Introduction

This paper will focus on order picking operations, in particular on order picking operations where items are selected in less than full case quantities. These "broken-case" or "each-picked" orders are among the most labor intensive of any type of common customer order. In this paper, we look at the equipment, methods, and materials, which are commonly useful in each pick environments. In my paper titled "Strategies for Optimizing Traditional Each Pick Operations Part I – Developing A Roadmap for Improving Order Picking Performance" we look at a general methodology for evaluating which solutions are best.

This paper focuses on equipment, systems and materials that are currently being used in the each pick distribution environment. We will start out looking at signage and labels and proceed through storage systems, computer aided order picking systems, and even AS/RS systems, ending with packing and manifesting functions. We'll cover all types of order picking equipment from paper to high-speed sorters. Hopefully after you've read through the paper, you will be in a better position to determine which equipment may potentially benefit your company. You can then apply the methodology outlined in Part I to evaluate and determine which ones are best for your company.

Storage Organization Tools

Signage and Labels

Signage and labeling are probably among the least expensive items to assist in the navigation of your facility. A well designed signage and labeling plan can dramatically cut down the learning curve for new employees, and help existing employees work more efficiently. The key is to have a logical location plan that is easy to understand. It is equally important that all markers and labels be easy to see and appropriately sized for the work being performed. Labels can be designed with bar codes to enable bar code driven verification of locations. Schemes can be designed to minimize errors and make locating the next item easy.

Aisle Markers

Aisle markers should be designed so that they can be seen from a distance. Markers can be hung from the ceiling or attached to the end bay or unit of a storage row. It should be easy to figure out where the appropriate aisle is from a distance. The storage layout should be designed to facilitate this ability (no hidden aisles).

Zone, Bay, and Level Markers

Zone and bay markers should be easy to spot and they should stand out from the local location information. The idea is to permit the order selector to quickly locate the bay, and then find the location on the bay, once there. Consider putting markers that stick out perpendicular to the storage unit so that they are easy to read by someone walking down the aisle.

Zone markers give the highest level of division, then bay markers mark the bay within the zone. Level markers will identify the level within the bay. Level markers should be placed on each level of a storage unit. A common technique is to start labeling from the bottom to the top. This way if additional shelf levels are added, they will not interfere with levels already in use. In tall storage environments like pallet rack, level markers may also be repeated on the lowest easily accessible beam. This permits operations to be performed on bar codes at the floor level, without having to travel up to the location.

All text on labels should be sized to be easily visible, and generally speaking, the more precise the information, the smaller it can be made. Obviously labels on pallet rack should be made larger than labels on shelving. Keep labels and text as large as possible for the storage medium being used. Also consider the size of the bar code you print. The larger the code, the easier it will be to "shoot" from a distance. Experiment with your equipment before settling on a final size.

Location Labels

Location labels can be designed with the zone, and bay printed in smaller type, and the level and location in larger type, to permit the order selector to focus on the particular item to be picked. Labels may include a bar code, which can be used to verify replenishment to the proper location and to confirm picks when no bar code is available on the product itself. Consider adding the bar code even if you don't yet have a bar code system in your facility. It costs very little more, and it eliminates a re-labeling of the facility at a later time.

Product Labels

Product labels can be printed for all items that do not have a readable bar code. Normally this is done at the time the product is received. As a trade off, you may want to consider using location verification if you have products that are small or hard to tag. Note that some computer systems allow you to store both a manufacturer's bar code and your company's product code and can then cross-reference between the two.

Storage Totes

Static shelving areas often have a great deal of wasted space above and to the sides of stored materials. Totes can be used to store product more compactly, and they permit material to be stored in areas with reduced clear heights. On shelving, totes can encourage better utilization through the use of variable sized compartments (either by using totes of varying sizes or by using compartments within the totes themselves). Some totes have removable dividers, which allow storage sizes to be redefined on the fly.

Totes are particularly useful with smaller parts and with loose parts. They can be marked with part numbers or bar codes on the individual compartments to insure replenishment and picking accuracy. Totes also can be designed with "cut-outs" on the front wall, which permits a picker to get his fingers in to grab the tote even when the space above the tote is negligible.

Totes can improve storage utilization in a shelving area by 50% or more. There is, however, a trade off between space efficiency and restocking speed. The greatest efficiency is gained when stock is taken out of vendor boxes and placed directly into tote storage cells. This, of course, requires an additional labor step when restocking. Also, it may be necessary to keep the bar codes on the vendor boxes, limiting which products can be placed directly into cells.

Order or Transport Totes

Order (or Transport) totes are used to accumulate order materials during an order selection run. The tote is a container used in a manner similar to a shopping cart at the supermarket. Items are picked into the tote, and the tote is brought to a packing area where materials are normally repacked into shipping boxes.

Captive Tote (Recycled) – in some operations, the picking tote can actually be shipped to the customer (usually a store) and then returned empty. This is commonly done in health and beauty distribution facilities. Obviously this can only be done when the totes are under control of the company distributing the product.

Pick to Tote or Pick to Box – Often a debate comes up between picking to a tote, and picking directly to a shipping box. There are a number of points, which need to be evaluated.

First off, picking directly to the box will reduce labor as long as three conditions hold. First, the items in the box don't have to be re-handled to pack them. Second, the conveyor or transport system will not damage or get jammed by the boxes. Third you know the size of the box the order will require in advance.

There are several reasons to consider a pick to tote. First pick to tote often makes sense when the size of an order is not known in advance. Second, if there are a wide variety of box sizes (or envelopes and boxes), this will potentially pose challenges for a conveyor based transport system. Third, if the process requires that items be re-handled in the box to wrap, tag, or verify them at pack, then the shipping box probably slows things down (since a tote has no flaps, and often has handles). Finally, if you have times when you need to stack orders before they are fully packed out (for example to hold short orders until requirements come in), totes are an ideal way to do this.

Static Storage Systems

Static storage systems refer to storage where there are no moving components. These systems include shelving, and racking where all movement onto and from the storage surface is done by an outside force (person or lift device).

