the warehouse it is usually too late to rectify most receiving issues. We believe there are many steps that need to be taken before the actual act of receiving takes place.

Pre-receipt

First we need to ensure that the supplier presents the products to the warehouse in the most appropriate way. It is normally the buyer who specifies the product and therefore may not have knowledge of the goods-receiving operation. Our suggestion here is that the warehouse manager is also involved in specifying and agreeing the packaging, items per carton, cartons per pallet, TiHi (cases per layer, layers per pallet) and any specific labelling required, together with the mode of transport to ensure that the products ordered are compatible with the storage facility.

All too often we see items arriving at warehouses in unsuitable packaging that overhangs pallets, has incorrect or badly positioned labels and with the goods packed in quantities that do not relate to selling-pack quantities. Our proposal here is that samples are ordered and despatched in their transit packaging to ensure full compliance. All these problems take time to resolve and are better handled at the supplier prior to delivery.

Areas that need to be discussed both internally and externally prior to the order being placed should include:

- size and type of cartons;
- type of transit packaging
- – cardboard, plastic, totes, metal stillages,
- roll cages, pallets;
- palletized or non-palletized delivery of product;
- size (length, width and height) and type of pallets, eg euro pallet,
- four-way entry;
- specific labelling such as product description, barcode and quantities;
- position of label on carton and pallet;
- carton quantities (inner and outer carton quantities, for example); and
- mode of transport, delivery quantity and frequency of delivery.

Delivery in the standard selling quantity is also crucial in assisting the manager to increase the speed of throughput and simplify picking. For example, many companies still place orders on their suppliers in multiples of 12 yet most customers order in multiples of 10 thus causing considerable extra work in computing quantities, opening cartons and re-packaging.

The method of delivery needs to be compatible with the unloading equipment available at the warehouse. The lack of loading bays, for example, will necessitate the use of tail-lift-equipped or side-(un)loading vehicles. The transfer of much production offshore has resulted in a significant increase in container traffic. The decision here is whether to loose load or palletize the cargo. Another option is to use slip sheets.

The benefits of palletizing product include protection from loss or damage during handling and transportation and a reduction in the number of people required to load and unload containers. The process of loading and unloading is speeded up whilst space required at the loading and despatch bays is also reduced.

In-handling

One of the main challenges for a warehouse manager is to match labour hours with work content. Handling a product the least amount of time possible (labour touch points) leads to reduced labour hours and as a consequence, reduced cost. Depending on the operation, labour can be the single biggest cost within a warehouse. It can be between 48 and 60 % of the total warehouse cost depending on the amount of automation utilized. It is also the most difficult cost to control.

In-handling makes up approximately 20 % of the total direct labour cost within a retail warehouse.

Preparation

Prior to the actual receipt a number of processes need to take place. The first step is to ensure that suppliers deliver into the warehouse when you decide, not when it suits them. There will be exceptions to this. For example, it is difficult for parcel delivery companies to adhere to booking times because of the nature of their deliveries; however, pallet and full-load delivery companies expect to be given specific delivery times, albeit this is not their preferred option. By providing delivery times for each supplier or their subcontractors, you are in control and able to match your work hours to work content. A booking-in or dock scheduling system needs to be introduced. Many of today's WMS have a dock scheduling module these days however an Excel spreadsheet will suffice. Initially you need to decide on when you are going to receive products into the warehouse. Are you going to have deliveries throughout the day or limit them to a morning shift, for example?

You then need to match the length of the time slots to the time estimated to fulfil the task. Standard time slots do not work as each delivery is likely to be different. For example, it could take 30 minutes to offload a 13.6 metre (45 foot) palletized trailer and a further 15 minutes to check and move the pallets to the storage area, whereas a loose-loaded 20 foot container could take up to three hours depending on the number of SKUs and staff deployed.

You need to keep records of the time it takes for each type of delivery and share this information with your booking-in team. This will give you the amount of labour and equipment required to undertake the task, thus making planning a great deal easier.

By introducing a dock scheduling system you are able to allocate accurate time slots, measure productivity, organize labour and also check demurrage and penalty charges.

Warehouse staff need to be aware of the products being delivered, the type of vehicle and the equipment required to offload. Once this has been ascertained and the time calculated, a suitable booking slot is allocated and a

booking reference given to the supplier.

Details of any pallet exchange agreements also need to be ascertained. The use of pallets within a rental system such as Chep, IPP Logipal, LPR and others requires both parties to accurately record movements within the system. Pre-advice of the products being delivered is also advisable so that the details can be entered in the warehouse management system (WMS). This is normally in the form of an Advanced

Shipping Notice (ASN). An ideal method of receipt is to accept the contents of the ASN as correct into the system as soon as possible through the use of RFID or bar-code scanning. Some WMSs will use this information to pre-allocate pallet locations for the products prior to arrival. The information is also used to check the delivery.

Offloading

On arrival, the vehicle details need to be checked against the booking reference and the vehicle allocated a loading bay or location in the yard. Any vehicle seals need to be checked against the delivery paperwork. Prior to offloading temperature-controlled vehicles, the temperature history of the vehicle whilst in transit needs to be checked, together with the current temperature of the goods.

Once the vehicle has backed onto the appropriate bay or has been positioned in the yard for offloading from the sides, the in-handling team should have appropriate labour and equipment to hand, to efficiently manage the offloading process.

Where vehicles are unloaded in the yard this usually necessitates the use of two lift trucks, one to unload the trailer and another to put the product away within the warehouse.

The introduction of articulated forklift trucks which can work both inside and outside the warehouse is going some way to reducing the requirement for two different types of truck for the latter operation. The most common method of unloading palletized vehicles onto a loading bay is with a powered pallet truck, hand pallet truck or pallet jack. Some companies utilize counterbalance forklift trucks; however, the weight of the truck, driver and load on potentially weak or damaged container or trailer floors can be an accident waiting to happen.

Unloading times will vary depending on the equipment used and whether the load needs to be staged prior to put-away.

Chaking

Once the goods are offloaded, you need to decide whether they need to be checked before put-away. The ideal scenario is to move inbound goods directly from the loading bay to the storage area or despatch area if goods are cross docked.

However, trust is an issue here and unless you are 100 % certain that your suppliers are totally accurate with their deliveries on every occasion, some form of checking will need to take place.

This can, however, take the form of a random check of certain product lines rather than checking the whole consignment. A count of total pallets may be sufficient.

A number of retailers have introduced GFR (good faith receiving) where products are accepted into the distribution centre or store without checking on arrival. Random checks are undertaken and any discrepancies found are charged to the supplier on a pro rata basis. This enables drivers to continue with their deliveries and pressurizes suppliers to increase the accuracy of their shipments.

This can be extended to other operations, providing agreements can be made with the suppliers.

Even if GFR is not introduced, by measuring supplier performance a warehouse manager can decide on the regularity and comprehensiveness of inbound product checks. The rate of checking can be based on the accuracy of recent deliveries.

A client we worked with checks 10 % of the lines on each incoming shipment. If they find a discrepancy they will check a further 10 %. Further discrepancies result in the whole load being checked.

Where new suppliers are concerned it is likely that you will want to check the whole of the consignment initially until you are confident of the accuracy of the supplier.

There is a trade-off here between the time it takes to check inbound deliveries, the delay in the product being entered onto the system and available for sale, the number of discrepancies found and the time it takes to deal with them. Another decision to be made is whether the delivery notes are used to check off the delivery or whether a 'blind' count is made (in which operators are not made aware of the quantities expected until the count has been completed) and the actual delivery cross checked against the paperwork once the whole load has been received into the warehouse.

From experience, although it is likely to take longer, it is more accurate to count the product and then compare it with the delivery paperwork than use the paperwork as a checklist.

The utilization of barcode scanners has speeded up the process significantly and improved accuracy. Products can be scanned and the details compared in real time (if wireless enabled) with the expected quantities to determine any discrepancies. Once scanned, the goods can be moved directly to the next staging point, be this quality control, a forward pick face, reserve storage or the despatch bay for cross docking.

Cross docking

The goal of most warehouses is to increase throughput rates and reduce the amount of stock held. Cross docking is a process where products are moved directly from goods-in to the despatch bays. This replaces the need to place the product into store and any subsequent picking operation.

Cross docking needs the full support of suppliers as to how they present the product. This includes clear labelling and advance notice of arrival together with accurate, on-time delivery.

Cross docking requires systems to identify the product that needs to be cross docked and a process needs to be in place to recognize and alert the staff. Once checked in, the products should be taken directly to the despatch area and their floor or temporary rack location recorded on the system, alerting staff that the product is now awaiting despatch. The details must be recorded in order to provide an audit trail.

Other points to take into account include the amount of space available at the inbound and outbound areas. Sufficient space is key to moving products quickly and safely. Any congestion in these areas will slow up the process appreciably and lead to tension between teams. There also needs to be a well-marked staging area where the products can be placed prior to despatch. An area of drive-in racking can assist in marshalling loads for particular collections.

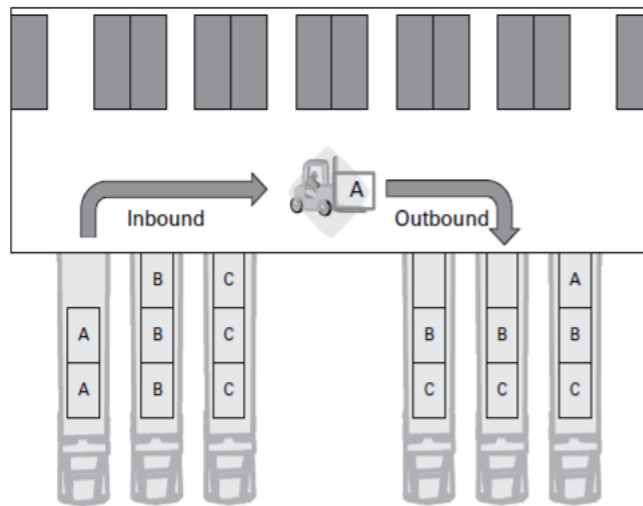


Figure 11 Example of cross docking

Cross docking is used significantly in the movement of perishable goods through the supply chain and retailers use this system in their distribution centres where they receive products from multiple suppliers and sort and consolidate them for onward shipment to different stores. It has been said that Walmart in the United States delivers approximately 85 % of its merchandise using a cross-docking system. This system is prevalent in many retail operations today. Just-in-time systems also rely on cross docking whereby manufacturers deliver parts to a cross-dock or sequencing centre where they are consolidated and delivered line-side in sequence.

Recording

Depending on the product, there could be a requirement to record more than just the standard data such as product code, description and quantity on arrival. Other information could include batch or lot numbers and serial numbers. Barcode scanning, which we will look at in the following chapters, is ideal for this type of data capture.

Quality control

It is accepted that certain products will require more stringent checking on receipt. These include high-value items, food, hazardous goods, temperature-sensitive product and pharmaceuticals. New suppliers will also fall into this category. An area close to the receiving bay should be set aside to spot check items on arrival. This needs to be done as promptly and as efficiently as possible so as to avoid congestion and to get the products onto the system quickly. If there are issues, the items need to be taken to a specific quarantine area or, if space is an issue, to the storage area

– but must be identified as defective or awaiting the results of tests. Most WMSs are able to block access to products on the system, making them unavailable for picking until cleared for sale. A physical sign at the location is an additional failsafe.

Put-away

Many of today's WMSs allocate product locations in advance and instruct the operator as to where to place the goods. This can be directly to the despatch area if the product is to be cross docked as discussed above, to the pick face as a form of replenishment or to a reserve or bulk-storage location.

In order for this system to work effectively, a great deal of information needs to be programmed into the system. This includes the following:

- size, weight and height of palletized goods;
- results of an ABC analysis or slotting, where fast-moving goods are
- placed closest to the despatch area (an area we will cover later);
- current order data;
- family product groups;
- actual sales combinations;
- current status of pick face for each product;
- size of pallet locations; and
- weight capacity of racking.

TOPIC 5: WAREHOUSE CHANE CONFIGURATION

Warehouse location

Locating a warehouse strategically and in the most cost-effective geographic location is one of the most important decisions a company will make. For example, in terms of fulfilment centres, because of the nature of deliveries, an important criteria is the need to be located near to the motorway network to delay the latest collection time from the parcel companies and therefore enable companies to introduce a later order cut-off time for next day delivery. Grocery retailers with online sales will have a requirement to be much closer to their customers due to the different temperature regimes of the products being delivered. The selection of a warehouse location requires multiple criteria to be assessed, including both quantitative and qualitative data. Many companies will look at the location and size of customers which, although relevant, is not as important as it would be when locating a retail outlet. Other factors include land cost, labour availability, travel minimization and total cost. The environment will also play a part in the decision-making process. The following are specific factors that need to be taken into account when deciding on a warehouse location:

- cost of land, rent and rates;
- access to transport networks;
- availability of affordable skilled labour;
- transport links for staff;
- availability of funding, grants, etc;
- availability of existing buildings;
- availability and cost of utilities including telecoms; ● availability of finance and resources;
- goods traffic flows;
- proximity to ports and airports;
- location of suppliers and manufacturing points; and
- the potential neighbours (eg proximity to oil storage depots can be a negative factor).

Fortunately the decision on where to site a warehouse does not have to be totally manual as there are a number of software programs available which will take the majority of these criteria into account and produce a number of viable alternatives. Many of these systems work on the basis of volume centre of gravity calculations which locate the warehouse at the centre of supply and demand by minimizing distances to customers and from suppliers.

A more accurate method is to utilize the cost centre of gravity calculation which locates the warehouse at the centre of supply and demand by minimizing transport

costs to customers and from suppliers. Route planning and optimization software will produce a viable location; however, supply chain optimization tools will further enhance this decision.

