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FROM THE AMERICAN PEOPLE

Guidelines for Warehousing Health Commodities

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Abstract

These guidelines were written for anyone trying to meet and solve the challenges of operating a warehouse today. They are an important reference tool for managers and staff, whether they are constructing a new warehouse, implementing a new warehouse system, or redesigning their current system.

Guidelines for Warehousing Health Commodities is for use by supply chain managers, logistics advisors, and warehouse managers who want to improve and increase efficiency in their current health commodity warehouse. It is designed to be interactive, with each specific topic accessible as-needed.

The remaining sections of the guide discuss each of the topics of warehousing contained in the self-assessment; they offer more detail on ideal warehouse attributes, practical advice on how to improve warehouse operations, and specific information on available warehouse equipment and technology.

Case studies are also provided in the guide giving real-life examples that illustrate the importance of improving warehouse operations.

Guidelines for Warehousing Health Commodities provides up-to-date information on all aspects of warehousing.

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Acronyms

1D one-dimensional

2D two-dimensional

ADC automated data collection

CCD charged-coupled device

CO2 carbon dioxide

PPE personal protective equipment

SDP service delivery point

SKU stock keeping unit

RF radio frequency

RFID radio frequency identification

UPC Universal Product Code

UPS United Parcel Service

U.S. United States

WMS warehouse management system

Introduction

The warehouse is a key component of the supply chain for health commodities. This is especially true in resource poor environments where they act as buffers against uncertainties and breakdowns within the supply chain. When properly managed and appropriately stocked, the warehouse provides a consistent supply of products as they are needed.

For many years, the private sector has taken a professional, systematic approach to warehousing; recognizing its importance to overall cost, customer satisfaction, and performance of the business. In turn, organizations involved in public health in the developing world have started to focus more attention on commodity warehousing, realizing its role as a critical resource for improving public health.

The professional and systematic approach used by the private sector is directly applicable to the challenges public health warehousing face in countries around the world. Challenges, such as the increase in variety of products in the public health system, or stockkeeping units (SKUs), and the demand for reduced processing time, can be addressed by improving inventory management; and, in some cases, using technologies, such as automated data collection tools. The demand for increased customer service requirements—cost and value—and the call for improved product and information flows can be addressed by focusing management and the training of staff within the warehouse, as well as considering the implementation of a broader information system, including a warehouse management system that can link information to other points in the supply chain. In addition, establishing a system of meaningful and measurable metrics can enhance performance.

It is important for public health warehouse management to have an overall plan for professional, reliable commodity handling and storage. They need to take a holistic view of their facilities, incorporating technologies where needed, and when appropriate. Not every technology, however, is appropriate or cost effective for specific local conditions. This guide will help you meet these challenges and requirements.

The Guidelines for Warehousing Health Commodities is for use by supply chain managers, logistics advisors, and warehouse managers who want to improve and increase efficiency in their current health commodity warehouse. It is designed to be interactive, with each specific topic accessible as-needed.

The guide begins with a *warehouse self-assessment*, which will help you understand the essential elements of warehouse structure and operations, and the present condition of the existing warehouse. *Complete this assessment first,* and then use the guide to focus on areas where improvements are most needed.

The remaining sections of the guide discuss each of the topics of warehousing contained in the self-assessment; they offer more detail on ideal warehouse attributes, practical advice on how to improve warehouse operations, and specific information on available warehouse equipment and technology. You can read the chapters in any order; they provide information in an accessible format to help you make informed warehousing decisions. You may not need all the tools and information, but we recommend that you review all the topics.

The case studies in the guide are real-life examples that illustrate the importance of improving warehouse operations.

Getting Started: Assessing Your Warehouse

A health commodities warehouse is much more than a building that provides a space for storage. It must be designed to receive, store, and organize products efficiently and must provide effective distribution for life-saving commodities. This requires adequate shipping/receiving docks, storage in appropriate conditions for the commodities, and adequate work space to access and compile onward shipments for products going to regional or district warehouses or service delivery points (SDPs). You will improve the efficiency of the warehouse and lower overall operating expenses if you carefully plan for the needed conditions for all of these functions.

To begin, go to appendix 1 and take the Warehouse Self-Assessment; you will be able to identify any existing gaps and learn where to focus the warehouse improvements. This assessment is not an exhaustive tool; however, it will detail key issues to consider when you develop a comprehensive warehouse plan.

The warehouse self-assessment tool covers seven categories:

A. Infrastructure

B. Layout & Operations Capacity

C. Warehouse Equipment

D. Special Storage

E. Inventory Management

F. Security & Safety

G. Human Resources

The tool questions several aspects of each category and assigns a score. This enables the user to establish an overall score for each category in order to help set priorities for further review and action.

"You will improve the efficiency of the warehouse and lower overall operating expenses if you carefully plan for the needed conditions"

Warehouse Guidelines

SECTION A: Warehouse Infrastructure Planning

Following are several areas of warehouse infrastructure and the attributes of a well planned and successful warehouse that you should consider, whether you are building a new warehouse or renovating an existing one.

Location

The warehouse must be accessible to all the health facilities or units to be served. Ideally, to enhance security and minimize human and automobile congestion, a medical store should be located by itself on a separate plot of land. Road access must be adequate for the largest vehicle that may need to come into the store; if possible, avoid locating the warehouse on routinely congested roads.

TREES

Although, ideally, shade trees on the site will help reduce internal warehouse temperatures, you should regu¬larly check their condition. Cut down any weak trees to prevent them from falling on the building during inclement weather and trim others to avoid falling branches. Ensure that tree roots are not damaging the building's foundation.

DRAINAGE

Build the warehouse on a raised foundation to allow rainwater to drain away from the store. If possible, locate the warehouse on higher ground that is not prone to flooding or drainage problems.

Building

DOORS

Plan the dimensions of the doors to ensure they are wide enough to allow for the free and easy movement of product and handling equipment. The overall building dimensions should be the same as, or have the capacity for, the specific equipment and other space needed for the required warehouse operations. Large facilities, such as those at the central level, often use forklifts and other handling equipment. Ensure doors are strong and reinforced for adequate security. Fit them with two strong locks, and install metal grills for extra protection. Limit the number of people with keys to the doors.

WAREHOUSE FLOORS

Warehouse floors must meet stress and strength requirements; otherwise, they may fail because of pressure from loaded racks. If warehouse floors do not meet stress specifications, damage can also result from day-to-day material handling traffic (forklift and others). A qualified engineer can help determine what is needed.

Some key requirements to review include—

- floor surface, including surface material, depth of material, sub-surface material, etc.
- door openings, including surface material around loading/unloading dock doors, warehouse exit doors, etc.
- loading dock and vehicle tailgate heights
- building column locations
- lift equipment aisle-width requirements
- loading and floor stacking of material
- overall length of rack rows: possible effects on floor surface.

"If the main source of electricity is not reliable, install a solar panel generator or alternative supply of electricity for cold rooms and refrigerators."

If rack equipment will be configured on the existing floors, a qualified engineer must thoroughly inspect the existing cement or floor surface material, as well as the material and supporting structures beneath the surface. For many reasons, an existing warehouse floor may not meet weight and overall durability requirements. Warehouse floors, for example, that do not meet stress and strength requirements may fail due to pressure from the rack base plate or diagonal tension. If the warehouse floors do not meet stress specifications, damage can also result from day-to-day material handling traffic (forklift, etc.). Some general ways a floor may fail include compression of the concrete, shear or tension, and sub-base failure.

ROOF AND CEILING

Consider the slope of the roof and the placement of roof support columns, and their impact on height clearances for rack configuration and other warehouse operations.

Avoid using non-insulated galvanized steel metal sheeting for the roofing because it will get very hot. If unavoidable, create as much airflow as possible by using ventilation fans and tiered roof sections.

For optimal use of space and protection from heat, the best choice is a building without an internal ceiling. Insulated roofing panels are highly recommended; for example, galvanized steel sheeting with a polyurethane insulation, which is available in 40 millimeter (mm)–100 mm widths; for the best performance, it should have a reflective powder-coated white paint or light gray. This is more efficient than an internal ceiling because it blocks the heat before it can enter any part of the building.

WINDOWS

To reduce the need for air-conditioning, place windows high and wide enough for adequate ventila¬tion. The height of the windows should ensure that shelves will not block them; install wire mesh and grating to keep out insects and to deter burglars.

Lighting

To reduce either florescent or incandescent bulb lighting, plan the storeroom with as much natural light—indirect sunlight—during the day, as possible. Florescent lighting emits ultraviolet rays, which can harm certain products. Incan¬descent bulbs emit heat. At the same time, ensure that the products themselves are not in direct sunlight.

Power

If the main source of electricity is not reliable, install a solar panel generator or alternative supply of electricity for cold rooms and refrigerators. If the generator is not solar-powered, maintain a stock of fuel to run the generator for at least a few days—see the section in this guide for storing flammables (section D). Run the generator regularly—at least once a month—to ensure the system is working properly. Larger facilities may want to contract out the maintenance of the generator and electrical system.

SECTION B: Layout Planning and Operations Efficiency

Importance of Layout Planning

The most critical factor in planning a warehousing is space. How materials are stored and how workflows are designed have a profound effect on the efficiency of the personnel and their ability to improve service delivery for their customers.

Layout planning is the discipline of assessing the space requirements of a warehouse or other storage facility and specifying how that space should be organized to facilitate identifiable warehouse activities.

The main objectives of layout planning are to—

- Use space efficiently.
- Promote the efficient handling of commodities.
- Provide economical storage.
- Provide flexibility to meet changing warehousing requirements.

The following section presents a methodology for general steps in layout and space requirement planning in an existing warehouse or storage facility.

The following three general steps should be considered when planning the layout for a warehouse:

1. Identify warehouse activities that require layout planning.
2. Determine the space requirements and ideal layout for each warehouse activity.
3. Develop a realistic layout by reconciling space requirements with existing constraints.

Step 1: Identify Warehouse Activities

In a standard warehouse or storage facility, two main activities require space or layout planning:

- receiving/shipping
- storing/retrieval.

Because the shipping and receiving tasks are often done in the same general location within the warehouse, they are often analyzed together.

- Receiving includes the tasks related to accepting usable commodities from outside suppliers and preparing those commodities for storage in the warehouse.
- Shipping includes the tasks that help prepare usable commodities for shipment to customers and the placement of those commodities on vehicles for transport to the customers.

Storing/retrieval are activities associated with the actual (semi-permanent) storage of usable commodities in the warehouse, usually on pallets, shelves, and/or racks.

- Storing is the task of moving usable commodities from the receiving area and placing them in pre-defined locations within the warehouse—either on the floor, shelf, or rack—until they are ready to leave the warehouse.
- Retrieval is moving usable commodities from one or more locations—for example, the floor, shelves, or racks—and transporting them to the shipping area where they can be processed for shipment to customers.