Bin Shelving

Bin shelving is probably the least expensive of any storage method used inside distribution centers today (other than the floor). Bin shelving can be purchased for less than $150 / bay including installation, so the initial investment is minimal.

Bin shelving is suitable for items that are slow movers, and it is best with items that have low cubic velocity. Cubic velocity refers to the measure of the unit movement of a product multiplied times the size of a unit. Note that items of varying sizes may have the same cubic velocity. For example a slow moving toaster than moves 1 unit a day will have the same cubic velocity as, say a CD that moves 30 units a day. Both may be candidates for bin shelving. In general bin shelving is best for items that move less than 1 or 2 cubic feet per week.

Many businesses start with bin shelving and then find that their shelving area has become inadequate as the business grows. Two problems occur. First, as volumes increase, the shelving becomes an inefficient place to store large amounts of a particular stock item. Second, as products move more quickly, shelving areas can become congested with lots of people looking for picks. Finally, as order volumes grow, other mechanisms that could not have been cost justified in the early days become more attractive in terms of their potential labor payback.

The biggest problem with bin shelving is that products are generally not stored very efficiently on this medium. There are a couple of reasons for this. First, since the shelving is inexpensive, it is easy to buy more when space becomes tight. Second, shelving tends to provide fixed locations that grow and contract as they are replenished. These locations often have a lot of dead space around them most of the time. The storage location spends a good portion of the time waiting for the next full stock replenishment, and open space tends to increase over time if it is not carefully managed.

As mentioned above, storage totes can significantly improve the space utilization of bin shelving, but at the cost of additional replenishment labor. Nothing, however, can solve the problems created by increasing volumes other than throwing more labor and shelving at the problem. In this situation, a storage medium suited for larger cubic movement is required.

Tilt Shelving

Tilt shelving is a particular type of bin shelving, where the static shelves are tilted forward, and the shelving units are open in the back. The idea is to use the tilt shelving with product replenished from the back and picked from the front. Note that it is possible also to have traditional bin shelving that is open in the back, and replenished in this manner.

By creating replenishment "flow" it is possible to enforce product rotation. Normally the shelving is designed so that the order selector can reach and pull the most rearward case forward without the assistance of any special equipment. The tilt is done to facilitate flow, and rather to make picking easier out of vendor cases, but it generally doesn't help the material move forward. The tilt angle makes it easier to select items, especially taller products like bottles.

Tilt shelving offers the same advantages of traditional flow rack (described below), but with only a fraction of the cost. The shelving is priced similarly to traditional bin shelving, since it really is just bin-shelving that has been configured for a special flow capability. As with bin shelving, tilt shelving should be used only with items that have low cubic velocity.

Shelving Mezzanines.

Shelving units can be constructed with multiple levels. The frames of the shelving can actually be used to support upper levels if designed properly. The advantage of this strategy is that you are purchasing storage equipment and the floor supports together, and this is generally less expensive than buying a mezzanine and then putting shelving on it independently.

Pallet Rack Shelving and Decking

Like bin shelving, pallet rack shelving is a static storage medium. Many of the comments applying to bin shelving also apply to pallet rack shelving. The main difference between the two is that pallet rack shelving can store more material on a location, and each location has the flexibility of storing a full pallet or individual cases.

Pallet rack can be turned into shelving by adding a wood base (such as wood planks or plywood) or by adding wire decking. Wire decking has a distinct advantage over wood in that it allows sprinkler access in the event of fire, and the decking itself is not flammable.

A significant disadvantage of pallet rack shelving is that levels of rack that are raised off the floor by more than a couple of feet become difficult to pick. This is especially true if product is located toward the rear of the second level pallet location. Items that are awkward or heavy are particularly troublesome when they must be reached for.

Movable Storage Systems

Movable Shelving

It is possible to place bin shelving units on carriages that allow the shelving to be easily moved. This is accomplished by either by pushing manually, by pushing or with a crank, or by moving the shelving carriages electrically with a motor. You may have seen these types of systems used to store patient files in a doctor's office.

As in the doctor's office, movable shelving is designed for use in environments with low access rates, but with a lot of stored items. Since only a single aisle needs to be open at a particular time, the shelving utilization of a particular footprint can often be doubled – that is – twice as many shelving units can fit in the exact same footprint.

Movable shelving systems are appropriate for very slow moving items, and low order rates. Since the number of available aisles limits the number of selectors who can work at one time, the overall throughput requirements must be low.

Movable shelving is relatively low in cost, and often can save expansion into another facility or building addition. The key is to make sure that product stored there is truly slow moving.

Storage Drawers

Storage drawers are very popular in environments where large numbers of small parts are being stored. As with storage totes, compartments as small as 2" x 2" can be created and resized within the drawers to make optimally sized stock locations for each part. Drawers can be ordered in a variety of heights (from 3 to 18") so that they will fit the particular products to be stored. It is also possible to order a variety storage compartments in a single drawer unit.

Drawers have two significant advantages over open shelving. First, they close, keeping their contents free of dust and grime. Second, drawers can be locked. Storage drawers can be placed on movable platforms (as with movable shelving) or even on devices like carousels (which we will talk about later).

A major disadvantage of drawers is that it is really not feasible to have a drawer higher than about 50" since most individuals would have a hard time seeing and reaching the product if it were stored higher than that, without the use of a set of stairs or a ladder. Often traditional bin shelving or cabinets are placed on top of drawer units to address this problem.

Since drawers tend to be deeper than shelving, this does tend to leave dead space. Finally, aisles where drawers are used must be larger than shelving aisles. The aisle must take into consideration both the drawer depth and the space required for the order selector. So, although drawers themselves offer very dense storage, they give some of this efficiency away in the total layout.

Drawers tend to be expensive, but for small parts storage, they are often a good choice.