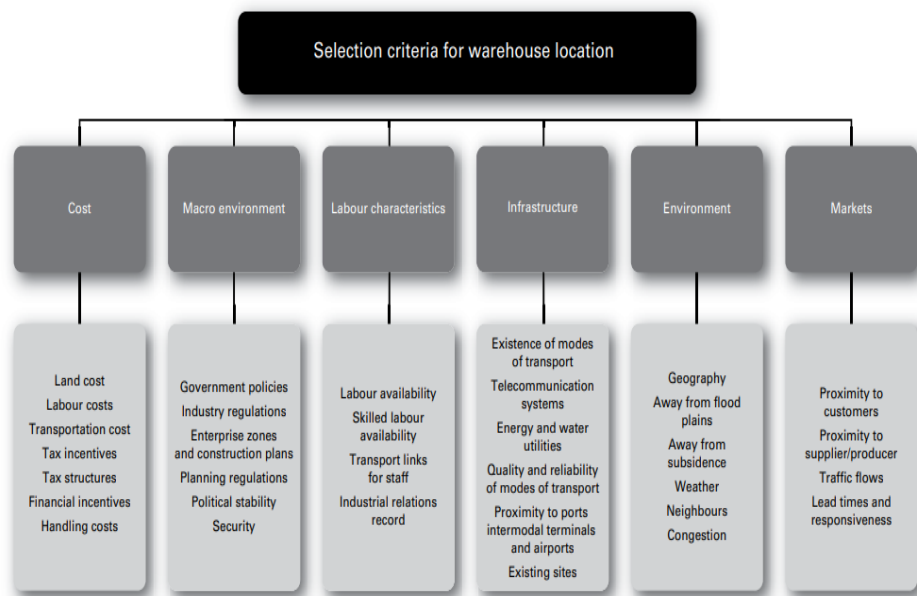


Figure 12 Factors determining the location of a warehouse

Number of warehouses

There is an ongoing debate as to whether companies are going to increase or reduce the number of warehouse operated within the supply chain.

The increasing cost of fuel, a move towards near-shoring and a requirement to be nearer the customer could see the number of local warehouses and distribution centres increasing with cross-dock operations being favoured by more companies. As with most areas of the supply chain there is a trade-off here. We can see from Table 1 that most costs are higher if multiple warehouses are chosen; however, all of these costs can be off-set by a significant reduction in local transportation costs and improved service. In terms of inventory we need to be able to calculate by how much we will increase or reduce our safety stockholding when we change the number of warehouses operated.

Table 1 Comparison between many and fewer warehouses

Criteria	Many warehouses	Fewer warehouses
Inventory costs	Higher	Lower
Customer reaction time	Quicker	Slower
Facility costs	Higher	Lower
Inbound transport cost	Higher	Lower
Outbound transport cost	Lower	Higher
Systems cost	Higher	Lower

One way of doing this is by using the Square Root Rule which was first introduced by David Maister in 1976. Maister's rule enables companies to quickly calculate the reduction or increase in safety stock required when the number of warehouses is changed. It states that the total safety stock in a supply chain is proportional to the square root of the number of locations at which a product is stored. The calculation is as follows: Reduction in stockholding (%) = $[1 - (\sqrt{x} \div \sqrt{y})] \times 100$.

Where 'y' is the original number of warehouses and 'x' is the proposed number of warehouses. This calculation cannot be used in isolation. Other factors, such as supplier and customer lead times, the product itself (different types of electrical plug for example), transport costs and distribution centre costs also have to be taken into account. The rule is based on the assumption that the amount of safety stock in each existing warehouse in the system is approximately the same.

TOPIC 6: WAREHOUSE LAYOUT DESIGN

Warehouse layout and design directly affect the efficiency of any business operation, from manufacturing and assembly to order fulfillment. Whether you're planning a shipping operation or designing your space around manufacturing or assembly, a sound warehouse floor plan will help you minimize costs and maximize productivity.

These are the five steps that a warehouse layout and design process must include:

1. Create a warehouse layout schematic
2. Plan your warehouse layout for efficient space utilization
3. Understand your warehouse storage & work area equipment options
4. Use efficient warehouse floor plan traffic flow strategies
5. Test your warehouse traffic flow plan

Let's look at the first step in warehouse layout planning, which is creating a warehouse layout schematic.

1. Create a Warehouse Layout Schematic

Your new warehouse space is a blank slate. Your goal is to transform it into a productive workspace that accomplishes your business goals.

A good warehouse layout always starts with putting it all down on paper first, no matter the size of your space. The easiest way to do this is to use a copy of your warehouse blueprint, especially if your space is large or not a standard rectangle shape. If you're renting, your landlord might be able to provide a blueprint you can use.

If you can't get your hands on a blueprint, it's easy to draw up your own warehouse schematic on grid paper. When drawing your layout, plan as though one square on the grid paper equals 1 square foot in your warehouse. That way, the spatial relationships on your plan will match your actual warehouse space.

When using a paper schematic, attach it to a piece of poster board or foam core so you'll have a sturdy platform on which to design your warehouse layout. Then, overlay a piece of tracing paper. This lets you sketch and play with different shelving and equipment arrangements without marking up your original. You can use paper cutouts to represent shelving and work tables and move them around to test different layouts.

You can also use layout software to create your warehouse floor plan schematic. The grid-based layout shown in the images above were created using Inkscape, a free graphic design program with an optional grid background.

If your budget allows, you can use an online layout tool that offers specific options for warehouse design, such as SmartDraw. A single user plan with SmartDraw costs \$297 and includes unlimited use. The upside with an online space planning and layout tool is that you can easily experiment with different layout approaches, as online tools allow you to move elements around on your screen with ease.

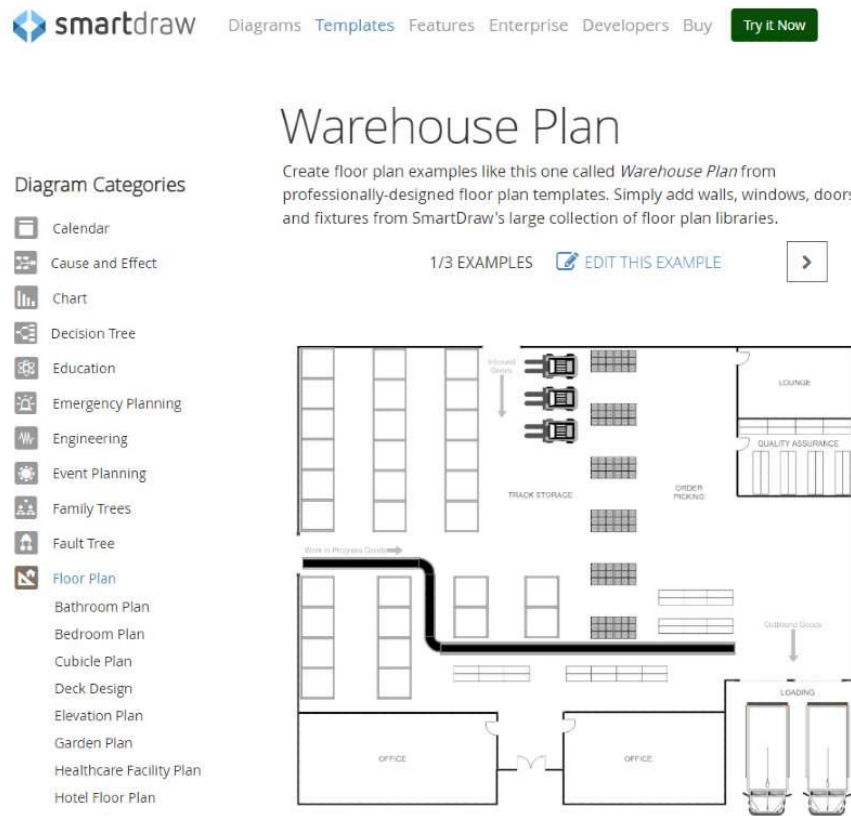


Figure 13 Example of a warehouse layout plan generated with SmartDraw

Whether you choose to design your warehouse layout on grid paper or with an online layout tool, it's important to ensure that the warehouse measurements you're using are accurate. This means measuring your warehouse interior spaces yourself.

In warehouse space planning, which we'll discuss in the next section, you need to take every inch into account. Failure to do so can lead to disaster once you start bringing in shelving and warehouse equipment, which may not fit if your warehouse measurements are inaccurate. You don't want to be making last-minute warehouse layout changes that can be avoided easily with proper planning. So, pull out a distance tape measure or rolling tape measure to take accurate measurements from the start.

Once you have a printed or online schematic with measurements drawn to scale, note any stationary features such as columns or supports, office area buildouts, sloping floors, stairways, installed equipment, and overhead doors. These areas will place restrictions on your warehouse floor plan, so you want to note them on your warehouse layout schematic accurately.

Many warehouse operations set aside some space for offices. In the example below, the office buildout takes a chunk out of the middle. A rough block-out of space is all you need, with one exception. Be sure to note when office doors open out into the warehouse as, if you omit this fact, you might accidentally block door access.

In the example below, you can also see that the receiving and shipping pick up doors have been noted on the warehouse layout. Most warehouses require special areas for receiving and shipping out inventory, and hence, be sure to include these entrances and exits on your design schematic.

Once you have noted major features on your warehouse design schematic, you're ready for the next step. It's time to start planning your warehouse layout.

2. Plan Your Warehouse for Efficient Space Utilization

If you want to create an efficient warehouse floor plan, you must begin with a thorough consideration of how you plan to use your warehouse. You might be designing a warehouse layout suitable for a manufacturing or light product assembly operation. Perhaps you are planning a warehouse layout for a product storage and shipping facility, a common warehouse design for ecommerce businesses. Your business needs will dictate how you allocate your warehouse space and configure your warehouse layout.

Plan Space for Warehouse Equipment & Surrounding Workspace

In planning your warehouse layout, your first step is identifying your key units. These are the things that take up most of your space and/or are the center of your production zones. For example, if you are an ecommerce company that stocks and ships goods, your key units would be pallet rack and metal shelving.

A business's key warehouse units will vary based on the primary goals of the warehouse. Your key units might be equipment or workstations. Whatever they are, you need to identify and place these elements on your plan first.

If manufacturing is your business, then your primary concern is designing your space around equipment and adjacent production workspace. Storage spaces, while important, are secondary in your plan, and will be dependent on where you place your equipment.

Most ecommerce companies' warehouses focus on accepting, storing, picking, packing, and shipping items. In this instance, stock storage units are the primary equipment, as shown above. Storage units used are typically either shelves or bins. The variety in size, shape, and weight of these storage units vary greatly.

For ecommerce companies, other activities that impact the overall warehouse floor plan include order packing and shipping as well as receiving stock. It's important to provide ample space around your various warehouse work centers so that employees can perform their tasks effectively and so that any equipment used—from hand trucks to forklifts—can navigate the warehouse aisles easily.

If you do light assembly paired with some shipping, assembly stations or light manufacturing equipment are likely to be a significant focus. After that, you'll need to address storage space for parts and finished goods, plus adequate packaging, packing, and shipping areas. You must conduct a thorough review of your needs before embarking on any warehouse floor planning process. Failure to consider the full nature of your needs could result in ineffective warehouse design.

Create Warehouse Production Zones & Workflow Areas

After addressing primary units like equipment, stock shelving, and assembly stations, the next step is thinking about how workers, materials, and goods move in and around your key elements. You also need to consider the space needed for your production work to safely occur.

Safety needs to be a prime consideration in all warehouses, although it may be more complex in manufacturing, where materials movement occurs around equipment. The Occupational Safety and Health Administration (OSHA) offers detailed

publications that you should review in planning your warehouse safety initiatives. Safe workflows apply to all types of operations, so it's important to include adequate production zones and workflow areas on any warehouse layout plan.

In manufacturing, you need to allocate space for workbenches, bins, tools, and safety stations needed for production. Plus, you need to reserve adequate production zones around equipment for workers to move materials and safely produce goods. There are no one-size-fits-all rules on what's considered adequate space that applies across all manufacturing equipment and production processes. Pay close attention to equipment manufacturing instructions, as each piece of equipment will come with complete directions for safe operation.

For a stock and ship operation, one primary work area is the aisle space between shelving units, as shown below. This is where you or your employees need adequate space to stock received goods and pick items for orders. You'll also need to allocate workspace for employees to move goods into, around, and out of the production zones, which are your packing, shipping, and receiving areas.

Assembly operations often combine the space needs of manufacturing and stock and ship. Assembly stations and related equipment make up the heart of your production zone. These can include workbenches or specialized stations, plus any needed bins for parts and finished goods. Like manufacturing, you need to allocate ample production space around these areas. Then, like stock and ship, you need to reserve space to efficiently package, pack, and ship finished goods.

The following areas must be perfectly defined when designing a layout: Loading and unloading areas, Reception areas, Storage areas, Picking areas, Dispatch area.