The layout should also include a plan for storing unusable commodities—separating unusable from usable stock—and moving the unusable stock to a pre-defined location within the store where it will remain until it can be evaluated and removed from the warehouse for proper disposal. Unusable stock is usually defined as commodities that have either expired or have been damaged and cannot be safely consumed by customers. Unusable stock may include items that were rejected during receiving/quality control inspection, or expired or damaged items in stock. Unusable stock can also include anything that the warehouse cannot use—e.g., broken furniture/equipment, broken pallets, and non-reusable packing materials.

When a layout plan is being developed, the storage of unusable commodities is often overlooked, but it may be just as important as receiving/shipping and storing/picking. This is especially true in dysfunctional warehouses where commodities often expire or become unusable. In warehouses where space has not been specifically allocated for storing items that can no longer be used; to accommodate these items, it is often necessary to use space that was dedicated for other activities.

Note: In some warehouses, space must be allocated for house administration functions: e.g., reception, finance, procurement, and others. For this guide, it is assumed that a separate space to facilitate administrative functions is available, including space to conduct meetings.

Step 2: Determine Space Requirements

When planning the space requirements for shipping and receiving, you should know that the activities will require more space than is usually thought necessary. When analyzing space for shipping and receiving, consider the following:

- truck docking
- shipment receiving maneuvering
- shipment receiving.

TRUCK DOCKING REQUIREMENTS

Space requirements for docking trucks, within or adjacent to the warehouse, are usually predefined. Normally, trucks are docked in one of two ways:

- at a 90° angle to the dock
- at less than a 90° (usually a 45°) angle to the dock.

When docking at a 90°angle, no space is required. In an unusual case, when the angle is less than 90°, the space requirement is proportional to the angle of delivery. If the angle is 45°, the amount of space required for each docking space is a triangular space approximately 4.25 meters (at entrance to warehouse) × 3 meters × 3 meters.

DETERMINE SHIPMENT MANEUVERING REQUIREMENTS

The maneuvering space required for shipping and receiving is the space necessary to enter and exit the truck and to move commodities between the truck and the shipment staging area or vice versa. The amount of space in the warehouse needed to exit and enter the truck depends on whether or not a leveling device is used, which lowers or raises the floor of the warehouse to facilitate the smooth movement of commodities from the truck to the floor of the warehouse or vice versa. If a leveling device is used, each device is usually 3 meters deep × 3 meters wide.

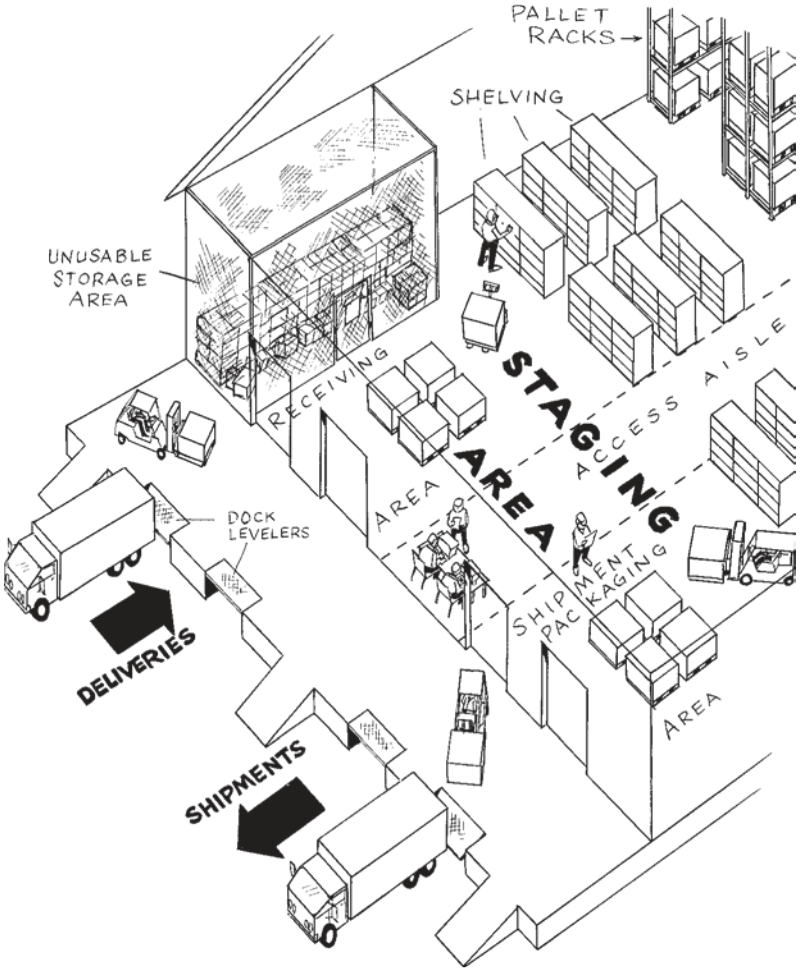
Whether or not you use a leveling device, a certain amount of space will always be required to move the commodities from the truck to the receiving staging area. The required space for this area ultimately depends on the type of material handling equipment used to move commodities from truck to floor and floor to truck. If manual material handling equipment is being used to move items from the truck to the floor (and vice versa), reserve at least 2.5 meters times (×) the length of the designated shipping/receiving area (usually the length of the warehouse) for this activity. If, however, you are using powered material handling equipment, reserve at least 3.5 meters times (×) the length of the designated shipping/receiving area.

Figure 1 represents the layout for the receiving/shipping activities of a typical warehouse. It depicts a warehouse where trucks dock at a 90° angle; it has four separate dock levelers. The diagram also shows an area for maneuvering commodities (shown outside the storage facility) and two staging areas (discussed in section C). There is one staging area on either side of the warehouse; the two areas are separated by an access aisle.

DETERMINE SHIPMENT AND RECEIVING STAGING REQUIREMENTS

Sometimes, warehouse managers allocate a specific space to process receipts and a separate specific space to stage

Figure 1. Typical Layout for Receiving/Shipping Activities



outgoing issues. Past experience is often used to determine the required staging size needed for these areas.

Public-sector warehouses in developing country settings, especially medical stores, are usually very different. In these settings, shipments are issued to customers much more frequently than supplies are received. Likewise, the size of the average receipt from a supplier is often many times greater than the size of the average shipment issued to a customer. Because of the disparity between receipts and issues, there should be interchangeable shipment and receiving staging areas: i.e., there should only be one combined shipment/receiving staging area. Do not separate shipping and receiving areas on separate sides of a warehouse.

Determining the size of the receiving/shipment staging area can be the most difficult part of planning the layout of a warehouse. It is important to be as accurate as possible when you estimate the size of the area. If you allocate too little space, stock from arriving shipments will probably fill storage aisles before it can be put away. If you allocate too much space, you may not have enough room on the available racks to store all the commodities that require storage.

To develop an accurate estimate of space requirements for the staging area, the estimation process should take place during a surge period. For these guidelines, a surge period occurs when the largest known or expected carrier arrival is received on the same day as the largest known or expected shipments are being staged for customers.

It is assumed that during the surge period, the commodities received from a supplier must enter the warehouse—they cannot remain at customs or elsewhere on the warehouse grounds—and any required inspection of the commodities must be completed quickly. It also assumes that the shipments being staged for delivery to customers must be staged or delivered on that day.

Step 3: Estimate Shipping and Receiving Staging Requirements

Three methods are used to estimate the space requirements for staging:

1. Complete data estimation methodology: Based on complete data on receipts and issues being available for at least the past year (preferably more). The data must include enough information on each shipment received or issued to completely identify the commodities received or issued, the number of cartons received or issued, and the volume of these cartons.

2. Partial data estimation methodology: When complete data on receipts/issues are not available, but data on overall amounts issued or received during the year are, or can be, readily estimated for all medium-to high turnover items. To use this method, estimate the dimensions for most of the cartons and the approximate number of individual receipts and issues that took place during the year.

3. Data-less estimation methodology: When you must guess the space needs because you have little or no information available to make a decision.

COMPLETE DATA ESTIMATION METHODOLOGY

When data are complete or nearly complete on shipments received and shipments issued, you can accurately estimate the staging space requirements. The information includes the (1) date of receipt/issue; (2) identity of commodities received/issued; (3) volume (width × length × height) of the packaging used (e.g., carton, bundle, wooden crate); (4) contents of each package (items per package); and (5) number of packages in the shipment.

1. When using this method, first gather all shipment lists for the past year (or two years, if available). Review the receipts to identify the date on which the warehouse received the largest shipment or shipments, by volume. After checking the receipts, review the issues to identify the date on which the warehouse issued the largest shipment/shipments, based on volume. Use the combination of the largest receipt(s) and largest issue(s) to simulate the largest surge the warehouse can expect.

Note: If the size of the largest shipment and/or largest receipt is expected to grow significantly in the near future, incorporate this information when estimating the needs for the surge period.

2. For the second step, use the data from step one to calculate the total volume of the receipts/issues expected during the surge period. Table 1 shows how to calculate the total volume if you only have one receipt with three commodities and one issue with two commodities during the surge period. An actual exercise would probably include one—or perhaps two—receipts that contain numerous commodities and several issues, with each containing many commodities.

3. After you determine the total volume in cubic meters of shipments received/issued during the surge period, you can estimate the number of pallets that will be required to hold the commodities, simultaneously, in the staging area. The number of pallets will be equal

Table 1. Sample Worksheet for Estimating Shipment Receiving and Staging Space Requirements: Complete Data Method

Type of Transaction	Date of Transaction	Commodity	Total Amount	Amount per Carton	Number of Cartons	Size of Carton	Cartons per One Cubic Meter	Number of One Cubic Meter Pallets Required
Receipt	4 October 2004	Amitriptyline Tablet, 25 mg	2,000,000	20,000	100	.5 m x .25 m x .25 m	32	4
Receipt	4 October 2004	Erythromycin, Tablet, 250 m	5,000,000	25,000	200	.5 m x .5 m x .25 m	16	13
Receipt	4 October 2004	Chloramphenicol, Vial, 1 gm	10,000,000	25,000	400	.5 m x .5 m x .25 m	16	25
Issue	4 October 2004	Amitriptyline, Tablet, 25 mg	200,000	20,000	10	.5 m x .5 m x .5 m	8	2
Issue	4 October 2004	Erythromycin, Tablet, 250 mg	1,000,000	25,000	40	.5 m x .5 m x .25 m	16	3
Total	4 October 2004							47

Note: Number of one-meter pallets required must be rounded up to next highest number.

to the number of cubic meters, because each pallet typically holds about one cubic meter of goods. Thus, the area required to stage these commodities is equal to the number of pallets (given in square meters). It would be prudent to add a few extra square meters to the overall estimate of space required for staging; because not all pallets are exactly one square meter in size, and some space must be left between the pallets.