Inertial Storage Systems

Systems, which operate automatically under the effect of gravity, are known as "Inertial Storage System". These systems can vary from something as simple as skate wheels or roller conveyor on an angle to rather sophisticated systems requiring specialized brakes and release mechanisms. For the purposes of this paper, we will look at systems that are used in an each picking environment. There are other systems used for bulk pallet storage, which will not be discussed here.

Flow Rack

Flow rack is the simplest of the inertial storage systems. Basically it consists of tracks or rollers that cases are placed on. The tracks or rollers are tilted at an angle so that cases placed on the track naturally "flow" from the high end to the low end under the force of gravity – hence the name "flow rack". The track the box flows down is called a "lane". In some systems, dividers are used between flow lanes to keep product moving in a straight line forward, in others the rollers themselves permit straight line tracking of the product.

Flow rack has a few very significant advantages over static storage mechanisms. First, because product is loaded on one end and picked on the other, the storage system itself enforces automatic rotation of stock (first in – first out). Second, product is automatically delivered to a "pick face" on the front of the unit without the order selector having to shuffle boxes around. Third, and very important, flow rack reduces the area required to select an item to a single face just slightly larger than the face of the box being picked from (Note that the first and last advantages are shared by tilt shelving).

Product stored in flow rack is stored in a "lane" so that only the forward case is presented at one time. When the case is fully consumed or selected, the next case rolls into position and the other cases index forward. Normally in an each-pick environment, cases are cut open at the time they are fed into the back of the lane, or in some situations, items are placed from cases into totes that are loaded into the lane.

An order selector has a tremendous density of pick opportunities in a flow rack aisle because he has access to the front case, and the front of the case only, for a variety of SKUs. Unlike static shelving, no cases are stacked to the side or above the pick face – all other cases are positioned behind the front case, ready to move forward.

This increase in pick density provides a substantial advantage to the order selector. He can travel less and pick more items with each step he takes. The order selector can pick at the same time that a replenisher fills the lane from behind, and the two workers will not interfere with each other in any way.

Flow rack is best used for medium to fast moving items. For very slow moving items, traditional shelving or tilt shelving should be used. For very fast moving items (items selected in a pallet quantity in a day or less) consider using pallet storage (discussed next). The problem with very fast moving items is that the labor to fill the lane is so intensive that it is easier simply to pick the items from pallet.

Ideally, it is best to select items that have the same linear movement characteristics so that they consume approximately the same amount of lane depth in the same period of time. Various depth flow racks can be purchased from just 3' deep to as deep as 12'. Deeper flow rack can be manufactured, but they pose problems for replenishment, since the back of the lane must be higher than the front in order to allow product to flow properly. When the lane exceeds 12', the top back lanes are generally too high to reach.

Pallet Flow

Pallet flow lanes are similar in concept to flow rack with a couple major exceptions. First, it is not practical to stack lanes one atop the other, because it would be impossible to pick from the top pallet. Second, it generally isn't helpful to make pallet flow more than two pallets deep since as soon as the front pallet is pulled out, a replenishment truck can easily move a replenishment unit load into place (unless a longer lane is needed to enforce strict rotation due to inadequacies of your computer system).

As with flow rack, pallet flow is designed so that when the forward pallet is consumed, the next pallet moves automatically into position under the force of gravity. Items can be selected as full cases from the pallet or as eaches from the cases on the pallet. The pallet flow system permits a tremendous volume of material to be picked in a continuous flow process without the danger of ever running out – as long as your replenisher is on the ball.

One disadvantage of pallet flow is that picks may vary from rather high up on a pallet, to just off the ground. If items being picked are small and light this generally isn't a problem. If items are heavy, there could be some ergonomic issues picking the low items, and with picking items from the rear of the pallet. Pickers must sometimes step up onto the pallet to pick from the rear most cases, and this is another ergonomic disadvantage. Lanes should be adjusted to an optimal height based on several factors including 1) weight of product being picked, 2) number of eaches in a case, and 3) the size of the vendor cases.

Picking Devices

Order Picker Truck

In some situations involving large SKU populations and relatively slow overall movement, it may make sense to use an order picking truck to select individual orders. An order picking truck is a device that permits the order selector to operate in three dimensions under powered control and assemble an order onto a platform on the truck. The platform may contain a pallet, a tote, or some other container. The order picker permits the order selector to pick items that are stored in the air in addition to those items that can be reached from the floor. This can substantially increase the number of SKUs available to be selected. Generally speaking, order pickers select full cases from locations, although they can be used to select items out of cases.

The downside to an order picking device is that picking in the air is slower than picking on the ground. Truck up and down movement speed is limited for safety reasons as is forward backward movement speed while the man is up in the air. The solution to this problem is to batch lines together to create enough density to that movements between locations are small. Software can also direct picking so that picking can be done a level at a time (so no up and down movement is necessary).

Order pickers normally select from either pallet locations or pallet rack shelving. Order pickers can work in aisles as narrow as 9', although wire guided order pickers can work in aisles as narrow as 6-7'. They can operate with rack heights up to 30' high. The combination of height with the narrow aisle density permits a lot of stock to be located in a very small area.

Major Computer System Categories

Computer systems used in modern distribution centers fall into 4 major categories. The simplest are organization or batching systems. The most sophisticated are full Warehouse Management Systems (WMS). In addition to these two extremes are two other major categories: 1) order picking subsystems and 2) order routing systems.

Systems that Organize Information

The company owning the distribution center most frequently writes organization systems. The requirements for these systems are often evolved over time and based on the unique requirements of the owner's facility.

The simplest system will print out orders in the exact sequence that the orders were entered. More sophisticated systems will permit orders to be rearranged by size, truck route, customer, or shipping type.

For individual orders, systems may be capable of breaking the order up into 2 or more zones and printing summary routing tickets for each order.

Very sophisticated systems will permit order to be released dynamically based on knowledge of whether the order can be completely filled and when the order is needed by. These systems may group orders of like size or customer class together in order to improve overall picking efficiency

Finally, some of these systems may have a full RF terminal interface. Some of the most sophisticated customer systems are as sophisticated as modern WMS systems.