An example of a layout that includes all of these areas is shown below:

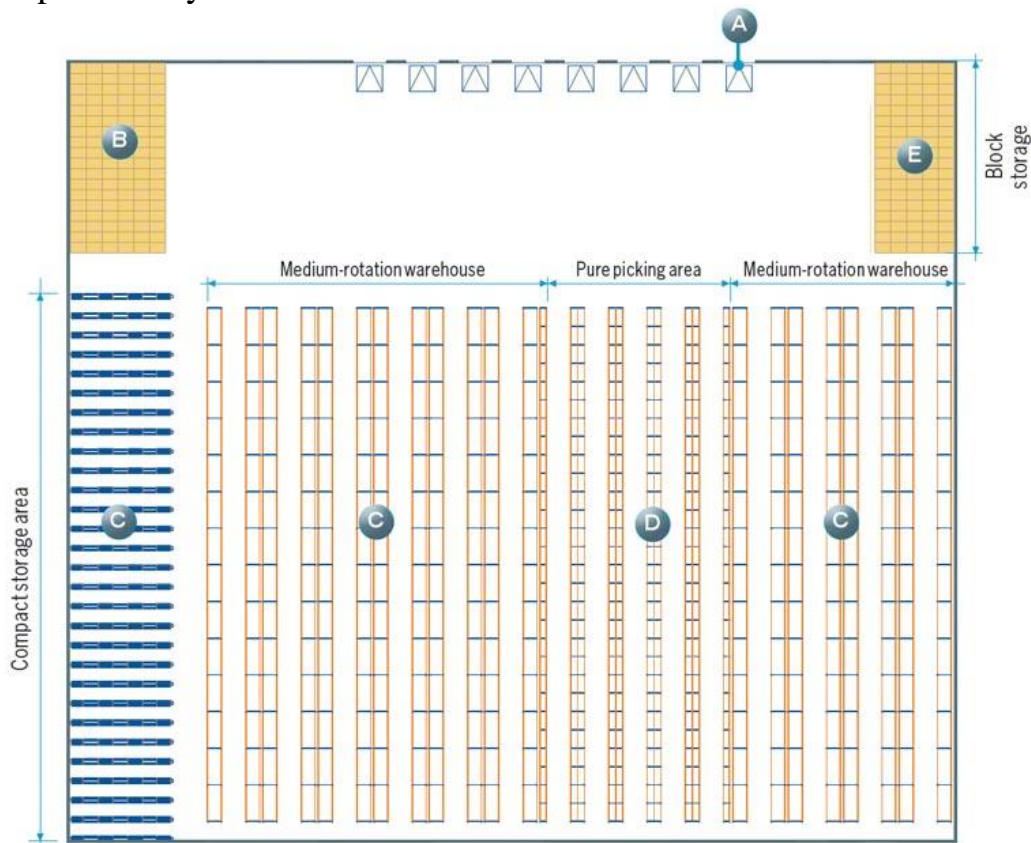


Figure 14 Warehouse areas

Loading and unloading areas.

Loading and unloading areas, which are normally located outside the warehouse or incorporated into it, are those that trucks and vehicles transporting and distributing goods have direct access to.

In a well-organized warehouse, it is useful to separate these activities from the rest of the installation, allowing sufficient space for loading and unloading. This area can be integrated into the warehouse or be independent.

Loading and unloading areas integrated into the warehouse

If loading and unloading areas are built directly into the sides of the warehouse so that goods are deposited and collected without the need for any detours, it is said that they are integrated into the facility. The main advantage of this is the greater load handling speed, which means it is preferable to non-integrated options if there is sufficient space for it.

Trucks are connected to the warehouse via the docks and these docks can be:

- Docks separated by an intermediate platform: They are appropriate when this separation is advisable as determined by the nature of the goods or the need to maintain the internal warehouse environment or when there are safety issues relating to the material stored. A typical example of applying this type of separated dock is for cold chambers, where cold loss could occur if a flush dock is used with an access door and where this must be avoided at all costs. Yet there are many other circumstances in which this design is preferable, particularly when the safety of the warehouse could be compromised.

- Flush docks: They allow trucks to back right up to the warehouse wall. To avoid affecting the internal environment of the facility, access doors must have, as a minimum, a hermetically sealed system. This seal can be metal or created through the use of a dock shelter.

Access points with metal seals have a manual or automated system that operates a flat barrier that can be fixed, folding, or rolling (as shown below). It opens when the truck backs up to the building, and closes when the vehicle has finished the operation. The internal environment can be more effectively preserved if the closing system is automated.

In addition to a metal seal, doors with inflatable shelters have a tunnel that encircles the truck when it is connected to the entrance, so that the internal environment is less compromised by conditions outside.

When this type of loading area is created, it is advisable for the warehouse floor to be above the level of where the trucks drive. Loading and unloading areas can also be designed in which trucks are driven into a pit. However, movement and operations are faster if the warehouse is at a higher level instead.

The necessary height difference can be achieved in several ways; therefore, it is not vital for the warehouse floor to be above ground level. Instead, for example, the area where trucks drive can be at a lower level, creating a gradual descent that avoids the steep ramps which, ultimately, make maneuvers more difficult and slow down movement.

Two different scenarios need to be considered when determining how to achieve this height difference. The first is when trucks accessing the loading and unloading areas are owned by the company. The second is when the trucks used are owned by third parties.

If only the company's own trucks are going to use the loading and unloading areas, and the height of the trailer is exactly the same in each case, the difference in level can be established precisely and no further considerations are required.

However, if the trucks that are going to access these areas are owned by third parties and come from different sources, they will have different trailer heights. So, a system must be created that allows the difference in height to be adjusted.

In general, an adjustable leveler system is essential because even when the company uses its own fleet, which in theory means there is no variation in the height difference between the vehicles and the dock. In practice, this difference is always present.

One of the reasons for this is the suspension in the trucks give way over time, either because different loads cause the height of the truck to vary or, more commonly, because eventually the company is obliged to purchase or lease other types of transport. Ultimately, a difference in trailer heights is practically inevitable.

Mechanical or hydraulic devices can be used to deal with these height differences. Mechanical devices are based on the use of (usually metal) bridges or walkways fitted manually between the dock and the truck. These elements are used so that forklifts, stacker cranes, and any other mechanical devices used to load and unload trucks can enter and exit the vehicle.

Another option is to use the second system mentioned above, which consists of a metal platform with one or more hydraulic cylinders. This platform facilitates access by acting as a ramp, when integrated into the dock itself, or by raising and lowering the truck. The image illustrates the second option, with the platform integrated into the dock.

Independent loading and unloading areas

Located away from the warehouse, but within the surrounding area, they operate completely independently of the warehouse itself. They normally consist of a large flat area that the trucks have direct access to, with the trucks positioned so that they can be loaded or unloaded using forklift trucks.

This option is best used in warehouses where only one of the two functions is carried out, i.e. where goods are loaded or unloaded. This option can achieve the necessary handling speed, as there is no need for the trucks to back up to the building. So, the time spent positioning them is reduced. In addition, with this option the process of loading and unloading goods is totally independent of the work cycle of the warehouse.

In these areas, goods in the trucks can be handled through the side or the rear of the vehicle. If using the side of the vehicle, forklift trucks are used to handle the goods, as shown in the image below.

If, however, the operation is carried out using the rear of the truck as shown above, there are two different options. The first is to access the truck using forklift trucks and ramps, which are normally made from metal and connected to the truck either manually or mechanically. While there is a wide choice of such products available on the market, at the moment two are most commonly used: modular ramps and those connected to the unloading docks.

Modular ramps are metal structures with a non-slip surface which can either be fixed (when the trucks used are all of the same height) or mobile (when using vehicles of different heights).

Ramps connected to the unloading docks are made with a brick or concrete structure, which can also be fixed or variable in height. If variable, their construction is similar to that of the integrated loading and unloading docks described previously.

The second option for the loading or unloading trucks by the rear is to **use roller conveyors**. With this system there is no need for the forklift to enter the trailer to carry out the operations. Instead, rails are installed which allow goods to slide along the inside of the truck. Movement is generated by pushing a few loads against other ones.

The loading process starts by placing one or more units at the entrance to the vehicle, which are then pushed in by a second group that takes the place previously occupied by the first group. In this way the loads accumulate, one after another, until the trailer of the truck has been filled.

Reception area

The reception area must be located as independently as possible from the rest of the warehouse, so that it can be used not just for receiving goods, but also for quality-control and sorting.

Once it has been ensured that the characteristics and quality of the delivery received matches those of the products ordered, the next stage is to determine where to position the load within the warehouse.

Depending on the type of warehouse, it may or may not be necessary to transform the units received. If this is necessary, a suitable area must be established for this function. For example, it may be necessary to split the pallets that have arrived into smaller units, remove parts that are strapped together, etc.

Given the impact that accurate checking and, above all, correct positioning, can have on the future performance of the warehouse, this area must be as large and as separate as possible.

Currently, almost all products handled in a warehouse come with barcodes that can be read using a scanner. Therefore, once the warehouse's central computer has identified the units, it can in turn immediately generate the position label for the goods. This label can subsequently be read by a forklift operator or by the scanners of the warehouse's automated system so that, in both of these cases, they can be positioned in the correct location.

Storage area

A storage area is, strictly speaking, an area used only to store goods. Goods can be stored in a number of different ways: directly on the ground; directly on the ground but stacked or in blocks; or on racking units. The choice of one or the other will depend above all on the type of product to be stored, whether it can be stacked, and on the storage quantity and time.

Product rotation: A-B-C

Another decisive factor that influences the speed and cost of operations is demand for the product or good. This is why items in most demand must be close to the loading and unloading docks. To this end, the concept of rotation is used. Products are classified as described below, according to their consumption:

A. High rotation: Units enter and exit continuously. These items are in high demand.

B. Medium rotation: Units enter and exit in smaller volumes than in A.

C. Low rotation: These are the items that spend the most time in the warehouse, and are in low demand.

In most warehouses, the 80/20 rule or Pareto Chart applies. According to this rule, 80% of sales can be attributed to 20% of the products, while the remaining 20% of sales come from the remaining 80% of products.

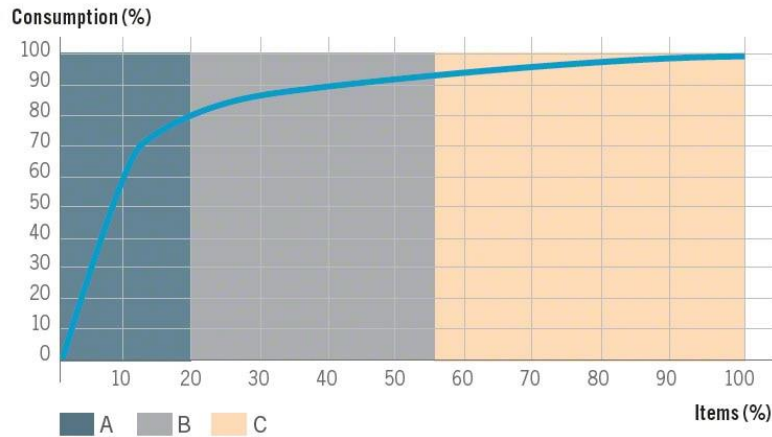


Figure 15 Graphic representation of a Pareto chart

Obviously, the flow of materials has to be treated differently according to the rotation in question (A, B, or C). Below it illustrates two examples of possible criteria to apply:

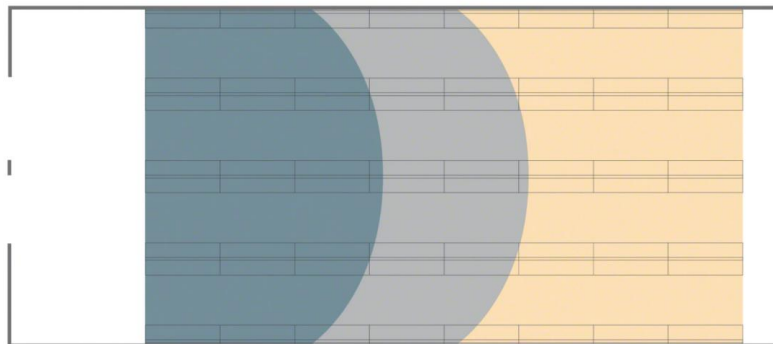


Figure 16 Product distribution throughout the warehouse according to rotation

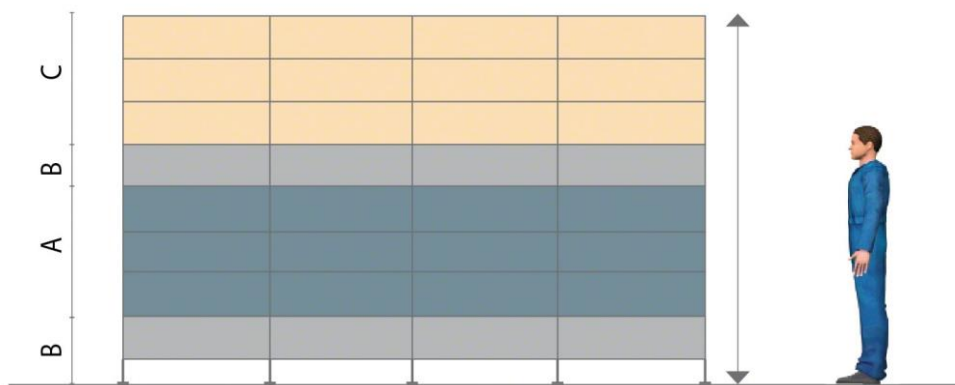


Figure 17 Distribution inside a rack (this normally applies to picking).

Storage in stacks involves placing unit loads on top of each other without anything in between them, other than the pallets that support them. This method has the

advantage of making better use of space, given that it does not generate unused positions. However, not all materials can be stored like this and it must be remembered that even goods that can be stacked have their limits in terms of strength and, therefore, have a maximum stacking height. The main disadvantage of this system is that it does not allow for access to the loads, and a load can only be accessed by first removing all the loads on top of it.

The use of stacking is mainly limited to two types of load: those with great internal strength, and those in rigid packaging. Goods with great internal strength, such as ceramic bricks, concrete blocks, etc., can be stored directly, at times even without the need for pallets or other support systems. Other goods, such as feed, cements, and aggregates in general, which are stored in sacks, can also be stored in this way thanks to their resistance to compression, although pallets or other support systems are required for their proper handling.

Rigid packaging, such as cardboard, wooden or plastic boxes, can be stacked in this way without problems, although the rigidity and resistance of these packages will determine the number of units that can be stacked, and therefore the height of the stack.

Racking units must be used when unit loads are not strong enough to be stacked to the required height, or when there is a greater need to access the product.

Goods are stored on racking units by placing them on metal structures, which are basically made up of suitable braced frames and beams. These elements create a multi-cellular structure that generates slots into which unit loads can be placed. As seen in "Storage systems" article, the configuration and layout of these spaces (or compartments) can vary to suit different operations and different needs in terms of the accessibility and accumulation of the load.

Order picking areas

These areas are not required in all warehouses, only when outgoing goods must have a configuration or composition that is different to the one they entered with, or when they require any type of modification.