USING PARTIAL DATA ESTIMATION METHODOLOGY

You can estimate, with reasonable accuracy, the space requirements for staging if detailed information on receipt and issue shipment contents is not available, but overall amounts of each (or most) commodity received and issued is known or can be estimated.

This method requires the following information:

- Total numbers—given in tablets, pieces, vials, etc.—received and issued during the past year (or two, if possible) for most or all commodities kept in the warehouse during this period. It is especially important to include high-turnover items. You can probably ignore very low-inventory items.

- Capacity and dimensions of the standard packaging for each of these items—e.g., 50,000 tablets in a carton .5 meters × .5 meters × .25 meters. These numbers are on the current packaging used in the warehouse.

- Estimate of the total number of shipments received and the total number of shipments issued during the appropriate workdays. Warehouse staff should be able to provide this information. Receipts should be infrequent enough that the total number during the past year can be quickly estimated. For issues, it might be easier to estimate the average number per workday or workweek and extrapolate to one work year.

Based on the previously mentioned data, it is possible to estimate the volume of each commodity in the average receipt and issue. These volumes can be aggregated to produce the overall volume that would have to be staged on an average issuing day that happens to fall on the same day that an average-sized shipment is received. Table 2 shows how the overall volume was calculated in a case where the average receipt contained three commodities; and the average number of issues, on a given day, was one issue with two commodities. An actual exercise would probably include one (or perhaps two) receipt(s) containing numerous commodities and several issues, each holding many commodities.

After calculating the total volume in cubic meters, you can estimate the number of pallets that will be required to hold the commodities, simultane-

Table 2. Sample Worksheet for Estimating Shipment Receiving and Staging Space Requirements: Complete Data Method

Type of Transaction	Commodity	Total Yearly Amount Received/ Issued	Average Number of Receipts/ Issues per Year	Average Amount in a Receipt/ Issue	Amount per Carton	Number of Cartons	Size of Carton	Cartons per One Cubic Meter	Number of One Cubic Meter Pallets Required
Receipt	Amitriptyline Tablet, 25 mg	10,000,000	5	2,000,000	20,000	100	.5 m x .25 m x .25 m	32	4
Receipt	Erythromycin, Tablet, 250 m	25,000,000	5	5,000,000	25,000	200	.5 m x .5 m x .25 m	16	13
Receipt	Chloramphenicol, Vial, 1 gm	30,000,000	3	10,000,000	25,000	400	.5 m x .5 m x .25 m	16	25
Issue	Amitriptyline,	8,000,000	40	200,000	20,000	10	.5 m x .5 m x .5 m	8	2
Issue	Erythromycin, Tablet, 250 mg	20,000,000	20	1,000,000	25,000	40	.5 m x .5 m x .25 m	16	3
Total									47

Note: Number of one-meter pallets required must be rounded up to next highest number.

ously, in the staging area. The number of pallets will be equal to the number of cubic meters, because each pallet usually holds about one cubic meter of goods. Thus, the area required to stage these commodities will be equal to the number of pallets—given in square meters. It may be prudent to add a few extra square meters to the overall estimate of space required for staging, because not all pallets can be stacked perfectly or placed exactly adjacent to one another.

In most cases, the partial data method will produce a reasonable estimate of the space requirements for staging. Because the issue and receipt staging areas are interchangeable, most or all, of the allocated space can accommodate an unusually large receipt and vice versa. Occasionally, however, an unusually large receipt will arrive on the same day that unusually large issues are being staged. If for this situation, it is likely to occur several times per year, the estimated space requirements for staging should be increased—a 50 percent increase may be reasonable.

USING DATA-LESS ESTIMATION METHODOLOGY

In cases where the warehouse is a new facility and/or data on receipts/issues are not available, it will be necessary to use a rule-of-thumb to determine how much of the warehouse to allocate to staging. In general, the warehouse staging area should take up at least 10 percent of the warehouse's total space, but never more than 40 percent.

Estimating the amount of space to allocate in these situations will depend on how much control you have over the carrier arrivals: i.e., to what degree can the warehouse specify exactly when a truck carrying incoming commodities can deliver its load? In these cases, use the guidelines in table 3 to estimate space requirements.

Note: It is important to maintain, at all times, an aisle space somewhere within the shipment and receiving staging area. This space provides access from the dock to other parts of the warehouse—most important, the storage area. The width of this aisle depends on whether traffic will be unidirectional (one way) or bidirectional (two way). Because commodities should be placed in the staging area from one end and removed from the opposite end, a unidirectional aisle should be sufficient. The width of this aisle should be about 2.5 meters, if you use manual material handling equipment; and at least 3.5 meters, if you use motorized material handling equipment.

CONSIDER OTHER SPACE REQUIREMENTS ASSOCIATED WITH SHIPPING AND RECEIVING

The shipping and receiving activities—and most other warehouse activities—need a dispatching area for processing information and for dispatching personnel to fulfill various tasks; e.g., to unload, put, pick, or load items. This area usually has a

Table 3. Estimation of Staging Space Requirements

Degree of Control of Arrivals	Percentage of Warehouse for Staging (%)
Complete control	10 to 20
Some control	20 to 30
No control	30 to 40

number of tables set aside for microcomputers and associated equipment. Sometimes, the dispatching area is located in a walled office, although more often it is located in an open area within the receiving/shipping section of the warehouse.

The dispatching section of the receiving/shipping area should require a minimum area of approximately 2.5 meters × 3.5 meters.

In addition to the dispatching area, you may need to allocate a set amount of space to hold empty pallets. The number of empty pallets should only slightly exceed the number of empty rack locations. Consequently, to hold empty pallets, you should allocate a minimum area of 2.5 meters × 1.25 meters of the receiving/shipping area.

SUMMARY OF SPACE REQUIREMENTS FOR SHIPPING AND RECEIVING

The following summarizes the expected space requirements for shipping and receiving:

- Truck docking. If trucks dock at 90° angle, no space is required. Otherwise, a triangular area measuring 4.25 meters wide (at the entrance to the warehouse) × 3 meters × 3 meters will be required for each docking space.
- Leveling for loading/unloading. If leveling devices are used, each device will require an area approximately 3 meters deep × 3 meters wide.
- Maneuvering for loading/unloading. If manual material handling equipment is used, an area 2.5 meters deep by the width of the designated receiving/shipping area is required. If motorized material handling equipment is used, an area 3.5 meters deep by the width of the receiving/shipping area is required.
- Staging. The space required for staging can be anywhere from 10 to 40 percent of the entire warehouse. Section B provides methods for estimating staging space requirements.
- Dispatching. If the warehouse does not have a dedicated walled office to house the dispatcher and dispatching computer(s), an area 2.5 meters × 3.5 meters is usually required.
- Storage for empty pallets. An area 2.5 meters × 1.25 meters is usually required.

See figure 2 for a layout of shipping and receiving activities in a fictional warehouse. In this example, there are four 90° docks; level, motorized material handling equipment is used on each dock. There are two staging areas (one for shipping and one for receiving); the dispatching area is located within the receiving/shipment staging area; and the maximum space requirement for the staging area is about 30 percent of the warehouse.

Although cross-docking is not evaluated in this manual, in some warehouses, it is a major part of the receiving/issuing activity. If cross-docking is likely to become part of your requirements, you may need to estimate its space requirements and establish a separate area in the store for this purpose.

Step 4: Determine Space Requirements for an Ideal Layout for Storage and Retrieval

The most difficult task in layout planning is estimating the space requirements and layout for storage and retrieval; to do this, you must complete a number of separate activities:

- Define the commodities to be stored.
- Establish a material storage method for each commodity.
- Estimate the total volumetric requirements for each commodity.
- Identify physical warehouse constraints.
- Generate an ideal layout using selective pallet racks and bin shelving.
- Determine when and how to consider alternative layouts.
- Develop methodologies for storing commodities in a given layout.

DEFINE THE COMMODITIES TO BE STORED

With layout planning for storage/retrieval, the easiest task may be defining the commodities to be stored. You have a complete list of commodities that are either already in the warehouse or will be procured in the future. In

some cases, predicting the types of products to be procured in the future may be a problem; however, most mature health programs know what items are or will be needed.

Each commodity to be stored must be defined as follows:

1. description of the commodity—the name should be unique to prevent confusion with other commodities; it is also necessary to define a stockkeeping unit: e.g., paracetamol 500 mg, bottle of 1,000 tablets

2. number of stockkeeping units per standard packing unit: e.g., 25 bottles per box

3. volumetric dimensions of standard packing unit: length × width × height

4. number of standard packing units per one cubic meter pallet.

For items that will only be stored on shelves—because the average level of stock is too small to require storage on pallet racks—you only need to describe the product (2, 3, and 4 are not needed).

ESTABLISH A MATERIAL STORAGE METHOD FOR EACH COMMODITY

All commodities being stored in the warehouse should be categorized in one of two general methods—fixed and fluid. In fixed-location storage, each stockkeeping unit (SKU) is always stored in a specific location. No other SKU is stored in that location even if the location is empty. In fluid-location storage, any SKU can be assigned to any free location.

It is possible to have both fixed and fluid systems operating in a warehouse simultaneously. In fact, this arrangement is sometimes preferable when a warehouse contains different types of storage systems. A typical arrangement would call for most bulk supplies to be stored on pallets and loose items to be stored on shelves. Use a fixed-location system for items stored on shelves; use a fluid-location system for the pallets stored on the pallet racks.

The volume of the inventory of each item would dictate the storage method for that item. See table 4 to determine the storage method for a given commodity.

Other storage arrangements are also possible. For example, high-volume items that turn over quickly and have an issue pack size too large to fit on a shelf—e.g., Ringer's lactate and other IV solutions—can be kept entirely in bulk storage on pallets using a fluid system of storage. In any event, it is important to identify the items to be stored on pallets—using a fluid-location system—versus those to be stored on shelves—using a fixed-location system.

ESTIMATE THE TOTAL VOLUMETRIC REQUIREMENTS FOR EACH COMMODITY

After each commodity has been classified by storage area and method—fixed versus fluid—you can estimate the total volumetric storage requirements for each commodity.

For each item to be stored on shelves in a fixed-location, it is usually appropriate to assign either one-half of one shelf or one shelf to store each item. Most warehouses will label the shelf according to the item or items stored on it. High turnover items should be assigned one entire shelf, while low turnover items should be assigned 50 percent of one shelf. In some unusual cases, it may be necessary to assign more than one shelf because of a combination of high turnover and large order size, otherwise too much time will be spent replenishing the shelves with stock from bulk storage. To estimate the total number of shelves required, add the total number of shelves needed for each commodity.