There is good news for those companies that don't already have a good order picking system in-house. Modern software systems will permit your company to immediately upgrade to a state of the art system without spending a fortune. Good warehouse systems start around $50,000 for collections of 10 or fewer employees, and can often be purchased for less than $200,000 even in large organizations.

Order Routing Systems

Going along with order organization systems are order routing systems. These systems permit orders to be automatically routed from one zone to the next or to an appropriate shipping destination. Many times, these systems are in control of the company's conveyor, and are provided as part of the conveyor system.

Order routing systems combined with intelligent slotting and zoning, and can be used to create opportunities where orders are able to bypass entire sections of the pick process.

Picking Subsystem

Several different types of order picking subsystems exist. These include RF bar-code scanner based picking systems, Pick-to-Light, A-Frames, Carousels, and Voice Directed Picking. All systems are designed to provide the ability to select orders under control of a computer by using the associated technology.

All these systems may be configured to interface to the existing customer host system or to a selected WMS system. The picking system's focus on the picking process and they generally do not manage inventory. It is common for order requirements to be sent and executed by the picking subsystem, and the results returned to the host or WMS system.

WMS Control System

A WMS system generally is more sophisticated than a picking subsystem in two significant ways. First, it handles other warehouse functions such as receiving, reserve stock management, replenishment, and shipping checkout. Second, it keeps track of all locations and inventory. WMS's can range in price from a low of 10 or $20k to a high of over a million dollars (obviously these two ends have a big difference in size and functionality)

WMS systems can range from, at the low end, a simple stockroom management system to, at the high end, an extremely sophisticated, multiple facility distribution system.

WMS should not be confused with Enterprise Resource Planning (ERP) systems, which generally are more focused on the manufacturing and/or business functions of a company. Note that some ERP systems claim that they also provide WMS capability, but few have a well-implemented WMS feature set.

WMS systems most frequently operate through RF based terminals, which have a display, keyboard, and bar code scanner. The systems tend to be very accurate because they are able to verify both put aways and pick with location or item scan confirmation. These systems will interface to both the client's host system on one side, and to other vendor order picking sub-systems on the other.

The WMS is responsible for managing inventory and orders within the facility. The WMS can track stock levels for reordering, or it can transmit completed order information back to the host so that the host can take care of this function.

The WMS knows both where the stock is and where the open slots or locations are in the facility. Often the WMS will sort and arrange orders for efficiency or based on required ship dates. The WMS directs receiving, put away, replenishment, and order picking. Some WMS systems will also verify the order at the pack station and even manifest each box.

The WMS does not try to manage customer orders or billing and it is not concerned with manufacturing demand issues, although it may pick orders for manufacturing once it is told what to pick.

Picking Equipment and Methodologies

Batch Picking Systems

"Batch Picking" is sometimes referred to as "Cluster Picking" or "Wave Picking". In this paper "Batch Picking" refers to the process of combining picks from several orders together in order to obtain advantages in order selection and travel time.

Almost any system can be turned into a batch picking system, including paper, pick-to-light, voice directed picking, bar code based, and carousel systems. In all situations, the goal is the same – to reduce the time it takes to travel between picks by grouping a larger number of picks into a single group of requirements.

To take an example, suppose I have 10 pallet rack bays, and I have 10 orders, each selecting one item from a different one of the 10 pallet rack bays. If I pick these orders one at a time, I have to walk (on average) 5 pallet rack bays to get the item and 5 pallet rack bays back to drop off my pick. If, on the other hand, I take all 10 orders and sort them by bay, I can now may one trip, stopping at each bay and picking one item. I eventually will walk 10 pallet rack bays to get the 10 items, and 10 pallet rack bays back to drop them off. In the first scenario, I walked a total of 50 pallet rack bays to pick the 10 items. In the second scenario, I walked a total of 20 pallet rack bays. I did have to sort paper in the second scenario, but a computer could have accomplished this task.

The same strategy can be applied to any set of orders, even orders that have more than one line item (a line item is a pick from one location in some quantity of 1 unit or greater). Modern computer systems can batch dozens of orders together, sorting the picks in location sequence. As each pick is made, the system can direct which order should receive the item selected.

The more orders that are combined together, the smaller the average walking distance between picks (since the storage area has a fixed size). The main constraint of this strategy is making sure that you can sort out the selected items to individual orders and transport all orders back to a drop off point so that they can be packed.

Carts with cubbies are commonly used in low line environments. In medium line environments totes on carts are used. I large line environments entire shelves may be used for one order.

The primary limiting constraint on order batching is that I be able to manage the orders of the batch through all of the picks. With most systems, this means that a person must be able to physically move the orders around as he travels though a storage area. As we will see later, some systems such as carousels, will allow us to have very large order batches due to the fact that that the orders can remain fixed in one location while all picking takes place.

Transport Equipment

Carts

As mentioned in the previous section, carts can be used to batch many orders together on a single picking run. They may also be used to accumulate a single order. The cart serves the same function as a shopping basket in a supermarket.

Carts come in a variety of styles from flat-topped push carts to multi-level shelf carts. The type of cart selected depends upon the application, the size and weight of the order, and the need to batch orders.

Conveyors

Conveyors are the most common transport mechanism used in distribution environments. They allow product to move from one location to another without human intervention. Aside from simple transport, conveyors can also act as work buffers and can work as part of sortation systems. Conveyors are a crucial component in large volume operations in that they manage and control the flow of products from the time the order is selected until it is manifest (and sometimes right into the shipping truck). For smaller operations, conveyors are often useful at the end of the process, where packing and manifesting take place.

Sortation Systems

Sortation systems direct orders to particular destinations in the facility. The destination may be an area where items are to be selected, or it may be a work process. When orders are complete, they are commonly sorted to a packing lane or truck door. In addition to providing general direction for work, sortation systems can also balance work, based on dynamic queue lengths, to various workstations.