Areas for preparing orders can be integrated into storage areas, as is the case when picking from rack units. They can also be separate from storage areas, creating specific picking areas, generally with automated or semi-automated systems.

Dispatch areas

These areas are used for packing orders prepared in the previously described areas. Even if this packing operation is unnecessary, this area also can be used for goods that have to be dispatched and loaded into the delivery or distribution vehicles.

To ensure the correct speed of movement within the warehouse, these spaces must be designed in a specific location and differentiated from the rest of the installation.

If separate reception and dispatch areas have been created, these must also have separate loading and unloading areas. If, however, the reception and dispatch are close to each other, a single loading and unloading space can be created. However, this option makes it more difficult to control the flow of goods and the movement of vehicles.

Service areas

Part of the warehouse must be assigned to support activities at the facility, such as general and management offices, changing rooms, bathrooms, and the area for recharging the batteries of handling devices.

The ideal solution is for the management office to be located in the reception and dispatch area and, if possible, between these two areas. This provides greater operability and efficiency in the work of the personnel in this department.

Changing rooms, bathrooms, and general offices can be located anywhere in the warehouse, although it is more logical to locate these close to the control offices. A good solution for bringing together these resources is to construct a mezzanine over the reception and dispatch area, and to locate these functions there.

Lastly, the space for recharging the batteries used by handling devices must be isolated and well ventilated, to improve health and safety and avoid any incidents involving operations taking place in this area.

Establish Warehouse Storage Areas

Storage is another key factor to consider in your warehouse layout. In fact, for pack and ship and some assembly operations, efficient arrangement of storage areas is your prime concern. Storage is important for manufacturing too, but usually secondary to equipment needs. To determine the storage space you need, and the shelving or other storage units you'll use, you first need to consider what you're storing.

Your warehouse storage needs may take many forms, including:

- Small assembly items housed in bins on light-duty shelving
- Pallets with machinery parts
- Boxed goods for pick, pack, and ship
- Overstock items
- Large raw materials for manufacturing

What you're storing dictates the type of storage you need to plan for in your warehouse layout. It also dictates the space you need to allow in and around storage areas, like aisle widths between shelving and clearance areas for moving goods in and out of storage.

How you move materials and/or goods around in your warehouse dictates aisle spacing. If you use a pallet jack or forklift to move pallets or equipment in your storage areas, you'll need generous space between shelves or around other units. Pallet jacks need a minimum aisle width of 4 to 5 feet to navigate between shelving.

Forklifts require much more open aisle space. If you plan on using a forklift in your warehouse, your required aisle width will need to be between 11 and 13 feet, depending on the type of forklift you plan to use. Before using forklifts in your warehouse operation, make sure you thoroughly review all manufacturer recommendations for forklifts you procure. Different machines have different use requirements.

If your warehouse plans involve hand-stocking small boxes for assembly or pack-and-ship, handheld bins or rolling carts are all you need to stock and pull stored goods. In that case, your shelving aisles will need to range between 3.6 to 4 feet wide in most cases.

In creating your warehouse floor plan, don't forget your overhead spaces. Most small warehouses easily accommodate shelving that is 8 feet tall or higher. Larger warehouses can house shelving 12 feet tall and higher. If you need overstock areas for large stock purchases or materials storage, using high shelves is a great way to preserve your warehouse floor space for production activities.

3. Choose Your Warehouse Storage & Work Area Equipment

Most small business warehouse operations, whether manufacturing, assembly, pick-pack-and-ship, or a combination of all three, need some form of storage and workspace equipment, such as assembly tables or packing stations. Here you have many options, and the storage you need greatly depends on what it is you do.

When planning your warehouse layout, the size and type of storage, shelving, and workspace equipment all come into play. Pallet racks, heavy-duty and light-duty shelving, cantilever racks, and all types of bins are common warehouse solutions.

4. Use Efficient Warehouse Design Traffic Flow Strategies

You now have a good idea of the types of equipment and storage solutions you will use for your warehouse space, which is essential for cost-effective warehouse floor plans. You also have a sense of where everything will fit in your warehouse layout. It's now time to drill into your warehouse schematic to arrange every element to create an efficient, productivity-boosting traffic flow.

You need to think about your operation by exploring the following warehouse usage needs:

- Consider how much time will you and your employees spend in various locations in your warehouse.
- Determine around which elements—manufacturing equipment, storage areas, or work tables—most work will center.
- Explore different needs you and your employees will have regarding how to move within the warehouse, how items will be gathered from various warehouse locations, and what items need to be close-by to complete daily tasks.

As you become more aware of what needs to be done, by whom, using what methods, you will more easily be able to layout work areas and predict traffic patterns within your warehouse. Remember, every business need is different so, while you can learn from other warehouse layouts, you must keep your needs foremost in mind.

Here is an example of an ecommerce warehouse floor plan with typical equipment, storage, and operational functions fully considered.

5. Test Your Warehouse Traffic Flow Plan

The last step before you start installing equipment, shelves, and tables is to walk your finished plan. To do this, measure off the space and apply masking tape on the floor to mark the positioning of your main units, be they equipment, tables, or shelves. You don't need to do this for every piece but do it in your key workflow and production zone areas. Then, walk the space as though you're conducting key tasks that will be performed in the warehouse.

Practice Performing Work Functions in the Planned Layout

Carry boxes, tools, or materials while you test your warehouse design. Make sure you have plenty of clearance in all directions. Roll carts or pallet jacks through the warehouse layout to ensure items navigate easily along the planned paths—even when heavily loaded down.

Get Employees to Test Your Warehouse Floor Plan

If you have employees, get them involved in acting out work processes. If you don't have employees yet, enlist some family or friends to help role-play key warehouse processes. Make sure your staff has ample room to conduct the tasks they will be required to perform.

Check Hard-to-Change Layout Areas Multiple Times

If you have large spaces within your warehouse layout that will house heavy equipment or large shelving units, test these areas multiple times. You do not want to

move these heavy fixtures and equipment once they are installed. It's far better to make traffic flow corrections at this stage while changes are easily made.

Your business' needs likely differ somewhat from the ecommerce warehouse examples shared here, but the principles of effective warehouse floor plan design remain the same. Make sure you put considerable thought into your planning and testing process, and you'll be rewarded with a cost-effective, efficient, productive space, no matter your size or operation.

Bottom Line

Effective warehouse design starts with identifying your needs, including the tasks to be performed within your warehouse and the equipment and fixtures that will best support those tasks. When you take the time and effort to create an efficient warehouse layout, you pave the way for saving time, money, and hassles for years to come.

TOPIC 7: STORAGE AND HANDLING EQUIPMENT

There are many different forms of racking systems available on the market today. Each one performs a different role and its use will very much depend on the type of operation envisaged.

In terms of storage systems we come across another warehouse trade-off.

The trade-off here is between speed, cost and capacity.

The greater the storage an operation requires, the greater the density of pallet storage needed. The potential option in these circumstances includes the introduction of drive-in, double-deep, satellite or very narrow aisle racking. There are many different forms of racking systems available on the market today. Each one performs a different role and its use will very much depend on the type of operation envisaged.

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Storage options

Block stacking

In circumstances where the warehouse height is reasonably low, where products and packaging are robust and budgets are tight, this type of storage is the most common method of storing large quantities of single SKU products. The goods are packed in unit loads, and stacked on the floor to their maximum safe height, which is governed by the weight and stability of the stack. This method is also used where products do not lend themselves easily to palletization and pallet racking is out of the question.

Typical products stored in this way include white goods such as washing machines and refrigerators, kegs and barrels, cans and bottles. Other storage media include metal stillages used for storing automotive parts and pallet boxes, for example. Block stacking is a cheap way to store robust products where there are a large number of units per SKU.

There are a number of disadvantages associated with block stacking. These include:

- Access. Sufficient space needs to be allocated for forklift trucks to access each stack. Also, in order to access the bottom pallet you need to move the pallets above.

- Damage. The items at the bottom can be crushed by the weight of the items above. Care needs to be taken with the number of unit loads stacked on top of each other. Items such as white goods have a maximum number indicated on the packaging.

- Stock rotation. Unless product can be accessed at both ends of the stack, items can only be despatched on a LIFO (last in, first out) basis.

Space utilization. Utilization can be very poor if stock does not move quickly through the warehouse. Picking stock from either the front or the rear of the stack can lead to unusable storage areas being left; this is sometimes known as honeycombing. Cubic utilization also tends to be poor when block stacking items where the clear height of the warehouse is significantly higher than the stack itself.

The use of pallet collars and converters can reduce the potential damage to underlying pallets and increase the stack height. The wooden, plastic or steel surrounds take the weight of the stacked pallets as opposed to the product itself. Those with drop-down front gates can enable some picking activities to take place. There is also no requirement to stretch wrap these pallets.

Racked storage The terms adjustable pallet racking (APR) and wide aisle racking (WAR) are seen as interchangeable. One point to note here is that APR is also used in narrow aisle construction. In this section we will discuss the advantages and disadvantages of the types of racking used in today's warehouses.

Wide aisle or selective pallet racking

This racking is present in the majority of warehouses worldwide. It is the most versatile of any racking without the need for any specialized handling equipment. The beam heights can be configured to any height as required.

The racking can also be configured to take pallets in either long side or short side configuration. One point to note here is that storing UK/industrial pallets (1200 × 1000), short side facing the aisle, means that euro pallets (1200 × 800) can also be stored in the same location without the use of decking.

Every pallet is accessible at any time and the racking is easy to install and, if necessary, move. Access is also quick and easy compared with most other types of racking.

As the description suggests, the disadvantage is in the fact that wider aisles are required to allow the forklift trucks sufficient turning circle. The use of reach trucks in this area reduces the amount of aisle width required compared with counterbalance trucks.

The introduction of articulated forklift trucks has further reduced the requirement for wide aisles.

One point to note here is whether you require the option of having two trucks operating in the aisle at the same time. If this is the case, aisles will need to be at least the width of both trucks plus clearance.

Double-deep racking



Figure 18 Double-deep racking

Double-deep pallet racking, as the name implies, allows pallets to be stored two deep in the racking thus eliminating an aisle. The pallets are still accessible from the same aisle. This system does require specialist equipment in the form of extendable forks and will require slightly wider aisles. Speed of access is slower. A further point to note is that the products on the pallets need to be the same otherwise the front pallet will need to be removed to access the rear pallet. LIFO applies.

By reducing the number of access aisles and using the space saved to accommodate additional racking, a double-deep configuration provides a highly space-efficient storage system.

Narrow aisle racking



Figure 19 Narrow aisle racking

Narrow aisle racking, as the name implies, utilizes APR and provides storage for a greater concentration of pallets by reducing the aisle width to circa 1.6 metres. This type of racking configuration requires the use of narrow aisle or turret trucks to deposit and access pallets. These trucks are not required to turn in the aisles as their forks extend from the side. They are able to access pallets from both sides of the aisle.

The trucks are manoeuvred within the aisles via wire-guided systems or guide rails. Narrow aisle racking requires a very flat floor, especially if we are looking at heights in excess of 10 metres. During construction, companies will use lasers to ensure the flatness of the floor.

The use of guide rails prevents the use of powered pallet trucks in this area to pick up and deposit pallets in the pick face as they are unable to access the pallets. Narrowing the aisles too much restricts the speeds at which a forklift can travel between picking locations.

The use of articulated trucks in narrower aisle racking means that similar aisle widths can be achieved but without the need for wire-guided systems or guide rails and a perfectly flat floor.

Drive-in/drive-through racking



Figure 20 Drive-in racking

Drive-in racking provides a safe and efficient equivalent to block stacking for loads that are too fragile or unstable to be stacked on top of each other. In place of the longitudinal beams that usually support the pallet and load on conventional racking, each upright of drive-through racking has an L-shaped rail for the pallets to rest on, between which there is enough space for a forklift truck to drive into the racking. The rails are carried on brackets that slot into the uprights. The pallets have to be stronger than for normal racking because they have to support the weight of the load across the gap between the rails. With drive-in racking there is no requirement for aisles, therefore floor space is fully utilized. Cubic space utilization will depend on the lifting height capability of the forklift truck.

Drive-in racking does not allow for first in, first out (FIFO); however, drive-through racking does enable you to extract pallets from the other end of the racking.

This does reduce the amount of storage space available, however, and also adds to the honeycomb effect as discussed previously. Drive-in/drive-through racking is a high-density storage medium suitable for large quantities of single SKUs. Note that products cannot be mixed in each row and stock counting can be very difficult.

Its disadvantages are the increased potential for damage, not only to the product but also to the racking, and the low speed of put-away and retrieval. This type of storage relies on full-pallet picks in the main as there is no scope for carton picking from the ground-floor locations. This type of racking can be used at the despatch area to stage outgoing pallets by truck, reducing the amount of floor space required in this area.

Pallet flow/live storage

Pallet-flow racking is driven by gravity. It is perfect for fast-moving product with FIFO stock rotation. Pallets are loaded at the upper end of sloping lanes, and move down by gravity, using heavy-duty skate wheels, when a pallet is removed from the pick face. One block of roller conveyor racking requires only two aisles: a loading face and a picking face, which means fast cycle times and high occupancy rates within your warehouse. Warehouse floor space utilization can be further maximized with fewer aisles by storing pallets back to back. Disadvantages are the potential reduction in cubic utilization and the fact that different products will require a different angle of incline based on the weight of the pallet. Each run also requires the same product to be stored in it.

Push-back racking



Figure 21 Push-back systems

Push-back systems work by placing pallet loads on a series of nesting carts fed forward by gravity on rigid structural steel rails. As a pallet is loaded from the front, it pushes the pallet behind it back one position. When unloading, the front pallet is removed and the rear pallets automatically come forward to the front picking position. This allows for easily accessible LIFO inventory management.

Operators can store product from two to five pallets deep, with front-only loading from a single aisle. Push back offers more versatile storage than drivein rack because each lane flows independently and vertical storage operates separately from the lanes below. Multiple pick facings for a variety of SKUs can be stored and retrieved without disturbing other product above or below in a single-lane or double-lane format.