Estimating the total number of pallets required for bulk storage requires additional information. If data are available on average monthly issues and the average inventory level for each commodity is either known or has been set by some authority, you can divide the average inventory level—given in cartons—by the number of cartons that can be stored on a

Table 4. Storage Methods by Commodity Type

Type of Commodity	Stor age Method	Example Items
Low inventory items stored and issued in smaller packs	Fixed (entire stock kept on shelves)	Specialized medicines
Bulky items stored and issued in complete pallets	Fluid (entire stock kept on pallets)	Equipment
Items contained in large cartons stored on pallets but issued in smaller packs	Fixed (stock to be issued kept on shelves) and fluid (bulk stock kept on pallets)	Essential drugs that are issued by bottles or small packs; condoms

Table 5. Sample Worksheet for Estimating Bulk Storage Space Requirements Based on Complete Data

Commodity	Average Monthly Issues (includes expected increase)	Average or Desired Inventory Level (in months of stock)	Average or Desired Inventory Level	Number of Cartons	Size of Carton	Cartons per One Cubic Meter	Number of One Cubic Meter Pallets Required
Amitriptyline Tablet, 25 mg	1,500,000	6	9,000,000	450	.5 m x .25 m x .25 m	32	15
Erythromycin, Tablet, 250 mg	2,500,000	3	7,500,000	300	.5 m x .5 m x .25 m	16	19
Chloramphenicol, Vial, 1 gm	3,000,000	5	15,000,000	600	.5 m x .5 m x .25 m	16	38
Total							72

Note: Number of one-meter pallets required must be rounded up to next highest number.

single cubic meter pallet to estimate the number of pallets required for each commodity. This number can then be added to determine the total number of pallets to be stored in the warehouse. If desired, this total value can be multiplied by some factor representing the expected increase in volume due to increased warehouse issues, over some period of time in the future. See table 5 for an example of a warehouse that holds only three items.

If average inventory levels cannot be determined because the monthly issues data are not available, you may need to estimate how much of the warehouse to allocate for storage, based on the size of the desired inventory level. The higher the desired inventory level, the more space will be required. Use the following guidelines in table 6 to estimate space requirements in these cases. The warehouse storage area can be from 60 to 90 percent of the warehouse's total space.

Table 6. To Estimate Space Requirements

Desired Inventory Level	Percentage of Total Warehouse Space Dedicated for Storage (%)
Low	60 to 70
Medium	70 to 80
High	80 to 90

IDENTIFY PHYSICAL WAREHOUSE CONSTRAINTS TO ACTUALIZING, COMPLETING, AND FINALIZING STORAGE/RETRIEVAL LAYOUT

Some warehouses have fixed obstacles that constrain the placement of pallet racks and shelves, such as building support columns, stairwells, elevator shafts, sprinkler system apparatus, heating and air-conditioning equipment. These objects can affect the successful use of material handling equipment. It is, therefore, important to map the location of all fixed obstacles prior to completing a layout of racks and shelves for storing/retrieving commodities.

GENERATE AN IDEAL LAYOUT USING SELECTIVE PALLET RACKS AND BIN SHELVING

After determining the amount of shelving and number of racks required to store the warehouse commodities, you can prepare a tentative layout based on available floor space for storage and any existing constraints. It is advisable to begin the storage layout planning phase by drafting a layout of selective or standard pallet racks and bin shelving. Selective pallet racks provide the greatest flexibility and are acceptable storage for fluid locator systems. Bin shelving can be used to implement a fixed locator system.

Some, or all, of the bin shelving is usually placed closest to the staging area. This allows personnel to quickly pick items to be packaged in the staging area. Because most of the stock on the bin shelves will be routinely replenished from stock kept on pallets in the selective pallet racking system, ideally, both sides of the bin shelving should have easy access—one side for picking and one side for replenishing.

It is advisable to separate the bin shelving into two sections, with an

aisle between the shelving. The aisle will have more direct access to the pallet racks from the staging area. Figure 2 shows a typical layout for bin shelving and pallet racks.

The placement of the selective pallet racks depends on the following factors:

- total number of pallet racks required to store the desired inventory
- ceiling height of the warehouse
- aisle space required by the material handling equipment.

The total number of selective pallet racks required is dictated by the average number of pallets to be stored. The aisles between the pallet racks must be wide enough to accommodate the selected material handling equipment. See appendix 3—Material Handling Equipment—for typical aisle widths for each type of handling equipment). The racks are normally placed in rows, with each row running from the front to the back of the warehouse. Cross aisles are often inserted in each row at 15-meter intervals.

If, after laying out the racks, significant free space is left in the storage area, that space should remain unstructured. This will enable warehouse management to easily install additional racks if they are required at a future date. When the volume of inventory and, consequently, the number of pallets, is not precisely known, purchase selective pallet racks to fill the area of the warehouse set aside for storage.

If pallet racks are not available to use or your warehouse is too small or ceiling is too low to accommodate pallet racks, Figure 3 shows a sample layout using pallet stacking and bin shelving. Again the same principles apply as with pallet racks, aisles must be wide enough to accommodate the selected material handling equipment. With pallet stacking, aisle width can usually be much narrower, therefore allowing more space in the warehouse to be utilized for storage. More information on pallet stacking is described in appendix 2.

Figure 2. Sample Layout Using Selective Pallet Racks and Bin Shelving

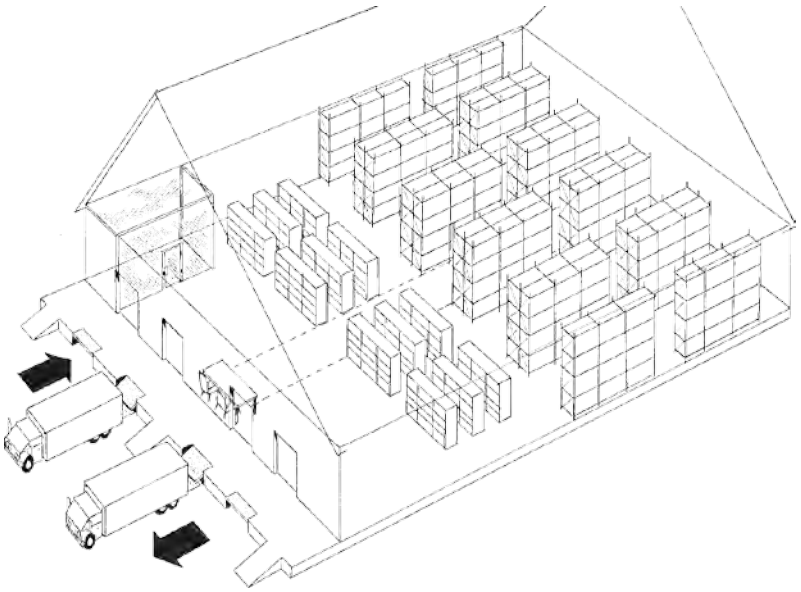
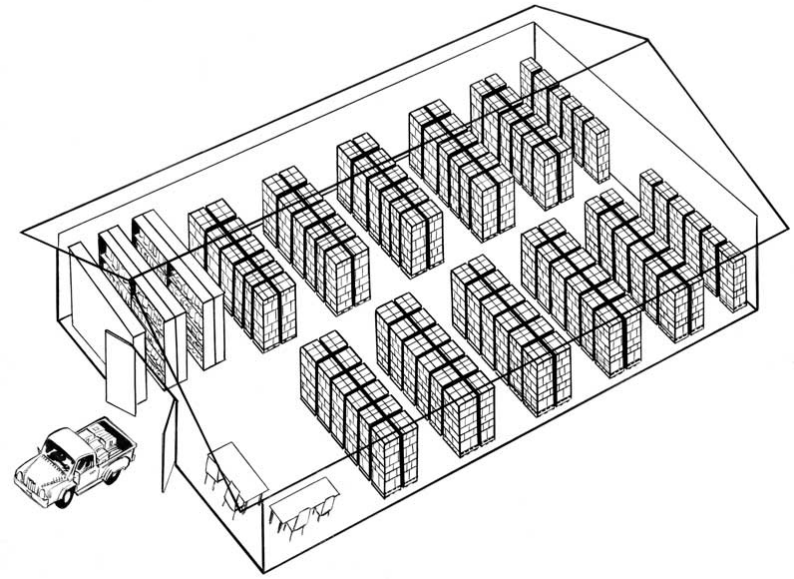


Figure 3. Sample Layout Using Pallet Stacking and Bin Shelving



Step 5: Establish a Realistic Layout by Reconciling Space Requirements with Existing Constraints

As stated before, the amount of space available and how the space is arranged are critical to creating an efficient warehouse. However, many existing warehouse facilities are faced with constraints that make warehouse space and layout design a challenge. Step 5 suggests ways to overcome existing warehousing constraints:

- when and how to consider alternative layouts
- methodologies for storing commodities.

DETERMINE WHEN AND HOW TO CONSIDER ALTERNATIVE LAYOUTS

It is possible that the warehouse will not be able to accommodate the ideal layout because of warehouse size limitations. In these cases, you must consider alternative layouts. You can manage this situation in many ways, without installing a new racking scheme.

A few methods include—

- Change the desired inventory level. The average inventory level used to determine the volume requirements to store the commodities is based on a desired buffer stock. It may be possible to reduce the desired buffer stock without jeopardizing the warehouse's ability to fill orders. Lowering the desired inventory level can dramatically affect the space requirements.
- Eliminate unnecessary aisle space. If cross aisles were included in the ideal layout, you may be able to eliminate some or all of them. Eliminating all cross aisles may result in unacceptable productivity losses; only consider this if other methods fail to free up adequate space.
- Reduce space allocated for receiving/shipping. This methodology, described earlier in this section, does not consider the possibility of storing pallets one on top of another. Though this is not ideal, in many cases, it is possible to store light-weight pallets on top of heavy-weight pallets without damaging the contents of the lower pallet. As much as half of all pallets can be stored one on top of the other, if necessary.

Note: It is not advisable to store medium- or heavy-weight pallets on top of each other.

- Use different material handling equipment. Some material handling equipment requires a larger turning radius than others. For example, an electric lift truck (sit-down) usually requires more aisle space to maneuver than an electric lift truck (stand-up). Switching from one type of material handling equipment to another may reduce aisle space requirements. For more details on the turning radius of forklifts, see the Racking and Material Handling Equipment section.

After you use the previously mentioned methods to free up space, and there is still not enough room to accommodate the expected inventory, you may need to consider expanding the existing space or look for warehousing space at an alternative location.