Paper Pick Systems

Pick-by-Paper

Pick-by-paper systems are still used today by many distribution centers. Better systems sort picks in location travel sequence. Sometimes, better pickers will try to pick from more than one list at once by doing a mental sort of the picks in their heads.

Paper-based picking is slow and it is prone to error. Since pickers can misread information or transpose numbers, it is much more common for the wrong product to be selected, than with modern computer-based systems. Paper based picking also causes picker fatigue since the picker is constantly changing focus from paper to location and back. Finally, paper based systems require hand writing of exceptions and then later keying of the exceptions into the system.

Pick-by-Label

Pick-by-label systems are nearly as old as paper, and they are an alternative to paper based systems. The primary difference between pick-by-paper and pick-by-label is that labels are consumed and placed on the items selected as picking takes place. Pick-by-label has been long been used in case picking environments, and permits picking with reasonable accuracy at reasonable rates.

A main advantage of pick-by-label is that a label identifying the pick is attached to the item at the time it is selected. While this does not guarantee accuracy, it does enforce good counts since picking must stop when there are no more labels to apply. Because the label is on the item, the pick can be quality checked in a downstream process.

Also, it is possible to batch a group of orders together and pick by label. In this case, the label may have an additional item of information printed on it – the order number. By picking and tagging items belonging to a batch of orders, the items can latter be sorted out to their appropriate order destination simply by reading the label. The picker does not need to do a mental sort of locations, and he does not even have to segregate orders with this methodology, since the sorting out can be done using the order information on the label at the dock.

Computer Assisted Picking Systems

Bar Code

The term "Bar Code" refers to a collection if identification schemes, which use bars or dots, printed on a flat surface to store information. Newer "bar codes" are really "dot codes" in that the solid lines have been replaced by collections of dots. Bar codes are a mainstay in our society and are on nearly all retail items and inside and outside many of the appliances and documents we use every day.

The advantages of bar code are 1) very fast data entry of information and 2) extremely high accuracy of input. In a distribution center bar codes are used 1) to identify products, 2) to identify locations, and 3) to identify supply chain transactions (receipts and shipments). Bar codes are used to rapidly identify product movements and they do it with extreme (almost perfect) accuracy.

Bar code systems may be used by any number of computer-aided systems although they are most commonly thought of as being associated with Warehouse Management Systems. Many picking subsystems such as pick to light, carousels, voice and others have been designed to accept bar code as an auxiliary input.

Pick-to-Light

Pick-to-light refers to the direction of order picking under the control of fixed mount visual display devices (commonly known as LED displays). The displays are mounted at picking locations, and they tell where to pick from, and the number of units to be picked.

Displays can be located under each location, or they can be placed at a location central to the particular bay or area being controlled. In the case where there is a central display, location lights are sometimes placed at each location to visually identify the location to the picker, while the quantity to be picked is on the central display.

Pick-to-light can significantly reduce errors because the picker is directed by lights which are physically underneath the product to be picked. Because lights direct the picking, the picker no longer has to refer to paper and then back to his picking location. Instead, he simply focuses on the lights as they are illuminated and transfers the required quantity from the pick face to his order. Since the picker is picking visually with lights, he can proceed significantly faster than if he were picking with paper.

Picking rates average around 220-240 lines per hour, and can be as high as 500. The actual rates achieved depend on the type of product being picked, the amount of non-picking work a picker needs to accomplish (like creating new boxes), and most importantly, the average distance that the picker must travel.

Exceptions such as out of stock or shortages can easily be communicated back to the system through the use of buttons on the system. Pick-to-light systems can also be used to verify that the correct stock is in the location, and to cycle count location on-hand quantities.

Pick-to-light is most commonly placed on flow rack, although it can be used to pick from pallets or shelving as well. Pick-to-light systems can also be set up with portable RF interfaces, and control picking out of shelving areas to orders on a cart.

Put-to-Light

Put-to-Light, like Pick-to-Light is directed under the control of a fixed mount visual display device (light). In Put-to-Light, picking comes from a set of inbound product SKUs and putting goes to a collection of orders. Note that Put-to-Light systems can operate on carousels as well as in shelving or flow rack environments. In all of these environments, there are collections of several order boxes or totes that accumulate items selected from one or more inbound SKU vendor cartons.

Put-to-Light systems are effective in environments where there is a substantial commonality of SKUs between orders. Good SKU choices for a put system are the fastest movers in a traditional distribution facility, weekly promotional items, or items that are being cross-docked or pushed through to most of the stores in a chain.

Bar Code Systems

Bar code systems are systems traditionally offered as a part of WMS systems. They consist of a terminal consisting of a display and keypad connected to a bar code scanner. Most modern systems operate under RF (short for radio frequency transmission), meaning that they are wireless and portable units. Bar code systems have gained widespread acceptance because of their flawless accuracy. Systems boast facility accuracy rates of 99.9% or more with most remaining errors being limited to the counting of a product quantity.

Bar code systems can be used for almost any warehouse function from receiving to put away, to picking to replenishment, to stock verification. Instructions are transmitted via the RF network to the local terminal. The operator follows the instructions displayed on a small screen, verifying that he has reached the proper location by scanning the bar code on the location (or the bar code on the product itself).

Voice Directed Picking

Voice directed picking is one of the newest order picking technologies in the distribution center. It just recently has started to be used very effectively for each picking applications. Voice systems are RF based, and give instructions and listen for responses in spoken words rather than keyboards and displays. Pickers are directed by voice and respond by voice.

In many ways, voice systems are functionally similar to RF scanner bar code systems. This is because just about any information that can be transmitted on a display can be spoken to the worker. In addition, voice systems are capable of verifying that stock movements are made from the correct location, just like bar code systems. This verification is accomplished by speaking the part number or a location check code when visiting a stock location. These check codes are often abbreviated to 2-4 characters, but still maintain excellent accuracy.

Voice systems are faster than bar code systems because the picker has both hands and eyes free while doing his work. The only time a bar code system might be faster would be if a long string of numbers and letters would need to be read for each transaction, and many voice systems permit a scanner to be attached for this function. Voice systems are also capable of working in many different languages, and even regional dialects. Thus a wide variety of labor can use them. Finally, voice systems are among the easiest of all computer driven systems to learn.