Mobile racking



Figure 22 Mobile racking

Where floor space is very expensive, a warehouse can be made very compact if the units of racking are movable by being mounted on rollers. Only enough space for one access aisle is then required, as the operator can ‘move’ the aisle merely by moving the units (by power, by hand wheel or by pushing) to create a way through to a particular bay. But here, of course, floor space is being saved at the expense of a slowing down in the load-retrieving operation.

Satellite or shuttle racking

A recent entrant into the pallet storage market is satellite racking. A satellite system is similar to drive-in racking. However, it is operated by placing shuttles at the front of the racking, utilizing counterbalance, reach or narrow aisle trucks, depending on the height of the racking. The shuttles are controlled remotely via a radio frequency (RF) battery-operated control system and special channel rails. There are no aisles and therefore the cube of the warehouse is well utilized, with the use of very long lanes. The storage system can store pallets within a system that can operate to lengths of 40 metres. The racking features guide/support rails that run the depth of the rack structure on which an automated shuttle travels. Pallets are loaded onto a shuttle at the front of the lane, which transports the pallet down to the other end. The built-in sensors on the shuttle detect the position of existing pallets and place the new load at a predetermined distance, before returning to the start face. The shuttle is easily moved between lanes by the forklift truck. Multiple shuttles can be controlled by one forklift truck.

Unlike drive-in racking, there is no necessity for the truck to enter the racking and therefore the potential for damage is minimized and the truck can carry on with other duties while the shuttle places the pallet in the correct location. The system operates in first in, last out mode, allowing racking to be set up against a wall of a warehouse, thereby gaining space. It can also operate with FIFO, using a system that offers separate entrances and exits. This method allows for the loading to be done from one side with a forklift truck and the unloading on the opposite side with another. The system automates the placement of pallets in the storage lane, reducing loading and unloading cycle times. Each level of racking is assigned to a specific product, unlike drive-in racking where every level has to contain the same product code.

Satellite racking can also utilize the space above the loading bays. As can be seen in Figure 24, the pallets are stored on a LIFO basis in this instance. This area can be used for marshalling loads prior to despatch. This racking can also provide picking areas as they do not require a forklift truck to enter the area.

Examples of shuttle racking and satellite racking are shown in Figures 23



Figure 23 Shuttle racking above despatch bays (courtesy of Toyota)



Figure 24 Example of satellite racking (courtesy of Toyota)



Figure 25 Mezzanine floors/raised storage areas

Cantilever racking

Where a warehouse has sufficient height it can be very cost effective to construct a mezzanine floor. Typical areas are above the inbound and outbound loading bays. This space can be used to construct shelving for storage and can also be used to undertake value-adding services or can be used for long-term storage. If the mezzanine is to be used for product storage, you'll need to ensure it's properly structured to take the appropriate load, and that the supports are also properly specified. The floor that the vertical supports stand on will also need to be properly surveyed.

To gain access to your mezzanine you'll need to consider whether you need a lift, conveyor, steps and any gating or barriers that will be required. For example, if you need to load pallets on to the mezzanine, you'll need access for your forklifts.

Warehouse handling equipment

Types of Material Handling Equipment



Figure 26 Types of Material Handling Equipment

The challenges of a 24/7 operations culture, together with an ageing workforce, demands for improved accuracy, shorter lead times and a reduction in cost have galvanized manufacturers into producing handling systems that require minimal manual input and provide increased throughput levels. This section reviews equipment currently in use from the humble pallet jack through to robotic systems. It examines some of the enhancements that have taken place recently and provides comparisons between different types of handling equipment within the warehouse.

The key principles of materials handling are as follows:

- continuous movement is most economic;
- economy is directly proportional to size of load;
- standardization reduces costs;
- mechanization improves efficiency;
- gravity is cheap; and
- simplicity is the goal.

In choosing the correct equipment we are looking to:

- lower unit materials handling costs;
- reduce handling time;
- conserve floor space;
- prevent injuries to staff; and
- reduce energy consumption.

It is essential to consider all aspects of an operation in order to ensure that the most suitable equipment is specified and the best handling solution selected.

Important factors include:

- the load and the means of transfer, eg type of pallet;
- type of storage;
- type of operation;
- warehouse dimensions (height and travel distances);
- overhead obstructions;
- surfaces and gradients;
- working area; and
- environment.

To be able to decide on how to equip our warehouses with the most efficient mechanical handling equipment we need to undertake the following:

- define the functions to be performed;
- review all stock items and define their handling requirements;
- understand the travel distance and speed relationship;
- understand the limits of the building and the structures within it;
- evaluate staff capabilities; and
- evaluate vendors, equipment alternatives and relative costs.

Horizontal movement

Examples of horizontal movement equipment include the following:

- hand pallet trucks (HPTs), pallet jacks;
- powered pallet trucks (PPTs);
- tractors/tugs;
- automated guided vehicles (AGVs); and
- conveyors.

TOPIC 8: WAREHOUSE PROCESSES FROM REPLENISHMENT TO DESPATCH AND BEYOND

Replenishment

In order to ensure a smooth and efficient picking process we need to ensure that the right products and quantities are in the correct pick location. This is replenishment.

As in the case of replenishing overall inventory to ensure customer satisfaction, the warehouse also has to replenish its pick faces regularly to ensure picker satisfaction. An empty picking slot, just like an empty shelf location in store can mean a lost sale. The result of a poor replenishment process is order shortages, increased picking times and therefore increased cost per pick and an overall reduction in service level.

Real-time WMSs will recognize the need to replenish pick locations through real-time data transfer. These systems are also able to identify the total actual order quantities and therefore replenish before the next wave of orders arrive on the warehouse floor.

Other systems will rely on a trigger that denotes when the stock level within a pick face falls to a certain level. This will rely heavily on timing as orders that have generated pick lists may not actually have been picked and therefore replenishment has been triggered early. Late replenishment can result where staff have picked out of sequence, for example, and emptied the pick bays before the replenishment team have had an opportunity to top up the location.

Timing is crucial. An early instruction to replenish can cause as many problems as late replenishment, with potentially overfull pick faces and issues with FIFO.

If product can be moved directly to the pick face from the inbound section this cuts out a number of processes. This will require a certain amount of preplanning to ensure that pick faces are not overfilled. Pallets can be de-layered to correspond with expected pick quantities.

In the absence of a warehouse management system the warehouse manager will need to first ensure that the pick faces are designed to take the optimum quantity of product based on predicted sales per day or per shift and cubic volume, and staff need to be trained to identify replenishment requirements and inform either the supervisor or the forklift truck driver, depending on how the process has been set up.

One other point to note here is that although real time dictates that replenishment and picking can occur simultaneously, there are issues of worker safety if forklift trucks and pedestrian pickers are working together in the same aisle. This can be alleviated by incorporating multiple picking locations for the same SKU, the utilization of flow racking where product is replenished from a separate aisle and by carrying out the two activities at different times of the day if feasible. For example, receiving and replenishment can take place in the morning whilst picking takes place in the afternoon.

Alternatively, replenishment can take place during breaks or after picking has been completed for the day.

Value-adding services

Many warehouses have introduced areas where value-adding services can be carried out. These are common in both dedicated and shared-user or public warehouses where third-party logistics companies are providing an all-encompassing service to their customers.

These value-adding services include the following:

- (re)labelling;
- pricing;
- tagging and kimballing;
- (re)packing;
- bundling, as in ‘buy one, get one free’ (BOGOF) offers;
- reconfiguration;
- sub-assembly;
- repair and refurbishment.

Undertaking shop-floor-ready labelling, tagging, bundling and pricing in the warehouse removes the task from the retail assistants who can spend more of their time selling.

More sophisticated services include some form of production as in the case of postponement where items are added once the customer’s order is known. This can include the inclusion of graphics cards and the loading of software in the case of personal computers and laptops. It can also include the fitment or inclusion of a particular part for a specific market.

Postponement can be described as a delay in the completion of an item until an actual order is received from a customer. Postponement not only saves time but reduces inventory holding by reducing the total number of SKUs held in stock.

Value-adding services can also include returns processing and a repair service.

Sufficient space needs to be made available for these tasks, with access to power and being close to the despatch area, thus reducing any unnecessary movement. An ideal location, if the height of the warehouse allows it, is above the despatch bays on a mezzanine floor.

Indirect activities

There are many support activities that occur in warehouses and are crucial to the efficient operation of the warehouse. These are, in the main, undertaken by supervisory staff, specialist teams and the housekeeping team. These activities include:

- ensuring optimum staffing levels and providing a pool of suitably trained staff for peak periods;
- managing the allocation of labour for value-adding services;
- ensuring optimum space utilization;
- monitoring work flow and congestion;
- provision, allocation and maintenance of equipment;
- identification and replenishment of fast-moving items;
- identification of non-moving stock;
- stock integrity and dealing promptly with non-conforming, lost or found stock;
- managing cycle counts and organizing full stock checks;
- security of high-value or hazardous stock;
- and ensuring the cleanliness of the warehouse and the safety of both staff and visitors.

The above tasks can be separated into three distinct sections:

- the management of labour, space and equipment;
- the control of stock; and
- the security and safety of stock and people.

Stock management

Inventory or stock management and warehouse management tend to be two very distinct roles.

Warehouse managers are in a position to advise their inventory colleagues on levels of safety stock and the specific movements and characteristics of particular stock items. However, they tend to stop short of determining stock levels. This function is a major part of a company's operation and the theories and practices are covered in many books on the subject of inventory management. Although the majority of warehouse managers are not involved directly in the choice, purchase and replenishment of stock, they can play a role in the identification of fast-, medium-, slow-, non-moving and obsolete stock. This can be done using one of the mainstays of a warehouse manager's armoury

- an ABC classification.

The goal is to identify the items in the A to C categories and act accordingly.

Obsolete or non-moving stock needs to be analysed and one of the following tasks undertaken:

- Return to seller if the contract allows.
- Sell to staff at a discount.
- Sell the item at a highly discounted rate either through normal channels or via companies who specialize in selling overstocks and obsolete items.
- Assess whether it is cost effective to break the item down into its constituent parts.
- Dispose of the product as cheaply as possible. This may incur charges but it will release space to store other faster-moving product in its place.

A quick and easy way of ascertaining whether there is an excess of slowmoving stock in the warehouse is to calculate the stock turn:

Stock turn = cost of goods sold ÷ average cost of goods stored

or:

Annual throughput in units ÷ average number of units held in stock

For example, an annual throughput of 1,200,000 units with an average stockholding of 100,000 units gives a stock turn of 12. That is, the stock turns over once per month.

A low turn in most operations suggests that stock sits in a warehouse for far too long, implying that the safety stock level has been set too high.

The higher the figure, the better the company is performing in terms of inventory management. Maintenance stores will always have low stock turns through having to hold stock in case of breakdown.

Stock or inventory counting

All warehouses are obligated to undertake some form of stock count. It depends on the law of the country and accounting requirements as to how frequent and comprehensive the count is.

We have seen over recent years a move towards cycle counting or perpetual inventory counts as a replacement for an all-encompassing annual count of stock in the warehouse.

A full stock count usually necessitates the closure of the warehouse for a period of time when all inbound and outbound movements are suspended. A significant draw-

back of a single annual count is the difficulty in reconciling the discrepancy as it could have occurred over 11 months ago.

The count is normally carried out at the company's year-end. Some companies will carry out quarterly or possibly half-yearly checks depending on the stipulations laid down by the auditors.

More recently, providing the company can prove that its cycle counting is accurate, auditors have agreed in some cases that if each stock line is counted and audited at least once per annum that will be sufficient for their needs. Providing the cycle counts are considered to be accurate, the year-end stock figures will be taken from the WMS.

Cycle counting or perpetual inventory counts

When undertaking cycle counts it is prudent to use an ABC your slow-moving, inexpensive items.

Mis-picks are more likely with fast-moving goods, and high-value items are prone to shrinkage.

It is suggested therefore that fast-moving and high-value items are counted monthly, medium sellers are counted quarterly and slow-moving items either once or twice a year. The following percentages can be used to ensure a comprehensive count:

- 8 % of A items counted weekly (ensures each SKU is counted approximately once per quarter);
- 4 % of B items counted weekly (counted twice per annum); and
- 2 % of C items counted weekly (counted at least once per annum).

The accuracy of the counts will also determine the frequency. A high error rate should result in more frequent counts until the accuracy improves. Each discrepancy needs to be investigated and procedures put in place to ensure that there is no repeat of the problem.

Increasing the frequency to daily ensures a more of that resource.

The trade-off here is the cost of the error against the cost of discovering it in the first place.

As mentioned previously, a number of auditors will be happy (or as happy as they can be) if stock in the warehouse is counted at least once during the year.

Despatch

The order cycle time or lead time from order receipt to despatch is continually shortening and there is increased pressure on the warehouse manager to coordinate all activities to ensure that product is despatched on time and complete.

Packing

- pieces/items/eaches

Once product has been picked there is the question of how it is packaged for despatch. As previously discussed, with individual order picks the operator may well package the product immediately, attach shipping labels and where required insert despatch documentation and invoices.

This reduces the number of touch points in the warehouse but does take the operator away from the prime task of picking.

Where there is the possibility of damage in transit, material can be added to the carton such as polystyrene and foam pellets, shredded paper, corrugated paper, air-filled bags, etc. This again increases time at despatch and puts the onus on the customer to dispose of the excess packaging on receipt. Where possible this material needs to be recyclable. The use of carton erectors which cut the cardboard to fit the contents is one way of overcoming this problem.

The trade-off here is the cost of the machine versus the labour and material cost of doing it manually and the cost to the customer.

If orders are required to be checked on despatch this is an ideal time to add the paperwork and affix labels. In terms of checking, items can be removed from the pick container, checked against the order and returned to the original carton or if the order was picked into a tote it can be transferred to a shipping carton. Other methods of checking include weighing the carton and comparing this weight with a system generated weight. This is preferable, providing the information held in the system is 100 per cent accurate. This also reduces the labour required in this area and assists with load planning.