CONSIDER METHODOLOGIES FOR STORING COMMODITIES IN A GIVEN LAYOUT

After a layout has been adopted, it is advisable to adopt a plan for storing commodities on the racks and shelves. Many methodologies can be used to store commodities.

ABC METHODOLOGY

In most warehouses, a large percentage of throughput is attributable to a small percentage of commodities. In most cases, about 75 percent of throughput is attributable to 15 percent of items (often called A items), another 15 percent of throughput is attributable to 15 percent of items (often called B items), and the remaining 10 percent of throughput is attributable to 70 percent of items (often called C items). ABC methodology states that A items should be located in an area of the warehouse with the most productive material handling; A items should be placed as close as possible to the staging area and should be easily accessible. All C items should be placed in the back of the store or in two-deep pallet racks, if they are available.

One word of caution when using the ABC methodology: although A items should be placed closest to the staging area, they should not be placed so close together that congestion from picking results. Space all items as evenly as possible.

SIMILARITY METHODOLOGY

In some cases, items that are commonly shipped together should be stored near each other. For family planning programs, this might mean that contraceptives should be stored in a similar location within the warehouse. Any other group of items that are shipped together should also be stored close together.

SIZE METHODOLOGY

The size methodology states that heavy and bulky items, which might include heavy furniture and equipment, should be stored close to the point of shipping to minimize the effort and cost of handling them. It also suggests that these items should be stored as close to the floor as possible.

PRODUCT CHARACTERISTIC METHODOLOGY

Some commodities have certain characteristics that dictate how and where they should be stored within the warehouse. Temperature is one of the most important of these characteristics. In tropical environments, certain medicines degrade under hot conditions. For this reason, these medicines should be placed in either a cold room or temperature-controlled area of the warehouse. Each commodity should be analyzed closely to determine its appropriate placement, given its temperature requirements.

It may also be desirable to place either high-value or controlled substances in the same location within the warehouse so that they can be secured or put in isolated storage.

In summary, any number of the storage methodologies can and should be combined to improve the productivity of the warehouse. It is important to give serious thought to selecting the optimal combination for the greatest warehouse efficiency.

Step 6: Determine Space Requirements and Ideal Layout for Storing Unusable Items

When planning the space requirements for storing unusable commodities, remember that you may have more unusable commodities than you expect. The amount of space depends on the policy for removal/disposal and whether unusable items can be safely kept outside the warehouse. For this manual, it is assumed that all unusable pharmaceutical or medical supplies must be kept in a special section of the warehouse until you can determine their final disposition; therefore, you need to designate this type of section for the warehouse.

Estimating space requirements for items that are not usable is directly related to the wastage rate at the warehousing facility. Wastage can occur from expiration or damage—any action that results in commodities unsafe to consume. Data on wastage is normally maintained in the losses/adjustments column of stock records or, if automaton is used, in a table that contains losses and adjustments information.

If accurate data on wastage is available, it is possible to determine when commodities were wasted and temporarily stored at the warehouse during the past year or two. If information on removal of the unusable items is also available, you may be able to determine the length of time these items remained in the warehouse before removal. It is then possible to construct a simple table with five columns: name of commodity, amount, estimated volume, date of wastage, and date of removal.

From this data, you can determine the maximum volume of unusable items kept in the warehouse at any one time by sorting the table on date of wastage and then plotting each row of the table—batch of unusable items—on a chart similar to a Gantt chart. The chart should clearly show the batches of unusable items that were in the warehouse at the same time. The sum of the volumes of these batches represents the maximum volume of unusable items that can be expected to be stored in the warehouse at any given time.

If you do not have data on losses/adjustments and removal of unusable items, or if the data are unreliable, you will need to rely on the memory of warehouse staff to estimate the maximum volume of unusable items at any one time. If warehouse staff explain that the only significant wastage data is available during physical inventory counts, it may be possible to use this as the basis for the maximum volume. Note that this assumes that any commodities found expired or damaged during the physical inventory were removed from the warehouse before the next physical inventory account. If this is not true, use the estimates of how much of the wasted stock remains in the warehouse and how long it has been there.

In some warehouses, you may also need to make special arrangements to hold the following items if they cannot be stored offsite:

- trash, including empty cartons, binding materials, broken pallets, and packing materials
- broken or unusable equipment and furniture.

You must consider space requirements for trash; otherwise, trash can result in congestion and loss of productivity. The most significant, and, in many cases, the only significant trash is corrugated box material. For these guidelines, it is assumed that all but the largest corrugated boxes received from suppliers are reused to package shipments to customers, and they are used at roughly the same rate as they are received. However, it is possible that large corrugated boxes will accumulate and take up a significant amount space; it is unlikely that they will be used for repackaging. However, in most cases, a 1 meter × 1 meter section should be large enough to hold a large number of broken-down corrugated boxes.

A NOTE FOR NEW WAREHOUSE DESIGN

When designing a new warehouse it is important to build and lay out the space in the most efficient way possible. As shown in figure 1, the main warehouse space should have the receiving and shipping area, as well as the main storage area.

Space and areas that serve the following functions usually do not require the high ceilings normally found in a warehouse and should not usually be included in the main warehouse.

- office space
- flammable storage—should always be away from main building
- cold storage
- restrooms.

By locating these areas off to the side of the main warehouse, storage space in the main warehouse will increase, and the material flow throughout the warehouse will also increase.

Section C: Warehouse Equipment

Overview

Warehouse managers are responsible for all aspects of materials management, including a total systems approach to plan, acquire, store, move, and control the inventory of materials. To complete these essential warehouse operations, materials must be well-organized, including equipment, such as racking systems and material handling tools.

The following criteria are typically used to select warehouse equipment:

- type of warehouse building, including size, design, and desired physical movement of products
- type and variety of products and load sizes—largest and smallest—stored in the facility
- total volume—inventory levels—to be handled by the facility
- unique handling requirements: barrels, single units, flammable
- degree of equipment flexibility needed for different uses
- human resources using the equipment, including the number of employees, skill level, training needs, and language constraints
- equipment maintenance and servicing availability in facility location, including new, used, and spare parts; availability of trained mechanics
- equipment cost, including new, used, and replacement equipment
- ability to adjust if the warehouse needs to expand.

Storage Systems

The main justification for storage systems—pallet racks, shelving/bins, etc.—is to make optimum use of the building space. Whatever type of measurement is used, incorrectly calculated storage space requirements can contribute to poor utilization and result in space shortages and increased warehousing costs. Conversely, creating a more compact area for warehouse operations usually reduces picking and traveling time, as well as energy costs related to lighting and climate control.

In addition to making optimum use of space, racking and shelving systems also provide simplicity and organization of materials and warehouse operations.

In general, there are three common types of storage systems used in public health warehouses: pallet racks, shelving, and simple pallet stacking.

1. Pallet racks are strong and can handle large products, as well as small, lightweight products, such as most essential drugs and HIV and AIDS products—antiretroviral drugs, HIV test kits, etc.—and reproductive health commodities. Today, pallet racks can be used in storage systems for single-level or multi-level structures; they can also be used to store single items or palletized loads and other types of containers. Additionally, rack structures provide access for order-picking case lots or individual pallets.
2. Shelving is usually easy to assemble and simple to use; they are the foundation of any small- and large-scale storage facility. Steel shelving consists of basic sections that can be accessed from the floor and used to store a variety of products.
3. Stacking, the most basic form of a storage system, consists of placing boxes one on top of another in an organized way. Preferably, commodities stored with this method are placed on top of a pallet to keep them off the ground and away from water and dust.

To learn more about storage systems equipment characteristics, options and appropriate use, please see appendix 2—Pallet Stacking, Shelving, and Pallet Racking.

Storage System Planning Considerations

Any major investment related to a warehouse facility should be accompanied by a long-range strategic plan. Before presenting information on the different types of storage systems, managers should review a number of important considerations and parameters.

Issues to consider before purchasing storage equipment include—

- volume: size and weight of loads
- variability in pallets/containers: type, condition, dimensions, and weight
- equipment clearance: standard height of equipment and height of equipment extensions, such as forklifts and load heights
- building dimensions
- warehouse floor conditions
- required accessibility to commodities.

VOLUME

You should first consider inventory volume before purchasing a storage system. For many warehouse facilities and their products, inventory levels are constantly changing. Products may be added or subtracted from the product mix; product sizes and weights may change. Fluctuating inventories or the inventory mix can create many challenges for the warehouse manager. A recent change in policy, for example, may require a facility to carry new products (for example, HIV and AIDS commodities), which can suddenly affect product mix and inventory volume levels. Additionally, seasonal changes may also have an impact on warehouse products and its operations; for example, malaria intervention products, which are needed more during the rainy season.

The facility's products and volume will help guide and determine the type of racks and/or shelves needed. To prevent overloading, select racks based on the specifications of the heaviest load; which can cause injuries to warehouse staff, fracture structural racks, and damage the products. Human safety and product safety are the highest priority during and after the planning process. Facility managers are responsible for regularly conducting facility safety reviews and safety reviews for internal equipment.

PALLETS/CARTONS

Another consideration before purchasing storage equipment is the pallet or type of carton or box that the facility will use for its products and warehouse operations. Relevant questions include—

- Does the facility use wooden pallets and, if so, what is the range of dimensions encountered/used?
- Does the facility receive a variety of different types of pallets: wood, metal pallets, fiberglass, cardboard cartons with wooden pallets attached?
- What other types of pallets or cartons will be used in day-to-day warehouse operations?

No matter what type of pallet or carton a facility is using, you should, at least, have a relatively clear idea of the largest dimensions and weights of the pallets, cartons, or boxes that will be stored before purchasing the racking equipment.

EQUIPMENT AND BUILDING CLEARANCE (DIMENSIONS)

You need to review the load and equipment clearance requirements thoroughly. Load and equipment clearances should address or reference height and width for aisles, doors, loading docks, ceilings, and any external areas that equipment and products will need to pass through, both inside and outside the facility. Again, throughout the planning process, you need to ask and review fundamental equipment questions, which include the following:

- When considering the clearance needed for fire protection—sprinklers, etc.—are there mandatory legal fire protocols that must be followed—height from ceiling, number of sprinklers/per cubic foot, and placement and number of fire extinguishers? Extinguishers placed on facility support columns could reduce aisle or floor space.
- Have all the various pieces of equipment used within the facility area—inside and outside—been checked for dimensions and the data collected for analysis?
- What issues, if any, do building columns present, and do doorways have the necessary clearance requirements for safe passage of both equipment and people?
- Do doorways and loading/unloading ramps pose needless dangers to people, equipment, and products?