Automated Storage and Retrieval

Carousels

A carousel is a moving shelf unit. The purpose of a carousel is to bring the product to the selector rather than having the selector travel to where the product is stored. Carousels most commonly travel in a “horse track shaped” oval just slightly wider than two back-to-back storage bins put together. These systems operate normally under the control of software and with the aid of pick-to-light systems, which direct the selections and placement to orders.

The key to an efficient carousel system is to group a bunch of orders together to decrease the distance the carousels must turn between picks. If the average distance traveled to the next pick is small, carousels can position product quickly, and create pick rates of over 300 lines per hour. Configuration of carousel systems is done through careful data analysis.

By keeping the distance small, the systems can position the next pick to the picker in just a matter of seconds. By combining more than one carousel together, it is possible to virtually eliminate waiting, except at the start and end of the batch, since while the picker is picking from one unit, the other carousel is pre-positioning the next pick.

Carousels offer a significant advantage over pick-to-light systems, in that the display lights are only needed in a single location for a pair of carousels. For example, for two 100-bin carousels, only one set of lights is needed in between the two units. The bins of each carousel can then be rotated to the picking lights, stopped, and the proper light for the level and side illuminated.

Carousels are generally useful for items with low cubic velocity. “Cubic Velocity” refers to the “number of units required times the size of a unit in a given period of time”. Very small items are ideal carousel candidates since they have low cubic velocity. Small items are fine as long as they aren’t very fast movers. Large items can be put in a carousel, but only if they are rather slow movers. Examples of products that work great in a carousel are small electronic components. Items such as medium to small auto parts will also work well as long as they are slow movers.

Carousels are masters at batching orders. Using a carousel system, it is possible to pick into 40 or more orders at once by using fixed carts that are rolled into position and left there until the batch is complete. Carts would be used in low line order environments as would be found in e-commerce. For larger order, conveyor systems are often used to batch 6 or 8 orders together at once.

Vertical Carousels

Vertical carousels are another form of carousel AS/RS system. In a vertical carousel, the shelves rotate around a vertically oriented "horse track" extending up from the floor rather than a horizontally oriented "horse track" lying on the floor. Individual shelves are accessed through a door ergonomically positioned for an ideal picking height.

The same comments apply to verticals as do for horizontal carousels. Vertical carousels are often applied in situations where there is a tall ceiling, and floor space is at a premium. Vertical carousels have an advantage that they completely enclose material inside the unit, keeping dust and dirt off of the stored materials. Verticals can also have the inside air conditioned for humidity, temperature, or even air quality (clean room application). Verticals are on average about twice the price of horizontals for the same storage capacity, but this will vary depending upon the height of the unit.

Mini-Load or Storage Tower

A mini-load or storage tower is a device that automatically retrieves entire shelf locations from a static location ***inside*** the machine. These machines are good for retrieval of relatively high-value slow moving parts or materials. Since the retrieval time is a function of the shelf location, it is useful to tie several machines together and have them process a batch of orders together as with carousels. These systems are most commonly used in manufacturing facilities and situations where products require special care and handling.

A-Frames

A-Frames and related automatic dispensing systems (such as V frames) are used to automatically dispense items into a tote or onto a moving conveyor, accumulating order requirements as the conveyor moves past the dispensing locations of the machine. The tote emerging from the machine (or conveyor slug emerging from the machine) will contain all of the order requirements for a specific order.

A-Frames are among the most expensive of each picking devices in terms of cost per product location, but they are also among the fastest. They boast speeds of up to 1,500 lines per hour and they are extremely accurate. These machines can push out a lot of orders in a very short timeframe.

The main disadvantage of A-Frames is that they must be continually replenished and are commonly replenished from flow rack. Since the machines pick so quickly, stock can be rapidly exhausted. Dispensing of multiple units to one order literally sounds like a machine gun being fired.

Replenishers must stand ready to immediately refill any location that is getting low, especially the fast moving locations. Failure to do this would result in the order being shorted, or the stopping of the machine. The main problem faced is that with too much replenishment labor, people are spending most of their time waiting for a refill opportunity. With too little labor, the machine will stock out when the replenisher can't make it to a location in time.

As a result, A-frames tend to have relatively labor-intensive replenishment operations (both to fill the machine, and to restock the ready reserve flow rack). These machines can be justified in situations where the order to delivery time window is compressed, and there is no other way to fill the orders in the allotted time frame.

Sortation and Consolidation Equipment

Conveyor

As mentioned above, conveyor can be used as part of a sorting system, which can direct product to particular packing lanes. Normally product travels around a "horse track" shaped path, and is diverted to the appropriate lane based on application logic. If all lanes are full, the sorter can re-circulate material indefinitely, although eventually, the sorter will fill up or back up the take away lines from the order selection areas. While conveyors can sort quickly, there are other devices specifically designed for high speed sorting (explained below).

Carousel

A carousel system can be used to hold full cases or totes, in preparation for shipping. A carousel system effectively becomes a random access three-dimensional accumulation buffer. What this means is that items intended for multiple destinations can be stored randomly in available locations in the carousel. When a particular destination is called for, the carousel system will retrieve those items only. Since carousels turn slowly, it is important that enough carousels be provided that the average travel time between picks is sufficient to keep a steady flow of material to the shipping operation.

High Speed Sorters

High-speed sorters are specialized sortation devices, which operate at extremely high rates. They are the king of all batching systems, in that hundreds of orders can be batched together and picked at one time from storage. In effect, the requirements for several hundred orders can be picked with one walk through a storage area. The selected items are brought to induction points (usually by a conveyor) and then placed one unit at a time onto trays of the sorter. The sorter is

able to keep track of what item is on what tray, and then it diverts items to those orders that have requirements.