The need to check every order before it leaves the warehouse may well be a requirement for very high value products and products such as pharmaceuticals but I have to question the need to check every despatch order when it comes to other products.

Packing

– cartons

Full carton despatch is somewhat easier to manage. Individual cartons may require the attachment of a shipping label which may be generated from the WMS or from a carrier system.

In terms of multiple carton dispatch, firstly there is a need to establish whether it is more cost effective to despatch via a parcel network or a pallet distribution or LTL carrier.

This will decide the means of shipment

– loose cartons or a palletized load. If palletized, the decision here is how to stabilize the cartons on a pallet for despatch. Many companies will use stretchwrap to do this. Some companies will stretchwrap manually whilst others utilize an automatic stretchwrap machine. The trade-off here is the cost of the machine versus the cost of labour and the reduction in the use of stretchwrap material.

Loading

The efficient loading of containers and trailers is crucial in today's environment of rising fuel prices. Unused space is inefficient and can cost a company a great deal of money.

Efficient loading of vehicles and containers begins with the initial packaging of the products.

Companies need to ensure that the outer packaging of their products is designed to fit perfectly onto the pallets used for both transportation and storage. The ideal is to ensure no overhang whatsoever with a reduction in unused space. It also needs to be robust enough to travel.

Pallet loads need to be configured to ensure that product damage is minimized, cubic capacity is fully utilized, load stability is ensured and the configuration is acceptable to the receiving location.

Fortunately there is software available to not only assist with pallet configuration but also container and trailer loading. The software can optimize packing within a container and trailer, on a pallet and even within an individual carton.

This sophisticated software optimization not only takes into account the cube of the products but also their load bearing strength and location within the container.

The latter ensures ease of off-loading at the receiver with all the cartons from the same product line being located together. The software also ensures that lighter items are packed on top of the heavier items.

Shipping

Many operations are now taking orders late into the evening and despatching that same night for next-day delivery. Next, a retailer, has a cut-off time for internet orders of 10 pm for next-day delivery.

Work plans are now centred around the latest despatch time for orders, and managers work backwards from this ensuring that all processes are completed and both labour and equipment are made available at the right time to meet these deadlines.

The despatch process has to be managed precisely and be aligned with most other activities within the warehouse. If, for example, receiving and despatch share the same doors, a daily schedule needs to be drawn up to ensure that labour and equipment are utilized as efficiently as possible, the work content is matched to the number of doors available and congestion is avoided in the dock area.

In many operations receiving tends to take place in the morning whilst picking and despatch occur during the afternoon and evening as order cut-off times continue to be stretched later into the evening.

Depending on the method of picking and the company's procedures regarding checking product before it leaves the building, sufficient space needs to be available at the loading bays to stage the loads and allow for whichever checking method is applied

– be it full-carton checks or random checks.

If coordinated correctly, the picked orders should arrive at the loading bay in the sequence in which they will be delivered. That is, the last delivery on the vehicle will be the first order to be loaded.

Documentation

Finally, despatch documentation and labelling needs to be within country or for export.

Any errors in the export paperwork can result in non-shipment, seizure, fines or delays.

When shipping hazardous material it is essential that products are labeled accurately and have the correct documentation.

Typical despatch paperwork depending on ultimate destination includes the following:

- advanced shipping notice;
- manifest;
- shipping labels;
- Bill of Lading;
- commercial invoice;
- shipper's export declaration;
- export packing list;
- certificate of origin;
- export licence;
- inspection certificate; and
- insurance certificate.

As mentioned above each country will have its own requirements in respect of the documentation needed.

TOPIC 9: WAREHOUSE MANAGEMENT SYSTEMS

As such a pivotal function in day-to-day operations of many businesses, logistics is still noticeably slow to change. While retail and eCommerce face disruption after disruption and keep coming out on top, 50 percent of trucks travel empty on their return journey and warehouses are either overfilled or standing idle. Digitalization will allow warehousing and transportation operations to elevate customer experience, deliver more value to partners, and consequently

- create an effective ecosystem of supply chain providers: manufacturers, carriers, freight forwarders, and more.

Digitalization often boils down to two approaches: automation and using data. In this article, we describe how logistics management systems (or LMSs) can bring value by automating processes and using data to make informed decisions. In addition, you'll find out how to integrate with 3PL companies if you're outsourcing logistics operations.

What Is a Logistics Management System?

Typically, logistics works in two directions

- forward and reverse. When we talk about logistics, we usually mean forward direction, which includes such operations as receiving and processing an order, checking and preparing inventory, packing and picking an item, dispatching it and selecting a transportation route that will deliver the product to a customer as quickly and efficiently as possible. Reverse direction means any operations with managing incorrect or damaged shipments, repairing items, and reusing or recycling.

In a digital world, to manage these processes in both ways, businesses use **logistics management systems**

- a combination of software tools that optimize all processes from making an order and delivering it to a customer's door. Introducing and integrating LMS in your organization can be done differently:

1. Building, purchasing, and managing LMS software on your own
2. Outsourcing

- engaging a third-party logistics (3PL) company that will run any logistics operations for you. Using a 3PL gives you a quick implementation period without needing to train your employees on new processes, devices and software.

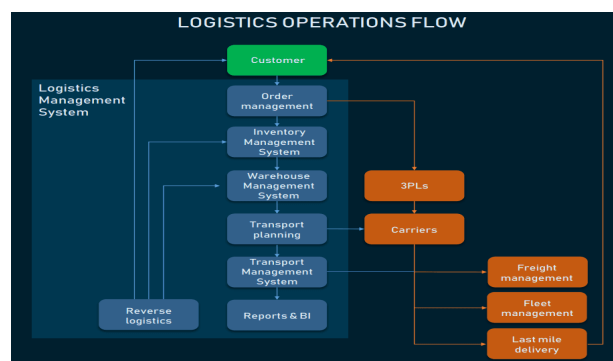


Figure 27 Logistics management system within logistics processes

Main modules of a Logistics Management System

Order management

Receiving and processing an order online usually includes operations of creating and editing inventory, managing customer service, accepting payments, checking for

fraud, and handling documentation between manufacturers, suppliers, warehousing, and transportation companies.

To manage orders effectively and avoid double handling errors, orders, inventory, supplier and customer data must be synchronized in one system. Order management software (OMS) receives orders from all your sales channels and monitors them from the moment they're placed until the customer confirms delivery. This is your main connectivity hub where all information about the order is displayed: routes, location, inventory, warehouse connectivity, and integration with accounting to create invoices and accept payments, etc.

ORDER #	COMPANY NAME	STATUS	INVOICED	PACKED	FULFILLED	PAID	TOTAL
INV008784	Acme	Draft	●	○	○	○	\$100.80
INV008779	Acme	Active	●	●	○	○	\$13.00
INV008771	Acme	Finalized	○	●	●	○	\$360.00
INV008766	Acme	Fulfilled	○	●	●	○	\$360.00

Figure 28 Sales order workflow

An integrated OMS is connected to your CRM and inventory database to complement the sales funnel and provide information for accounting and marketing departments. Additional features include connectivity to popular marketplaces, vendors' inventories, and multi-currency options.

Inventory management

Inventory management is a vital part of the supply chain responsible for controlling and documenting the amount of product for sale. Receiving, storing, and tracking inventory, while dealing with its rapid and constant changes, requires highly accurate product information management. So, automating from classic spreadsheets to inventory management systems (IMS) delivers the needed clarity centralizing all the data in a single location through an inventory management system.

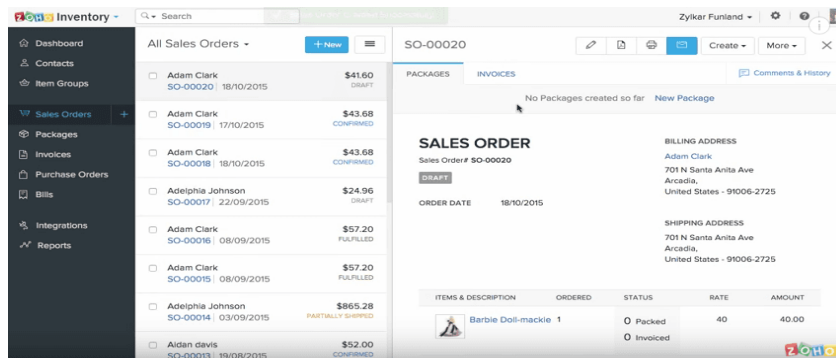


Figure 29 Zoho Inventory has integrations with shipping companies, warehouses, accounting, and CRM software

IMS tracks and reports any inventory changes. It maintains balance in replenishment avoiding stock-outs and excess stock. The system tracks low stock levels and sets automatic re-ordering for each product. Meanwhile, it reduces the risk of ordering excess by estimating product demand.

Warehouse management

Warehouse management is a set of processes maintaining, controlling, and automating warehouse operations. This includes receiving items, moving them, managing

warehouse staff using KPIs, maintaining safe work conditions, and using software and hardware to locate and track items.

A warehouse management system consists of tools that streamline the workflow of managing goods from arrival at the warehouse through storage and tracking within the location to order management and dispatching further. SAP analyst Matthew York says that “*warehouse management software can give a huge break with fulfillment and stock tracking.*” Matt adds that in the case of 3PL companies, they also provide a massive storage area for an organization’s products.

Typically, WMS is responsible for the following operations.

Warehouse design. Providing a manageable 3D map of the warehouse building, this feature allows for maximizing storage space, managing inventory placement, and improving the flow of items and labor by prioritizing the areas of the shipping queue that require extra attention.



Figure 30 3D visual warehouse design

Picking. Synced with a scanning device, the software helps pinpoint items throughout the warehouse building. Tracking the barcodes assigned to items, WMS guides the order assemblers to the needed products through the optimized picking route. To ensure the correct lot is selected, pickers doublecheck it: on scanning the attached barcode, the system verifies it. In terms of velocity, batch picking function can be a real timesaver, as it allows for picking many orders in a single run.

Packing. Orders can have specific packaging requirements to guarantee safe shipping or improve the unboxing experience. The WMS helps make sure the packing is performed in the correct order, and as efficiently as possible, according to the rules set by the business.

Labor management. Supervising the human side of warehouse operations entails the use of a labor management system integrated into WMS. First, the system assigns tasks to individual warehouse workers using workforce planning and scheduling capabilities. This allows you to track productivity, identify underperforming shifts or workers. The task history environment shows employees’ entire history of activities that can be used for analyzing peak labor, optimizing workflow, and finding solutions where obstacles come into play. In the long run, it will increase productivity and efficiency while lowering labor costs.

Strategic transport planning

After the order is assembled and wrapped, the last thing left before it leaves the warehouse is optimizing its shipment, namely:

Choosing a shipping method. LMS figures out from a variety of transportation logistics options the one that will fit your freight needs best. Shipping methods range from dry van freight for products that don’t need refrigeration to refrigerated freight

for temperature-sensitive items; from less-than-truckload (LTL) freight for efficient shipping of smaller loads to heavy freight for oversized loads and bulk freight for large amounts of raw materials, etc.

Connecting to the carrier network. LMS connects shippers with carriers providing visibility to all concerned to find the best shipping option. To decide on the cheapest carrier, there're transportation procurement tools. These tools assist in customizing a client's request for proposal, responding to queries, taking in proposals, and evaluating bids.

In the case of 3PLs, they usually have no assets of their own, but rather match vendors' shipping requirements to qualified fleet providers. You can consult our article on [the specifics of fleet management software](#) to find out how this solution functions and what value it brings.

Defining customs fees and documentation for global fulfillment. Although international shipping entails dealing with much paperwork and ever-changing export control regulations, LMS can make it much easier. Supporting multiple languages and currencies, the system calculates value-added taxes, cross-border fees, and freight forwarding charges. In addition, LMS manages necessary shipping papers, ensuring compliance with both in-country and cross-border regulatory programs.

Transport management

The main software suite addressing freight transportation needs and managing all shipping details is transportation management software (TMS). Implementing TMS solutions, companies are looking for the following capabilities:

Delivery management and scheduling. TMS allows clients to schedule their shipments through their personalized, online TMS account. Delivery estimation is based on such critical parameters as population density, vehicle type, and capacity, predictive traffic analytics, etc.

TMS ensures on-time delivery through automated asset tracking and timely alerts to both shippers and consumers if the shipment is falling behind schedule.

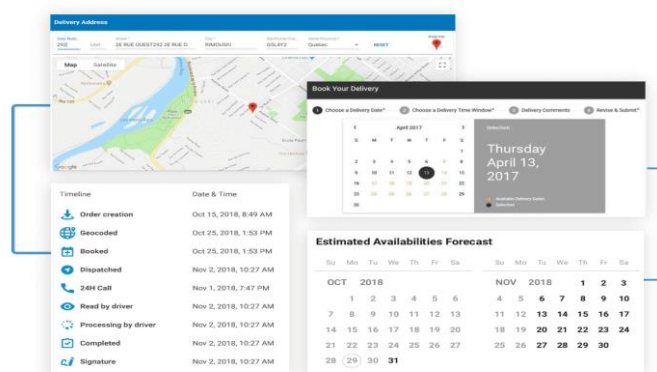


Figure 31 Dashboard of the delivery management & scheduling software

Cross-docking. This feature identifies a delivery type that eliminates the need to store the products in the warehouse, as they are shipped straight from manufacturer to customer. This can reduce delivery time while saving on labor and warehouse space. However, cross-docking risks losing control over inventory. So, handling cross-docking effectively requires robust inventory control processes.

Last mile logistics. The final step of the delivery process

- from a distribution center/facility to the end user

- can range from a few blocks to 50 or 100 miles. To deliver orders to consumers, last mile logistics engages parcel or small package carriers.

Providing same-day and instant delivery services, final mile logistics drives order delivery velocity.

Order tracking. To gain full visibility into product movements, clients are provided with access to an online portal that monitors shipment on the road, alerting to any transit exceptions or unforeseen delays.