WAREHOUSE FLOORS

In most situations, floors were in place long before anyone thought about putting in a racking system. As mentioned earlier under the infrastructure category, if rack equipment is to be configured on existing floors, the existing cement or floor surface material—as well as the material and supporting structures beneath the surface—must be thoroughly inspected. A qualified engineer must check the floor or slab design and the load (weight) of the rack post on the floor. A thorough floor analysis can prevent sustained floor damage from occurring, as well as protect people and products.

ACCESSIBILITY TO COMMODITIES

The type of storage system is governed by the need to access commodities. In general, public health warehousing has a large variety of SKUs, with batch numbers and expiration requirements. For this reason having access to each pallet or box is usually preferred.

Material Handling Equipment

Today, with improved technology, modern material handling equipment has become more complex. But not every warehouse needs the most sophisticated and modern equipment, which will require greater initial costs, higher maintenance, and training. Extensive research and analysis is needed before the final equipment selection is made, based on what is actually required in the warehouse.

As discussed earlier, to ensure that the warehouse design will work together as a whole, look at storage systems and material handling equipment in parallel with all aspects of the planning stages. A functional and

well-run warehouse system should be treated like a carefully designed and properly integrated unit. Warehouse systems need to operate together so the overall performance is smooth, efficient, and safe. This section includes more information about the planning process, and also presents the characteristics of the material handling mechanisms of a warehouse system.

The planning process can be demanding, but time spent in planning can educate all concerned about the challenges to be faced, and can provide direction and a vision for a facility's operation that will produce long-term benefits by ensuring that your facility has the right equipment.

General Selection Criteria to Determine Material Handling Equipment Needs

With the variety of complex equipment on the market today, it is not a simple assignment to select a forklift or any other type of material handling equipment. The average user or warehouse management team can easily be overwhelmed. A good starting point in specifying material handling equipment is to review and examine the following criteria:

- Human—Who are the personnel that will be using the equipment?
- Mechanical—Which equipment best fit the inventory and the warehouse?
- Operational—What are the operating conditions in the warehouse?

Major variables within each of these criteria include the following:

HUMAN VARIABLES

- What degree of skill is required to operate a forklift or other material handling equipment?
- What are the different degrees of physical abilities and depth perception that certain high-lifts and some larger equipment may require?
- What is the severity of fatigue caused by operating the equipment?

MECHANICAL VARIABLES

- Travel distance—If looking at an electric truck, determine the ability of the battery to sustain an eight-hour shift.
- Physical characteristics of the equipment—Determine the maximum lift capacity, stocking heights of certain equipment, speed, operator comfort, turning radius, etc.
- Required maintenance schedules—Determine the amount of time the equipment will be unavailable because of routine service maintenance.
- What are the safety features of the equipment? Do they meet specific needs of the warehouse?

OPERATIONAL VARIABLES

- Traffic patterns of equipment and staff—What is the anticipated volume of product, human congestion, and width of aisle and loading docks.
- Type of surface or floors—What is the impact of the size of equipment, type of tires, and impact of the power plant capacity.
- Operating hours—Is equipment necessary during picking or replenishment, or both?
- What is the load—including the physical properties of the product to be handled—height, weight, overall dimensions?
- What is the type and condition of the physical structure—building—where the equipment will be used?
- Will the equipment be used outside the facility; if so, what is the type of surface and landscape, and what other challenges might the operator of the equipment encounter?
- What is the condition of the facility's floors; do the floors have load limits?
- How effective is the ventilation inside the facility? Which lift truck is best—gas or electric?
- What is the overhead clearance (ceiling/roof) of the facility—minimum and maximum?
- What is the height of the doorway or other passages that the equipment needs to pass through?
- What is the height of the vehicle?
- Are the existing racking system, as well as other storage systems—bins, shelving, etc.—compatible with the material handling equipment?
- What aisle width is required?
- If the lift will enter a truck, what are the dimensions of the truck?
- Where is the nearest dealer located?
- Will spare and new parts be available and at a reasonable cost?
- Will the dealer be able to provide on-site technical assistance and training?
- What is the cost of the equipment?
- What is the availability of fuel for internal combustion or electricity for battery-powered vehicles?
- How many hours will the equipment be used per day/week?

While this list is not complete, it does address some key variables that impact the equipment selection process.

In addition to the selection criteria listed, an appropriate operator training and certification program must be incorporated into the planning process. One of the most important components in the selection process is to consider all safety features and training strategies before making a purchase. A safe speed for a fork truck is much more important than the maximum speed. To maximize return on investment, lift truck operators must be trained in the correct use of the equipment. If a lift truck and other material handling equipment are not used in a safe, efficient way, workers can be seriously injured; and product, equipment, and facility structures can be damaged. Training will prevent most of these situations. Most of the major lift truck manufactures offer driver's training programs—included in the purchase package—that can be tailored to specific models of lift equipment.

To learn more about the different types of material handling equipment, such as pallet lift trucks and their options and features, see appendix 3—Material Handling Equipment.

Section D: Special Storage Requirements

Cold Storage

Most public health warehouses need to have cold storage for certain products. If the warehouse already has stand-alone or walk-in refrigerators or cold rooms, or if cold storage will be installed, ask the following questions:

- Is the size of the cold store facilities adequate for the inventory?
- Does the equipment have a maintenance schedule? Is it being followed? Are the refrigerators or cold rooms properly maintained?
  - Long-term, setting up regularly scheduled maintenance visits could save money from costly repairs.
- Does the electricity shut off regularly?
  - Investigate obtaining solar panels to either power the cold storage full time or as a supplement when the main electric source is down.
  - If solar isn't an option, make sure a diesel or gas generator with adequate capacity can sustain the refrigerators/cold rooms. Budget for extra fuel for the generator.
- Are the refrigerators/cold rooms dispensing too much heat into the warehouse? Are they taking up too much room and are they interfering with the other storage?
  - Consider relocating refrigerators/cold rooms to auxiliary rooms off the main warehouse, this will remove the heat from the larger storage area and allow for better material handling flow in the main warehouse.

Secure Storage

All medical warehouses should have a secure stor¬age area for products that are likely to be stolen or abused, or that need to be quarantined. Commodities that are designated as controlled substances, or high-value items, such as ARV's, should be marked as such and kept in a secure area. A locked cabinet or cupboard may be sufficient for some facilities, while other facilities may require a larger vault or cage.

Flammable Storage

Some flammable liquids commonly found in public health warehousing include acetone, anesthetic ether, alcohols (before dilution), and kerosene.

Store large supplies of flammables in a separate location away from the main storage area, preferably outside the building but on the premises, and not less than 20 meters away from the other buildings. Never store large supplies of flammables in the same areas as medicines. Firefighting equipment should be easily available.

Flammable liquids each have a flash point, which is the minimum temperature at which the liquid gives off vapor in sufficient concentration to form an ignitable mixture with the air near the surface of the liquid. The flash point indicates the susceptibility to ignition.

- Acetone and anesthetic ether have a flash point of –18°C.
- Undiluted alcohols have a flash point of 18° to 23°C.
- Kerosene has a flash point of 23° to 61°C.

It is not necessary to store flammables below their flash point, but it is very important to store them in the coolest location possible and never in direct sunlight. It is important to control the evaporation rate and avoid the build-up of pressure.

Section E: Inventory Management

Warehouses, clinics, and any facility that stores products—including your food pantry at home—need to have an inventory management system to determine when to order products, how much to order, and how to maintain an appropriate stock level for all products to avoid shortages and oversupply.

In general, there are two ways to manage inventory in a warehouse: manually or an automated system.

Manual Inventory Management

Public health warehouses commonly use manual inventory systems, which are hand-written stockkeeping records, such as ledgers, stock cards, and bin cards.

A manual system is organized according to date and transaction reference, which is the unique number of the corresponding transaction record for a receipt or issue, and/or the name of the facility from which products are received and issued. They record receipts; issues, losses, and adjustments; balance on hand; and, sometimes, batch or lot numbers and expiry dates. They also record the date and results of physical inventories; i.e., when items are counted to verify the quantity in storage.

Manual inventory management methods are a low-cost, effective way to manage inventory for a limited number of SKUs, if the volume doesn't reach an overwhelming amount.

Primary elements of a manual inventory system are—

Figure 4. Bin Card

BIN CARD								
Commodity Lot/ Batch No.:				Proct Name & Description:				
Unit:				Expiry Date :				
Date	Transaction Reference	Received from/Issued to	Quantity Received	Quantity Issued	Losses	Adjustments	Quantity on Hand	Initials

BIN CARD

A bin card is an individual stockkeeping record that contains information about a single product, by lot or batch number (see figure 4). Every item in that lot has the same expiration date. For example, one bin card could have information about a single lot of paracetamol at a storage facility. The card should note the stock on hand for that lot only, as well as any losses and adjustments for that lot. Bin cards are usually displayed on or at the bins—or shelf or pallet position where the lot is located.

INVENTORY CONTROL CARD

An inventory control card is an individual stockkeeping record that holds information about all the lots of a single product.

Keep one inventory control card for each product. The inventory control card can summarize many bin cards for a particular product. For example, one inventory control card could hold information about all the paracetamol in a storage facility. It should note the total stock on hand of paracetamol in the warehouse, as well as the record of losses and adjustments, without regard to lot number or where the product is located in the warehouse. See figure 5 for an example of an inventory control card. To ensure that each lot is managed correctly, in larger warehouses, which may have many lots of each product stored in different places, it is usually advisable to maintain both inventory control cards and bin cards. In smaller storerooms, a single stockkeeping record, such as a stock card or inventory control card, would be sufficient.

Figure 5. Inventory Control Card

INVENTORY CONTROL CARD								
Product Name:								
Unit:				**Product Code :**				
Date	Transaction Reference	Received from/Issued to	Quantity Received	Quantity Issued	Losses	Adjustments	Quantity on Hand	Initials

STORES LEDGER

A stores ledger is a stockkeeping record that contains the same information as the inventory control card. However, unlike inventory control cards, a stores ledger is bound like a book. In some countries, government policy requires the use of stores ledgers.

Managers may believe that ledgers increase accountability, because missing pages are obvious. However, the ledger format is less desirable than individual cards, because it is easy to run out of space for an individual product and it is also difficult to add new products. Individual inventory control cards can be alphabetically organized as new cards are added. In many countries, the Ministry of Finance determines the format of stockkeeping records; all government units use the same format because commodities are considered assets of the government and must be accounted for carefully. See figure 6.

Automated Inventory Management

As the quantity and volume of products increase—either stored in or moved through a warehouse—more and more warehouse managers are turning to computerized warehouse management systems (WMS) to keep track of inventory. These systems can be a stand-alone software product, or a module within an Enterprise Resource Planning (ERP) system that includes the entire supply chain.