There are three important points to understand with sorters. First, sorters dramatically reduce picking labor by cutting out a lot of the walking that is normally done in an order picking operation. Second, items are delivered via sorter chutes to packing stations in random order – it is virtually impossible to control the sequence of product received down the chute. Third, there are three touches of each product in order to complete a sorter based pick – one a the time of pick from reserve – one at the sorter induct – and one at the time of packing. Since each task is highly specialized sorters do generally reduce overall labor requirements in an operation.

Packing Equipment

Peanuts

Peanuts and paper run neck in neck in popularity. The decision is sometimes driven more by concern for consumer opinion as much as it is by which is most efficient. Peanuts are very easy to work with, and will fill a void quickly. They provide good product protection, although they cannot protect product that is not centered well in the box.

Peanuts either arrive in large bags, or they can be shipped in bulk form in a truck. Bulk systems use blowers to move the peanuts fro the truck into large holding "bags" in the facility. Other blowe rs then move the peanuts to the individual pack stations. Alternately, peanuts can be loaded manually into bags and dispensed by gravity.

Consumers hate peanuts because of the mess they make when the box is opened. There are also consumers who do not like Styrofoam peanuts for environmental reasons. Starch based peanuts solve the environmental problem, but can jam up equipment in long periods of high humidity.

Air-Based Dunnage Systems

There are several types of air-based dunnage systems. These include bubble wrap, automatic air pillows, and manually inflatable pillows. We will take them one at a time.

Bubble Wrap

Bubble wrap is relatively easy to work with, but since it is manufactured elsewhere, it takes a lot of space to ship and to store. Bubble wrap must be cut or torn and then wrapped around the material to be protected. Some bubble wrap rolls are perforated at regular intervals like paper towels. This product provides good protection, but is expensive and it tends to be more labor intensive than other methods.

Air Pillows

Air pillows have the advantage that they are simply flat sheets of plastic until they are filled with air. There are two varieties of pillow systems:

Automatic air pillows – as the name implies, automatic air pillows can be filled automatically by an inflation machine. The pillows are filled in a continuous plastic tube and then the ends of the tube are sealed shut by melting the plastic together. The amount of air can be adjusted based on user preference. Systems exist to automatically create and store the pillows in a holding buffer. Pillows are easy to work with and can be quickly placed into a box. They create less mess for the consumer, but still pose environmental concerns.

Manually Inflatable Air Pillows – Manually inflatable pillows are filled at the pack station under manual control. This permits exactly the right amount of air to be applied to fill the void. Usually, these are physically large pillows (1' square or bigger). A problem with manually inflated pillows is that they will cover the top or bottom of a box, but not the sides. This permits product to shake around inside the box unless other dunnage is added to the sides.

Paper Based Dunnage Systems

Paper based systems like pillow systems are shipped with the dunnage material in its "flat state". This saves substantially on shipping and storage of raw materials.

Paper Pad – is a system that creates paper pads out of craft paper. The machine "scrunches" the paper and perforates it slightly so that the flat craft paper is turned into a pad with some loft. The paper is cut into pads of user-controlled length. This type of dunnage is easy to work with and is particularly good at forming a top and bottom layer for a box. Again, the problem is filling the voids on the sides of the box.

Paper Waterfall – This system "scrunches" paper into a lofted form and continuously feeds it into a box at high speed, cutting the paper under operator control. This system can rapidly fill a void, but may not be as good as peanuts at filling small spaces. Since the stream of paper is continuous it can be run until the user feels an appropriate fill has been established.

Tissue/Kraft Paper – This system (currently only one manufacturer) perforates craft paper and dispenses it with a layer of tissue paper. The system is particularly well suited for wrapping very fragile items. Like the Paper Waterfall system this system dispenses paper continuously.

Tapers

Tape machines come in many varieties and capabilities. Tapers can tape the top only, or top and bottom. Some tapers require an operator to close the box tops and push the box through, while others automatically close and seal the case. Sometimes the more sophisticated machines end up being the most trouble, and end up still requiring help from a person, even though they are supposed to be automatic.

A Note about Packing Equipment

There is more variety in packing areas than just about anywhere else in a distribution center. Products vary in fragility. Companies have different consumer concerns. Box sizes can vary widely. Products can leak if not secured properly. Companies may feel that the appearance of the shipping package is very important to making a good impression on the customer.

For all of these reasons, when it comes to packing systems, one size definitely does not fit all. The best advice is to get vendors to let you try their systems out, and select the systems that work beset for your particular operation. It is generally possible to get loaner equipment since unlike some other big-ticket items, single machines are not hard to transport and are not extraordinarily expensive.

Also consider combining systems together, or using systems based on the type of product. For example, you might combine pad systems with peanuts to reduce the problem of having peanuts all over your customer's living room floor.

Manifesting Equipment and TMS Systems

Many manifest systems exist which will shop for the best price among the shippers you do business with, and then print the shippers' label on the fly. These systems actually weigh the package and then apply the shipping label. A straight path roller-ball scale is helpful to speed this process.

In higher volume operations, the entire process can be automated with an in-line scale and automatic label applicator. Whenever considering automation, always evaluate how many exceptions there will be, and how they will be handled.

TMS systems (Transportation Management Systems) can determine the best LTL carriers for partial and full pallet loads. Some of these systems will work with your WMS to actually plan order release based on shipping transport times.

Points to Think About when Evaluating Alternatives

This section covers points that are important when considering the purchase of capital equipment. Some of these points were made in my paper "Strategies for Optimizing Traditional Each Pick Operations – A Roadmap for Improving Order Picking Performance" and are repeated here, because the points apply equally to capital or non-capital changes.

Historical Data can Yield A Wealth of Information

If it is available, use historical data to evaluate the solutions being proposed. There is nothing more valuable than performing a "show me" analysis with real orders and real products to confirm that a proposed system will give the benefits that are advertised. If you don't have someone who can do data analysis in house, see if the vendor will do this for you, or consider hiring an outside consultant.