Usually, location tracking involves subsequent reports in a real-time, vehicle-position database. Another package tracking method is to report the arrival or departure of the object and record the object identification, the location where observed, the time, and the status.

Not only vendors but certainly customers need insight into the progress of delivery. Provided with an order ID, they can track the progress of the goods in a corresponding application.

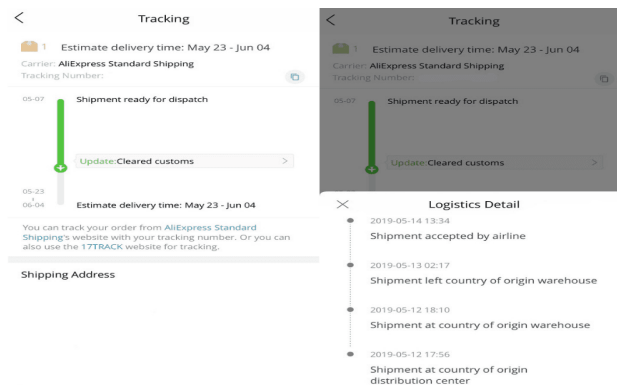


Figure 32 *AliExpress app* allowing customers to track the location status of their order

Transportation accounting. TMS keeps clients informed of their shipping expenses as it gathers all shipment-related documents in one place. The system simplifies accounting by allocating costs, assigning billing codes for accountability and budgetary purposes, and generating and paying freight invoices, etc.

Reverse logistics

Managing returns from the consumer back to the producer is a logistically challenging process. So, it's worth applying a reverse logistics system (RLS) that will help streamline repair, return, and product reallocation processes.

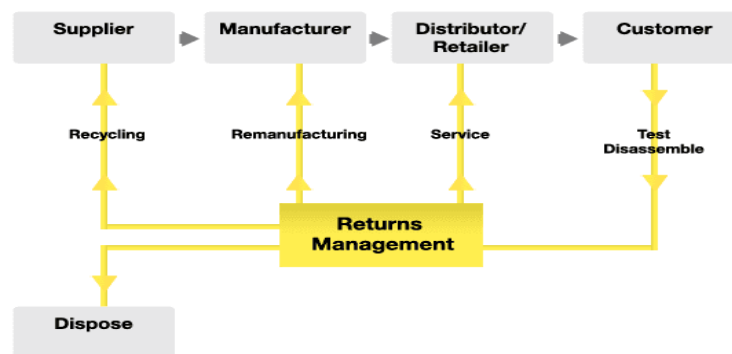


Figure 33 *Returns management process*

Returns logistics services include:

Information tracking. When a return is made, information about product location and the reason for return must be tracked. RLS can help manage this information, so you know what items have been returned, the reason for the return, and if it was shipped back to the customer.

Returns status. By giving customers visibility into their returns, you will increase their satisfaction. A good way of doing that is providing instant feedback on the return activities for their order in the returns portal or by using e-mail/SMS notifications.

Quality assurance tracking. When quality issues arise and products need to be quarantined, recalled, or repaired, the system will notify the appropriate people so they can handle the issue.

Logistics analytics

Using analytics and big data, the software can analyze the shipping history and improve clients' operations that will minimize logistical costs and reduce shipment delivery times. Applying Business Intelligence, the software can develop performance metrics and KPIs, and create computer models to predict supply chain issues.

As LMS collects a huge range of data, it should be put to good use. Reporting capabilities of a logistics analytics software (LAS) contribute to better visibility and control over future logistics outcomes.

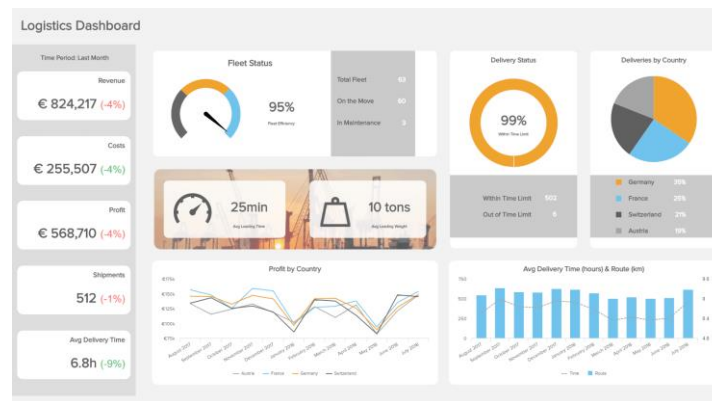


Figure 34 Logistics analytics dashboard

Among the important reports LAS runs are:

Freight accruals track the costs associated with the transportation of your goods to a customer. They facilitate calculating the company's true net revenue at any given time.

Carrier reports can identify least-cost carriers, track their performance like on-time pickups and deliveries, and routing compliance.

KPI reports provide an immediate snapshot of the overall performance of the company, focusing on indicators that are particularly meaningful.

How to integrate logistics management solutions

As we mentioned before, you can digitize logistics functions in two ways: by using LMS independently and by integrating it with a 3PL. These methods require different integration approaches.

Integrating LMS

Using any module from the family of logistics management systems requires some basic connectivity with a company's Enterprise Resource Planning (ERP). ERP integrates processes essential to running a business: inventory, order fulfillment, accounting, human resources, customer and supplier relationship management, etc.

It has a shared database allowing for synchronized reporting and automating various back-office functions, so smooth integration would allow any warehouse and transportation management functions to fit right in.

You can choose one of the following opportunities to utilize LMS in-house:

Using LMS from your ERP provider. Check whether your ERP provider has software functionality for logistics. Providers such as SAP have a big ecosystem of APIs, extensions, and open integrations to expand your ERP seamlessly.

Using IT resources. In most cases, you will have to use systems from different providers which means that integration should be hard coded. In this instance, make sure your IT staff can take the load or outsource integration to external resources.

Building your own LMS. If you have the time, budget, and a use case for designing and engineering your very own logistics software, create a custom LMS and hardwire it into your ERP.

Integrating with 3PLs

Third-party logistics companies are used when a business wants to outsource all or some of its distribution and fulfillment functions. For them to have access and ability to manage and change your inventory, you have to take care of data exchange technology and provide connectivity.

Before integration, any time a client wanted any kind of information, they reached out to the accountant manager, who reached out to so-and-so until they found the answer, and it went back through the players. Now, integrated systems empower direct interaction with the clients

– all of the shipping info throughout the product life cycle is visible to them.

1. Integration through Electronic Data Interchange (EDI). EDI is a form of structured documents exchange between business partners. Formats of EDI documents called EDI standards, specify what information goes where within an EDI document.

EDI communication methods

– how data from one system is transferred to another system

– are a key aspect of integration. Among the most common communication methods are:

- Point-to-Point EDI
- – individual connections
- EDI Network
- – value-added services
- Internet communications protocols
- – FTP/VPN, SFTP, FTPS, AS2
- Web EDI
- – via a standard Internet browser
- EDI Outsourcing
- – using an external specialist to manage the EDI environment

2. Integration through Application Programming Interface (API) suite. API-based integration connects two systems by interpreting and translating data between two systems via their APIs.

3. Integration through non-EDI format files. As opposed to direct connection, file-based integration allows data to be passed between different databases or operating systems in a file.

TOPIC 10: PERFORMANCE MANAGEMENT

There are a number of reasons why we need to measure performance and productivity within the warehouse. We measure because we need to:

- ensure customer satisfaction;
- ensure that there is a culture of continuous improvement within the operation;
- discover potential issues before they become major problems;
- train staff in the right areas; and
- reward staff where appropriate.

Unless we measure our performance against our customers' expectations and continually improve on that performance, we are not only in danger of losing our customers but we will also incur additional costs.

For example, incorrect item or quantity of items sent will incur the following:

- Finance department is affected by delayed payments and possible penalties.
- Inventory department has to provide extra stock cover.
- Sales department has to handle complaints and authorize returns.
- Transport department has to effect extra deliveries and collections.
- Warehouse has to re-pick, re-pack and duplicate activities.
- Returns procedure has to take place.
- Possible product disposal/write-off.
- Review of processes needs to take place.
- Potential additional training required.
- Loss of product if client keeps the over-delivered product.
- Potential loss of customer.

We should be measuring four areas within the warehouse:

- reliability;
- flexibility;
- cost; and
- asset utilization.

Reliability includes on-time delivery, fill rates and accuracy. Order cycle time is probably the best measure of flexibility as it covers all aspects of the customer order process: how we handle the order initially, whether we have the stock available, how quickly we can process the order through the warehouse and, finally, how quickly we can deliver to the customer.

Cost measurements include cost as a percentage of sales and productivity against labour hours. Asset utilization will include efficient use of warehouse space, MHE, staff and storage equipment.

Warehouse utilization is normally measured in the amount of floor space utilized. However, it is more realistic to measure the cubic utilization of the building. Other companies will look at the number of pallet locations utilized against the total number of locations available.

Third-party logistics companies will look to increase space utilization to the maximum as this is a revenue stream for them. However, productivity reduces significantly when space is at a premium. The coordination of pallets out and pallets in (in that order) is paramount, otherwise major bottlenecks appear. In order to ensure that you provide your customers with the service they require, you need to understand your customers' requirements both as a whole and individually and, secondly, the limitations you have within your company and operation.

Performance is a broad term that covers both overall economic and operational aspects:

- High-quality operations don't waste time or effort having to redo things, nor are their internal customers inconvenienced by flawed service.
- Fast operations ensure a quick turnaround of orders.
- Dependable operations can be relied on to deliver exactly as planned.
- This eliminates wasteful disruption and allows the other microoperations to operate efficiently.
- Flexible operations adapt to changing circumstances quickly and without disrupting the rest of the operation.
- Low-cost operations lead to higher profits as well as allowing the company to sell their products at a competitive price.

One of the main things to understand is that in terms of performance measures, you need to:

- monitor performance against the criteria that are important to your customers (delivery of the perfect order);
- monitor performance against the criteria that are important to you (costs).

Productivity measures

There are many traditional productivity measures in use in today's warehouses.

The first of these group measures are based on labour, space and equipment utilization:

Labour hours utilization

This measurement looks at the utilization of labour hours within the warehouse based on the total number of labour hours available to work over a particular shift, day or even week. These hours should not include breaks.

The calculation is:

$$\text{Labour hours utilization} = \frac{(\text{Labour hours used} \times 100)}{\text{labour hours available}}$$

Warehouse area utilization

This can be measured in a number of different ways. We can look at floor space utilization but more realistically we should measure the cubic capacity of the warehouse.

Alternatively we can measure the number of pallet locations utilized against the total possible locations.

The calculation is:

$$\text{Warehouse area utilization} = \frac{(\text{Space used} \times 100)}{\text{space available}}$$

If your warehouse has a number of different sections with racking in some areas and floor storage in others then a number of calculations will be required. Note that you need to measure the space that can be specifically used for storage. Areas used for goods in, despatch, value-adding services, etc should not be included in your calculations.

Although improving space utilization is an important goal for any warehouse, the key to improving overall warehouse productivity, that is space and labour, is to find the best compromise between storage utilization and handling efficiency.

MHE utilization

The calculation is:

$$\text{MHE utilization} = \frac{(\text{MHE hours used} \times 100)}{\text{MHE hours available}}$$

The next group of measures looks at cost performance.

In financial terms, measures include cost as a percentage of sales and cost per order despatched.

These are calculated as follows:

Cost as a percentage of sales

The calculation is:

$(Total\ warehousing\ cost \times 100) \div total\ sales\ revenue$

Cost per order despatched

The calculation is:

$Total\ warehouse\ cost \div total\ number\ of\ orders\ shipped$

The above performance cost measures need to be handled with care. Cheaper products despatched from the warehouse can result in a higher cost per order, which is not a reflection of increased costs in the warehouse but a strategic decision made by the company.

The third group is based on productivity measures:

Units picked per hour

The calculation is:

Units picked \div total hours available

The unit in this example can be an individual item, a carton or a pallet.

Dock-to-stock time

This is the time taken from arrival of vehicle on the receiving bay to visibility of stock on the system

The final group is based on customer service measures:

Order accuracy

The calculation is:

$(Orders\ picked\ and\ despatched\ accurately \times 100) \div total\ orders\ received$

On-time shipments

The calculation is:

$Orders\ delivered\ as\ per\ customers'\ requests \div total\ orders\ received$

In terms of performance measures, the 12 metrics most commonly used in distribution centres are as follows:

- 1 on-time shipments (orders delivered as per customers' requests);
- 2 internal order cycle time;
- 3 dock-to-stock cycle time in hours (time from stock arrival to available to pick);
- 4 total order cycle time;
- 5 order-picking accuracy (correct number of lines and units delivered);
- 6 lines picked and shipped per hour;
- 7 lines received and put-away per hour;
- 8 percentage of suppliers' orders received damage free;
- 9 average warehouse capacity used;
- 10 order fill rate (orders filled completely on first shipment);
- 11 percentage of supplier orders received with correct documents; and
- 12 peak warehouse capacity used.

New performance metrics

One of the most common measures today is **OTIF** (on time and in full).

This metric has been joined by the perfect order metric as the most popular customer service metric. This not only requires on time in full delivery but also the item has to be damage free, have the correct documentation and label and finally an accurate invoice.

In the following example all four metrics are measured individually and then multiplied together to produce the perfect order percentage:

On-time delivery = 97%

In full delivery = 98.5%

Damage free = 99.5%

Accurate documentation, labelling and invoicing = 98%

Therefore the perfect order metric is $97\% \times 98.5\% \times 99.5\% \times 98\% = 93.2\%$.

In terms of OTIF, we get a result of 95.5% ($97\% \times 98.5\%$).

Warehouse KPIs

An effective lean warehousing strategy depends on measuring the right key performance indicators (KPIs). Warehouse KPIs determine how efficiently you turn a profit. You probably already have a software package that compiles data and analyzes information. What you do with that information may determine the success or failure of your logistics business.