Before purchasing and implementing a WMS, it is important to ask the following questions:

DO I REALLY NEED A WMS?

Not every warehouse needs a WMS. Although most warehouses could benefit from a computerized process, a cost/benefit analysis would help managers decide whether the benefits are enough to justify the initial and ongoing costs. Usually, the number of stockkeeping units (SKUs) your facility or program handles will be the deciding factor. The larger the number of SKUs, or the larger your order quantities, the more likely it is that you need a WMS.

WHAT ARE THE BENEFITS OF A WMS?

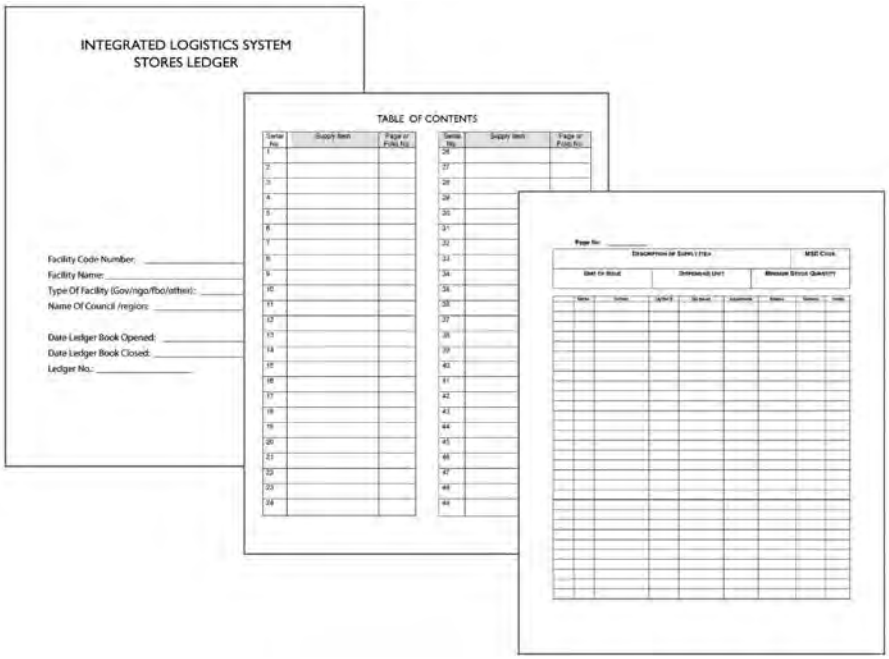
A WMS is primarily used to help manage materials within a facility and aids in processing the associated transactions. When set up correctly, a WMS should direct picking, replenishment, and put-aways.

WHAT STORAGE AND DISTRIBUTION TASKS DOES A WMS SUPPORT?

The tasks commonly supported by a WMS include—

- Receiving: Receipt of products into the warehouse, quality assurance for some products, and staging of products for put-away.
- Put-away: Placing products into storage locations after they have been delivered to the warehouse.
- Replenishment: Moving products from secondary storage to primary storage locations to facilitate picking.
- Picking/packing: Gathering the products listed in a customer order and packaging them for shipment.
- Shipping: Loading packages onto transport for distribution to customers.
- Management reporting: Compiling and presenting data on inventory levels and locations, inventory aging, customer orders, order fulfillment rates, and purchase orders.

Figure 6. Stores Ledger
(cover, table of contents, product page)



- Cycle counting: Doing physical inventories on a rotating basis, usually according to the value and throughput of each product or physical location.

A WMS WILL—

Increase inventory accuracy. If set up and used correctly, a WMS should be able to specify where and how much of each product you have in your facility.

Increase labor productivity. A WMS can increase labor productivity by directing the tasks of warehouse personnel. It can also enable warehouse managers to plan for highs and lows in warehouse labor, based on expected tasks for a given time period.

Reduce reporting time. By reducing information errors, a WMS reduces the time and effort needed to gather and compile data on inventory and customer orders; and report to officials, donors, and other stakeholders. With the push of a button, warehouse managers can view the current quantities of all products in inventory; review consumption rates per product and per customer; identify commodities nearing expiry; and see the forecasted demand, based on the current consumption of each product.

Optimize space utilization. Many WMSs can inform warehouse personnel about where to put away products in particular locations, based on the known dimensions of both the product and the available storage space, or a product's previous location.

Improve customer service. By increasing inventory accuracy and using direct picking, it should be possible to respond to clients' orders faster and more accurately.

A WMS COULD —

Reduce labor costs. A WMS can improve labor efficiencies by significantly reducing the time spent on unproductive activities, such as looking for lost products or shutting down operations to conduct physical inventories. However, a WMS requires more training and system maintenance; this could be more than the labor saved on the warehouse floor. As demands increases, however, additional tools could well offset the cost of hiring additional staff to maintain the existing levels of service.

Increase storage capacity. While a WMS provides the tools to optimize what and how goods are stored, which could result in increased storage capacity; this improvement will depend on how disorganized the processes were before the WMS.

A WMS WILL NOT—

Reduce your inventory. If you improve the accuracy and efficiency in the receiving process, you may reduce the level of safety stock required, but the impact will probably be negligible compared to the overall inventory levels. When you are extremely overstocked, or have significant quantities of expired products, the WMS can help you see your inventory and assist you with your inventory management. But, after operations return to normal, it is unlikely that the WMS will help reduce your inventory. The main factors that control inventory levels are lot sizing, lead times, and demand variability, which a WMS will not impact.

WMS REPORTS

WMS systems are able to generate many different types of reports. Some, such as picking lists and packing slips, are an essential part of routine warehouse operations. Other reports enable warehouse managers to monitor performance and identify potential inventory problems before they occur. Table 7 lists essential WMS reports.

WHAT SHOULD YOU LOOK FOR IN A WMS?

At a minimum, a WMS should adapt to your requirements. It should—

Table 7. Warehouse Management System Reports

Report	Description
Picking list	Lists storage locations for each product in a customer order. Storage locations are listed according to first-to-expire, first-out. Warehouse personnel can use this report to assemble a customer order for shipping.
Inventory by storage location	Lists product quantities and expiration dates at each storage location. Warehouse storage location personnel use this report to verify reported inventory quantities against physical counts.
Inventory by expiration date (aging)	Lists products at each storage location according to expiration date. This report identifies products that will expire within a specified time frame, and enables warehouse personnel to reallocate or remove products about to expire.
Closed customer orders	Lists product quantities shipped for each customer order that has been completely shipped.
Open customer orders	Lists product quantities ordered for each customer order submitted to the warehouse, but not completely shipped (includes customer orders that have been partially shipped).
Closed purchase orders	Lists product quantities ordered for each purchase order that has been completely received.
Open purchase orders	Lists product quantities ordered for each purchase order that has been submitted to the vendor, but not completely received (includes purchase orders that have been partially received).
Inventory velocity reports	List products according to attributes—date, volume, high/low throughput.

- have a flexible location system that allows you to determine where to stock and where to pick
- has user-defined parameters to direct warehouse tasks and uses live documents to execute these tasks
- have some built-in level integration with data collection devices, such as barcode readers.

HOW DOES A WMS WORK?

One software application could be significantly different from another application; but, in all cases, the basic logic will use a combination of the following data elements:

- item—including attributes, such as unit of measure, batch/lot, expiry date, etc.
- location
- quantity
- order information.

WHAT ARE THE MAJOR CHALLENGES WHEN INSTALLING A WMS?

Warehouse management systems are large, complex, and data collection intensive. They require a substantial amount of initial setup, need system resources to run; and, in more complex systems, interact with external data from the accounting, procurement, and shipping departments.

Set up can be quite extensive. The system needs to capture the characteristics of each item, such as the exact dimensions and weight of each item, including each unit of measure in which the item is stocked. To store specific items in different ways, for example, in cases and pallets, this level of detail is necessary. The location of each item must be maintained, either at the detail level or by grouping similar items and locations into categories. Based on your setup, the WMS will be able to determine the storage location of your product—where the product will fit and at what location, as well as the sequence for put-away (stocking) and the sequence for picking (filling the order).

RESOURCES FOR MANAGING THE WMS

Someone will need to manage both the software and the hardware for the WMS; if the system is extensive and complex, you may need a team with the sole responsibility for managing the WMS.

ONGOING DATA MANAGEMENT

As new products, in new sizes and new quantities, come into your facility, to both locate the space for put-away and locate your product when you need to fill an order, the system must be continually updated. Depending on the environment, this can be highly automated or manually processed. Entering known data about new products after a tender is awarded, but before products are delivered, can help streamline the receiving process.

THINGS TO REMEMBER WHEN SETTING UP A WMS

The selection of automated data collection (ADC) hardware, such as barcode scanners, must be integrated

with WMS software selection. Higher-priced WMS packages may be less expensive in the long-term, because they may have a higher level of support for the types of ADC hardware that may be used in the future. If the WMS selected does not have the specific ADC functionality presently in use or planned, initial programming estimates can easily go over budget. Also, to increase efficiency, you should consider integrating automated handling equipment and advanced shipment notifications with the WMS. It is also important to examine how the WMS will link with other institutional operations, such as procurement, finance, and sales.

BOTTOM LINE

A WMS can greatly improve processes, but you must take care to ensure, before purchase, that you have identified the most appropriate tool for present and future needs. It is important to systematically review existing processes and make decisions regarding optimizing the present system by eliminating dysfunctional or non-value added processes. As with many software solutions, WMSs have evolved over time to include a broad range of functionalities. Today, they can include transportation management, supply chain planning, distribution requirements planning, and a variety of other tasks. The multiple choices can lead to confusion and create overlap with other software functionalities. It is important to determine what the specific process-based functional requirements are and the level of sophistication of IT systems the present capacities are able to support; then compare these functional and system requirements against the range of WMS solutions. Choosing the best fit between warehouse requirements and WMS functionality will enhance selection of the right combination of software and hardware for warehouse needs.

Automatic Data Collection: Barcoding and Radio Frequency Identification

The previous section discussed the WMS and the challenges and benefits of adopting this technology. ADC can be a practical complement to computerized warehouse management systems. The following is a brief description of ADC options and how they work.

Barcoding is probably the best known of the ADC technologies; others, similar to ADC, are voice systems, radio frequency identification (RFID), pick-to-light, laser scanners, charged-coupled device (CCD) scanners, handheld batch and radio frequency (RF) terminals, vehicle-mounted computers, and wearable computers. The following section describes the most commonly used technologies in a warehouse setting; discusses advantages, as well as implementation challenges; and briefly discusses their use in international public health settings.