Implement Manual Changes First

If your situation permits, we recommend taking on the easy manual changes first, before contemplating involved capital equipment purchases. By following this course, you will be able to achieve immediate benefits without facing substantial risk and expense. Just make sure that your manual optimizations fit with the path of your anticipated capital enhancements.

It is always easier to automate a well-tuned facility than one with lots of operational problems. This also simplifies the transition process when you do decide to turn on the automation, since part of the transition has already been put in place ahead of time.

ROI of Capital Systems will Change

Once the manual optimizations have been accomplished, you are in a better situation to evaluate the true ROI of the automated systems. Understand that the projected ROI will be longer, if you first optimize your manual systems.

In some cases, you may decide that the capital equipment is no longer justified to obtain the new ROI benefit. In this case, you can make a conscious decision to postpone the capital expense due to the savings you've already realized with low cost modifications.

Consider Hybrid Solutions – One Size Does not Fit All

Whenever developing solutions for material handling problems, keep in mind that each system or piece of equipment has a range of usefulness where the equipment is most valuable. Don't try to fit all of your products into the same system.

For example, it wouldn't make sense to use pick-to-light for all 25,000 SKUs in a facility, since there are many systems that are just as fast, but much less expensive for selecting slow moving products. Pick-to-light might be the best technology, however, for your fastest moving items.

The most efficient facilities combine technologies together and focus each technology on those areas where it is most effective. Of course, you also need to make sure you don't bring in so many systems as to make controlling them all together too difficult.

Consider Peak Periods

One rule, which is very important in material handling, is ***never***, ***never***, ***never*** plan systems and equipment based on averages. You must always consider the peak periods (of the day, week, month, and year). Be sure to evaluate the proposed system's performance at your busiest time. Consider seasonal spikes and anomalies based on historical experience.

In peak periods, some systems permit you to add labor, while others require you to run longer shifts. Generally speaking, automated systems (such as conveyor based pick systems, carousels, and other automated equipment) are more likely to be sensitive to peak periods. People-based systems such as paper, RF-scanner, or Voice can generally be augmented with more labor (assuming that the computer system can handle it and that any necessary extra terminals are available).

Always consider peak periods before deciding to purchase any type of equipment. Whether you choose to add labor, or extend shifts, make sure that you have answered the question.

Permit room for Growth

Never box yourself in. Whenever possible, leave room to expand systems if, heaven forbid, your business grows faster than you anticipated.

This is particularly true when purchasing automated equipment. It is much easier to plan for expansion, and develop an expansion plan before the equipment is installed. Often the plan can use an area for a floor operation (where all equipment is easily movable), and then relocate the floor operation to a mezzanine or other area when expansion is required. The automated equipment can then be expanded into the open space.

Consider Future Plans

You should always consider strategic business plans in determining choices. If your business future has a lot of uncertainty, you may want to choose a less automated solution in the short term.

Fight the Urge to Do Everything at Once

Wherever possible, try to phase in changes gradually. This is particularly true for manual system changes or changes to your company's host software. If it is possible to test and operate these changes independently, do this first.

Always look at ways to phase in changes in logical incremental steps. By phasing changes, your organization has an opportunity to assimilate the changes at a more reasonable pace and make minor adjustments as experience dictates. If too many changes occur at the same time, it becomes difficult to evaluate where the problems are and how they should be corrected.

Test Software Modifications Before your Live Date

If new software is involved in a startup, make sure that you thoroughly test the software with live business data well in advance of the start up date. Continue to run the test for a period of time to make sure that any unusual situations are evaluated (like end of month or end of week variations).

Prepare a Transition Plan

Once you've done you homework and fallen in love with a particular system or technology, make sure you give plenty of though to the question "How will my business continue to operate in the time period that this new system is being installed?"

Consider requirements for mirroring stock, system testing, hours of installation, interference of installation with live operations, etc. If an open space exists somewhere in your layout or if an open space can be created by relocating a non-critical activity, it is often useful to do this. How will training be done? How will the final system be tested and commissioned? How do I know when I'm done?

Plan Enough Time for the Transition

When re-slotting product to a new area, make sure you plan enough time for the physical move, and then time to debug the slotting arrangement. When moving large numbers of locations, mistakes are bound to be made, and you don't want to be debugging the slotting situation while you are shipping large order volumes.

"Go-Live" in off period – Parallel vs Cold Turkey Startup

Whenever possible, plan your "Go-Live" startup in a quiet period. This gives plenty of time to respond to, tune, and repair problems.

You may wish to run your existing operation in parallel, while initially providing a reduced load to the new system. As the system is validated, the order level can eventually be ramped up until the new system is managing all of your orders. This is called working in "parallel".

The other option is to go cold turkey and start shipping with the new system. Obviously, there is a large risk element here, but the transition can take place literally overnight. Just make sure that you have a back up plan in case the worst happens and you find the new system has a problem that can't be immediately resolved.

Summary:

A large variety of equipment and systems are available to help you obtain the most from your operation. Before trying to figure out which ones will work best, first take time to understand your current operation and the current problems. Once that is done, investigate simple solutions and low cost alternatives first. Get as many of these in place as you can before going after the large ticket items.

By implementing simple solutions first, you will get a more realistic perspective on what the big dollar systems really can do for you. Look at implementing a hybrid solution containing components that are best suited for each category of product. Be sure so select systems that you know can be supported from your existing host system and/or WMS system.

Make sure that you allow enough time to investigate solutions, that you create a transition plan, and that you implement slowly and deliberately. Don't rush into changes before you are ready. Be sure to have a well-planned training and startup plan, and have a fallback in case things don't work out.

About the Author:

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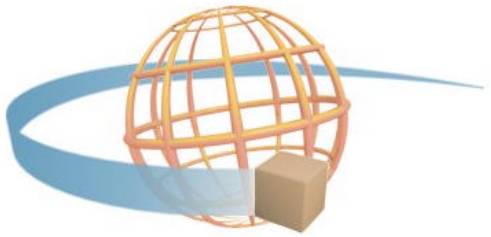

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