Inventory KPIs

1. Carrying Cost of Inventory

Every warehouse manager knows that stagnant inventory costs money. Quantifying these specific carrying costs — including capital costs, inventory risk, inventory service costs and obsolescence — enables warehouse managers to make smarter buying and forecasting decisions, which leads to higher inventory turnover.

Inventory Carrying Rate \times ***Average Inventory Value*** = ***Carrying Cost of Inventory***

2. Inventory Turnover

Speaking of inventory turnover: You already know that the higher the rate of turnover, the better; but calculating your specific turnover rate helps you gauge your buying practice and product demand. Your warehouse management system (WMS) is designed to provide visibility and enable forecasting to keep goods moving.

The inventory turnover KPI quantifies how many times per year your distribution is able to go through its entire inventory. Compare this rate against industry averages to get a clear picture of your distribution center performance.

(Cost of Goods Sold) / (Average Inventory) = Inventory Turnover

3. Inventory-to-Sales Ratio

The inventory-to-sales ratio is affected by economic conditions and a company's ability to weather unanticipated disruption. This ratio helps warehouse managers identify early cash flow problems by holding increasing inventory levels up against declining sales rates. It can also prevent back orders by highlighting an influx in sales and the potential for an increase in buying in order to satisfy a spike in demand.

The inventory-to-sales ratio of a successful warehouse distribution center will reflect a streamlined order fulfillment process. Warehouse managers should carefully monitor this KPI and leverage it as a tool for forecasting and predicting future inventory needs.

(End of Month Inventory Balance) / (Sales for Same Month) = Inventory to Sales Ratio

4. Inventory Accuracy

The accuracy of your physical inventory should correspond with that listed in your data but, realistically, there's often a disparity between the two in any large distribution center. A high rate of inventory inaccuracy can result in unexpected back orders, dissatisfied customers and, ultimately, higher overall costs. Visibility is key to a high-performing warehouse. You can improve your inventory accuracy rate by conducting regular checks against your database, using cycle counting as a means of continually validating your database records.

(Database Inventory Count) / (Physical Inventory Count) = Inventory Accuracy

5. Inventory Shrinkage

Inventory shrinkage is a KPI used to monitor the loss of inventory due to theft, damage, clerical error, lost items, obsolescence or supplier fraud. Shrinkage is calculated by comparing recorded inventory against actual physical inventory to pinpoint any discrepancies.

A high rate of shrinkage can have a negative impact on company profits, so it's important that warehouse managers thoroughly investigate every case of shrinkage to get to the root of the problem.

((Cost of Recorded Inventory – Cost of Physical Inventory)) / (Cost of Recorded Inventory) = Inventory Shrinkage

6. Order Lead Time

Order lead time, more commonly known as just lead time, refers to the length of time it takes for a customer to receive an order once it's been placed. Order lead time not only has a direct effect on customer satisfaction — the shorter the lead time, the happier the customer — it also affects the amount of inventory a warehouse needs to carry at any point in time. Long lead time contributes to customer dissatisfaction and can force a company to rely heavily on demand forecasting to make orders, so it's important that you monitor this KPI closely.

Supply Delay + Order Delay = Order Lead Time

Picking KPIs

7. Perfect Order Rate

This KPI measures how many orders your warehouse delivers without incident. In order to meet this standard, the correct item must have shipped on time and been received in good condition by the customer who ordered it. Lean practices are designed to help catch errors or inaccuracies before orders leave the warehouse.

You can improve your perfect order rate by strictly adhering to warehouse and distribution center best practices. By identifying problems as they arise and rooting them out at the source, you can catch imperfect orders before they ship to the customer.

(Orders Completed without Incident) / (Total Orders Placed) = Perfect Order Rate

8. Order Picking Accuracy

In addition to tracking shipment and delivery status, you should also measure order picking accuracy. An inaccurate order can result in inventory being returned to shelves, increased shipping time per average order, a higher rate of return and so on. This is also considered to be an eCommerce KPI.

Lean distribution practices eliminate waste and streamline order-picking processes to help maintain a higher order accuracy rate.

(Total Number of Orders) / (Perfect Order Rate) = Order Picking Accuracy

9. Units per Transaction

Units per transaction (UPT) is a common metric for many businesses. Depending on your industry, you may or may not be realistically expect your UPT to increase. Compare your warehouse distribution center UPT with historical averages and trends within your industry for the most useful analysis. In some industries, such as retail and CPG, you can increase UPT through sales training and checkout experience improvements that encourage upselling.

(Number of Units Sold) / (Number of Transactions) = Units per Transaction

10. Back Order Rate

Your warehouse's back order rate is a telling indicator of whether you're successful at forecasting purchases and inventory supplies. A sudden spike in demand will understandably result in a temporarily high back order rate for any given item, but a consistently high or increasing back order rate is a sure sign of poor planning and lack of responsiveness.

You can decrease your back order rate by accurately forecasting and vigilantly monitoring your warehouse's inventory-to-sales ratio. A high inventory accuracy rate will also improve this KPI.

(Orders Unfulfilled at Time of Purchase) / (Total Orders Placed) = Back Order Rate

Distribution KPIs

11. Rate of Return

Rate of return is an incredibly useful KPI in a distribution center, especially when segmented by cause for return. Identifying causes for return — such as damage, late delivery, inaccurate product description or wrong item shipped — makes it easier for warehouse managers to address underlying issues and make the necessary improvements.

(Number of Units Returned) / (Number of Units Sold) = Rate of Return

12. Cost per Line

In receiving, the cost per line KPI is used to measure the cost to receive a line item on a purchase order. Generally speaking, the higher the cost per line, the less efficient a warehouse's receiving process. Cost per line enables warehouse managers to better understand the costs associated with receiving and implement process improvements for better inventory management.

(Total Cost of Receiving) / (Total Line Items) = Cost per Line

Receiving KPIs

13. Receiving Efficiency

Receiving efficiency is a metric used to evaluate warehouse workplace productivity when receiving stock. Inefficiencies in your receiving area can have a ripple effect across warehouse operations, so it's vital to detect and eliminate inefficiencies as soon as possible in order to streamline the rest of your workflow.

Volume / (Number of Man Hours) = Receiving Efficiency

14. Receiving Cycle Time

The receiving cycle time reflects the total amount of time it takes to process a delivery. A short receiving cycle time is a clear indicator of an efficient delivery process, whereas a long receiving cycle time points to process inefficiencies. If your warehouse currently has a long receiving cycle time, you may want to consider decreasing the number of deliveries or rescheduling them so that your receiving area has more time to process each incoming delivery.

(Total Time for Delivery) / (Number of Deliveries) = Receiving Cycle Time

15. Accuracy Rate

An effective and efficient put away process is one of the most critical components of good warehouse management because it has downstream effects on fill rates, which can lead to congestion in staging areas. Accuracy rate refers to the percentage of items put away correctly the first time; the higher your warehouse's accuracy rate, the more efficient your put away process, with the ultimate goal of a 100% put away rate.

(Inventory Put Away Correctly) / (Total Inventory Put Away) = Accuracy Rate

16. Put Away Cost per Line

The put away cost per line KPI is essentially the same thing as the receiving cost per line KPI, with the clear exception that it measures the cost to put away a line item on a purchase order. Again, the higher the put away cost per line, the less efficient a warehouse's put away process is.

$$\text{(Total Cost of Put Away)} / \text{(Total Line Items)} = \text{Put Away Cost per Line}$$

17. Put Away Cycle Time

Again, similar to receiving cycle time, put away cycle time measures the total amount of time it takes to put away items. A short put away cycle time is an indicator of an efficient process, whereas a long put away cycle time signifies that there's room for improvement. One easy way to improve your put away cycle time is to rearrange your warehouse or invest in better employee training.

$$\text{(Total Time for Put Away)} / \text{(Total Time)} = \text{Put Away Cycle Time}$$

Safety KPIs

18. Time Lost Due to Injury

It goes without saying that the safety of your warehouse staff is a priority for non-business-related reasons, but the fact of the matter is that injuries sustained on the job can have a serious impact on workplace productivity and overall costs.

Any time an employee misses work due to injury, warehouse managers need to draw on supplementary resources and even offer other employees overtime to make up the difference. As a result, time lost due to injury is a valuable metric to monitor because it can help warehouse managers identify preventative measures they can take to ensure workplace safety in the future.

$$\text{(Lost Time in Hours Due to Accidents)} / \text{(Total Number of Hours Worked)} = \text{Time Lost Due to Injury}$$

19. Accidents per Year

No equation needed here — the accidents per year KPI measures exactly what its name implies. Obviously, every warehouse manager aims to keep this number as low as possible, with the ultimate goal of zero accidents per year.

20. Time Since Last Accident

Again, like accidents per year, this one's pretty self-evident and is a key indicator of warehouse safety. Think of it this way: You want your number of accidents per year to be low, and the time since your last accident — typically measured in days — to be high.

21. Total Recordable Incident Rate

Your warehouse's total recordable incident rate (TRIR), sometimes referred to as the total case incident rate (TCIR), is the total number of work-related injuries per 100 full-time workers during a one-year period.

TRIR is an incredibly important KPI to track because the Occupational Safety and Health Administration (OSHA) uses this metric to gauge companies' safety performance and monitor high-risk industries. The higher your TRIR, the more likely your warehouse will be subject to surprise OSHA inspections and, potentially, penalties. Your insurance company might also use your TRIR to help determine premiums — the higher your TRIR, the more you pay out of pocket.

$$\text{((Number of Recorded Injuries in a Year} \times \text{200,000))} / \text{(Number of Hours Worked in a Year)} = \text{Total Recordable Incident Rate}$$

Cultural KPIs

22. Employee Turnover Rate

Although employees and employees go, a high attrition rate is cause for concern because it usually points to larger issues within your warehouse. Your employee turnover rate (ETR) is a critical KPI because it enables you to gauge the stability of your workforce. If your warehouse has a high ETR, you might want to consider consulting your staff to find out where there's room for improvement.

(Employees Who Have Left) / (Average Number of Employees) × 100 = Employee Turnover Rate (%)

23. Employee Net Promoter Score

Using the same logic as the Net Promoter Score, the employee net promoter score (ENPS) enables you to determine how engaged your employees are, how satisfied they are with their jobs, and how loyal they're likely to be.

Employees simply rate how likely they would be to recommend your company's workplace on a scale of 0 to 10, with 0 indicating "not at all likely" and 10 indicating "extremely likely." Employees who rate your company anywhere between 0–6 qualify as "detractors," while those who rate it a 7 or 8 are considered "passive"; you should take time to address employees who fall into either of these categories to find out what would make their workplace experience better and what cultural improvements they recommend. Employees who rate your workplace a 9 or 10 are considered "promoters" and are strong proponents of your company and its culture.

24. Manager Satisfaction Score

Good leadership is a vital component of a strong company culture, therefore, it's just as important to evaluate manager satisfaction as it is employee satisfaction. The easiest way to gauge this is by applying the same concept as the ENPS, except to your team of warehouse managers.

Additionally, you'll want to understand the relationship between managers employees and how that affects overall employee workplace satisfaction. The best way to evaluate this KPI is to conduct anonymous surveys asking employees to rate their managers in order to see how well the management bench is doing.

25. Cultural Entropy Score

Cultural entropy refers to both the amount of energy spent doing unproductive or unnecessary work, and the level of dysfunction within an organization driven by fear-based actions from leaders. To that end, your company's cultural entropy score is a measure of the overall cultural health of your workplace environment. The more fearful your leadership team — meaning, the more given they are to control, manipulation, bureaucracy, internal competition, etc. — the higher your cultural entropy score and, consequently, the lower your level of employee engagement. A low cultural entropy score is an indicator of strong leadership, a culture of accountability and trust, a highly engaged workforce and an overall positive workplace environment.

ECommerce KPIs

Although all of the KPIs listed are important to eCommerce fulfillment performance, there are a few that are critical indicators of your ability to deliver value directly to the consumer:

26. Order Fill Rate

Partially filling an eCommerce order is one of the quickest ways to lose an online sale. Order fill rate refers to the percentage of orders that are immediately — and

completely — fulfilled by available stock. A high order fill rate requires seamless visibility between your WMS and your storefront, inventory synchronization and the ability to optimally service customers from various distribution locations. To calculate your order fill rate, divide the number of customer orders shipped in full by the total number of orders placed and multiply by 100.

(Number of Orders Shipped in Full) / (Number of Orders Placed) × 100 = Order Fill Rate (%)

27. On-time Delivery

Thanks to the Amazons of the world, consumers now expect near-instant gratification, meaning online channels must be able to deliver at increasingly rapid rates in order to remain competitive. On-time delivery (OTD) is one way to stay on top of these expectations. OTD is a measure of customer order lines shipped on or before the requested delivery rate. In order to determine your company's OTD, divide the total number of units delivered on time by the total number of units shipped.

(Number of Units Delivered on Time) / (Number of Units Shipped) = On-Time Delivery

28. Time in Transit

As its name implies, time in transit refers to the total number of days or hours from when a shipment leaves your distribution center to when it arrives at the customer's location.

УЧЕБНОЕ ИЗДАНИЕ

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КОНСПЕКТ ЛЕКЦИЙ по дисциплине «Логистика складирования» на английском языке

*Текст печатается в авторской редакции,
орфографии и пунктуации*

Ответственный за выпуск: Почко Е. О.
Редактор: Митлошук М. А.
Компьютерная верстка: Рогожина Ю. А.

Подписано в печать 13.10.2021 г. Формат 60x84 ¹/₁₆. Бумага «Performer».
Гарнитура «Times New Roman». Усл. печ. л. 4,19. Уч. изд. л. 4,5. Заказ № 1137. Тираж 18 экз.
Отпечатано на ризографе учреждения образования «Брестский государственный
технический университет». 224017, г. Брест, ул. Московская, 267.
Свидетельство о государственной регистрации издателя, изготовителя,
распространителя печатных изданий № 1/235 от 24.03.2014 г.