BARCODE CATEGORIES

Before discussing the actual devices, it is important to understand the two different categories of barcodes: one-dimensional (1D) and two-dimensional (2D) matrix. One of the most familiar examples of 1D barcodes is the Universal Product Code (UPC) code seen on many products, such as those purchased at a grocery store; but many other varieties of symbology use the same idea.

Two-D barcode matrices, such as the Aztec Code or UPS's MaxiCode, can store more data than 1D bar codes; however, they require special scanners to read them. Most warehouses and smaller stores continue to use 1D barcodes because the technology is less expensive and it still stores a sufficient amount of data for management purposes.

Depending on the circumstance, supply chain partners may decide to create a symbology through a standardized label program; to ensure that all partners are able to read the barcoded information, all must comply.

In other cases, individual entities in the supply chain are not bound by this requirement; they determine their own symbology and print their own labels for the products they manage.

There is an international movement to standardize the use of barcodes. This was spearheaded by GS1, which is a non-profit organization dedicated to the design and implementation of global standards and solutions to improve efficiency and visibility in supply-and-demand chains, globally and across sectors (www.gs1.org). When considering the use of barcoding, it is advisable to review the global standards and determine if they are a good fit for your warehouse. Complying with already-in-place global standards usually makes operations easier in the long run.

BARCODE SCANNERS

Laser or CCD

Most barcoding equipment uses either laser scanners or CCD scanners. Laser scanners use a laser beam, which moves back and forth across the barcode to read the label; CCD scanners take digital images of the barcode, which are then decoded. Although they cost less than laser scanners, CCD scanners have more limited use because they need to be a few inches away from the barcode. Laser scanners are more common in warehouses because they can scan barcodes at significant distances.

There are many types of barcode scanners, including handheld, that

enable workers to carry the device with them; and fixed position scanners, where the product is moved in front of the scanner. Choosing the best type depends on the function required. For warehouse use, handheld scanners usually are more practical, especially with hands-free stands that allow the worker to use both hands; while fixed-position scanners are useful in a conveyer packing line.

Portable Computers
Portable computers, such as laptops or tablets, are suitable for use in warehouses to scan barcodes and relay information either (1) to batch terminals, where data is collected into files and then connected to a computer for downloading the information; or (2) they use RF terminals, where RF waves send live data to the host system or network.

Handheld Devices
Small and nimble, handheld devices include keyboard-wedge scanners that connect between a computer keyboard and a computer and can be used successfully in a warehouse setting, especially for cycle counting. However, they do have drawbacks: holding a handheld device implies that you can no longer use that hand to handle materials or equipment, decreasing ease of use. Using the pistol-grip models, which allow workers to more quickly holster the device between scans and use both hands, will improve worker mobility. However, the small screen and keypads also make it difficult to operate. Before deciding on implementing this type of device, consider whether it appropriate for the activities workers will be performing.

Vehicle-Mounted Systems
These systems have larger screens than handheld devices and the keypads are similar to true keyboards; because they are mounted on either a warehouse vehicle or distribution vehicle, they are more difficult to drop or lose, or forget to charge them. It is more likely that they can easily integrate with existing programs designed for desktop computers, because these systems probably have a Microsoft Windows interface or something similar. Their use is constrained by the range of the vehicle to which they are attached.

Wearable Systems
These systems are gaining popularity because they offer greater mobility than the handheld devices or the vehicle mounted systems. They usually strap to the wrist or forearm and use a small ring-type laser scanner for reading bar codes. Some also have voice technology, which is explained below.

Voice Technology
Voice technology includes both voice-directed and speech recognition. These systems have a headset with a microphone and a wearable computer. There are many advantages to voice technology, the most obvious being greater mobility for the warehouse worker. Studies have shown that voice technology has not only increased efficiency significantly—not looking at the computer screen saves picking time—but it also has decreased the number of accidents.

RFID
RFID are devices attached to an object that transmits data to an RFID receiver. This technology is getting a lot of attention in the supply chain management world because of its potential to store large amounts of data on the device. Another advantage is that an RFID tag can be read through other materials, although not all materials. Theoretically, this means that an RFID reader could read all of the tags of a mix of products on a palletized load without physically moving any of the materials or opening any cases. Tags are read so quickly, it seems instantaneous. In addition, the more expensive read/write tags can change or add data as they pass through different operations, adding information to the tags at each step of the supply chain. RFID tags also are more durable against harsh conditions than most barcodes, avoiding lost or unreadable information because of tears, spills, or rain. As this technology decreases in size and cost, it will be more and more attractive.

However, RFIDs have some drawbacks—the most significant at this time is the cost of both the technology and the tags. While a barcode sticker may cost less than one cent (U.S.$0.01), the least expensive RFID tag is $0.50 per tag, which represents a significant burden for individual products, or even to individual shipments. More expensive rewritable tags cost as much as $40.00 and can be recycled for multiple shipments, but the cost may still be prohibitive. In addition, the tags may hold more information than what is needed for most warehouses and distribution centers.

PICK-TO-LIGHT SYSTEMS
Pick-to-light systems use lights and LED displays for each pick location. The software lights up the next location to pick and displays the quantity to pick. This is expensive software but has proven to not only increase accuracy but also productivity. It is most useful when there are a very high number of picks per SKU.

ADVANTAGES AND CHALLENGES OF ADC/BARCODING
Several advantages and challenges are involved in implementing ADCs.

An ADC system/barcoding—

- human errors are less likely
- scanners are easy to use

- data captured is uniform and standardized
- feedback is usually more timely
- many activities improve streamline workflows, increasing productivity and efficiency, and can save money in the long term
- different settings are appropriate: manufacturing, warehousing, shipping and receiving, retail, and transportation.

But, ADC, or barcoding, has challenges—the two greatest being the cost of hardware, but more important, the cost of integrating the ADC within the facility, including any existing WMS. And, as mentioned earlier, the cost of changing systems, training staff, and maintaining/servicing barcode printers and scanners must be carefully considered.

AUTOMATED DATA COLLECTION IN INTERNATIONAL PUBLIC HEALTH

In summary, many public health facilities share the same challenges as large commercial warehouses and distribution centers; they can benefit from the ADC systems developed by them. Options range from low-cost options for recording receipts and issues data in a warehouse to more comprehensive systems that can track commodities from shipment arrival, through storage, to final distribution; and can help track lost or stolen products, prevent counterfeits, and follow tracer products data. These often are used as indicators to measure the effectiveness of the supply chain.

As with all IT systems, however, before deciding to invest, a significant amount of work needs to be done in terms of defining the scope of the work to be automated and an assessment of the different options.

After the decision is made to pursue ADC and the scope of the work is defined, management should consult with multiple vendors that specialize in this type of equipment to review the options available before making a final decision.

Section F: Security and Safety

Safety

FIRE

To prevent damage to products from fire, do the following:

- Install a sprinkler system, if possible.
- Keep standard fire extinguishers available in every storage facility, following national regulations—see the various types of extinguishers in the text box to determine which are appropriate.
- Visually inspect fire extinguishers every 2–3 months to ensure that pressure is maintained and the extinguisher is ready for use.
- Service fire extinguishers at least every 12 months.
- Place smoke detectors throughout the storage facil¬ity; check them every 2–3 months to ensure they are working properly.
- Strictly prohibit smoking in the store.
- Conduct fire drills for personnel every six months.
- Clearly mark emergency exits and check regularly to be sure they are not blocked or inaccessible.
- Display fire precaution signs in appropriate places in the storage facility, especially locations where flam¬mables are stored.
- Use sand to extinguish fires if there are no fire extinguishers or sprinkler system. Place buckets of sand near the door.

FOUR MAIN TYPES OF FIRE EXTINGUISHERS:

Dry chemical extinguishers have an extinguishing agent, such as potassium bicarbonate—similar to baking soda—and use a compressed gas as a propellant. They are effective for multiple types of fire, including combustible solids, like wood or paper; combustible liquids, like gaso¬line or grease; and electrical fires.

Water extinguishers have water and compressed gas; use them only on ordinary combustibles, such as paper and wood. Never use water on fires caused by liquids—such as gasoline or kerosene—or electrical fires.

Carbon dioxide (CO2) extinguishers are most effective for fires caused by liquids—such as gasoline or kerosene—and electrical fires; but not on fires caused by combus¬tibles—paper, cardboard, or lumber. The gas disperses quickly and does not leave harmful residue.

Halon extinguishers are often used in areas with computer equipment or other machinery because they leave no residue. They can be used on common combustibles, flammable liquids, and electrical fires. However, halon is dangerous to inhale and harmful to the environment. They are most effective in confined spaces, but remember that the area must be ventilated before it can be occupied again.

- Ensure that medical store staff are trained in how to use the specific fire extinguisher or other equipment available at your warehouse.

FIRST AID

- Keep a well-stocked first aid kit for employees or visitors.
- Place the kit in a central location that is easily accessible to all employees. Ensure it is clearly marked and that all employees know its location and contents.
- Provide first aid training to selected employees.

PERSONAL PROTECTION EQUIPMENT

Personal protective equipment (PPE) protects workers from workplace injuries. Warehouse operations present a wide variety of hazards for the worker and proper precautions should be taken.

Typical PPE used in warehousing situations are—

- steel-toe shoes or work boots
- hard hats
- gloves.

The Occupational Safety and Health Administration (OSHA) of the United States Government, publishes and enforces worker safety standards in the United States. They have numerous publications and information on how to conduct job hazard assessments. Below is a link to a publication directly focused on worker safety in warehouses. This publication has helpful ideas on how to protect workers and how to make a warehouse a safer more productive work environment.

https://www.osha.gov/Publications/3220_Warehouse.pdf

Security

Limiting access into the warehouse compound and the warehouse itself is the first step to ensure a secure environment for the commodities. Fencing, or a perimeter wall topped with wire, is often used to surround the compound. Security guards at the entrances are also advisable. Having a guest/visitor registration book will also help track who is coming and going.

Try to avoid hiring day-laborers or temporary workers. The more people who have had or have access and have seen the warehouse, the more likely the chances are of a break-in.

Ensure the entrance to the warehouse building has a sturdy door, with at least one lock. If the situation allows, install two locks with keys and give the keys to two different people; this is the best way to ensure that one person never goes into the warehouse alone. Outfit all windows and other ventilation openings with metal bars.

Within the warehouse, keep valuable (high cost or high demand) commodities in a locked cage, room, or cabinet.

Section G: Human Resources

While space and equipment are important, having well-trained people with the appropriate supervision and accountability is the most essential factor in determining whether your warehouse is productive and successful or not. In addition, hiring too few people can be as detrimental as hiring too many—too few staff can result in unacceptable order turnaround times and customer dissatisfaction. Too many staff can result in poor productivity and increased cost. Finding the correct mix is critical, particularly when there are unpredictable highs and lows in the workload.

Personnel Required for a Typical Warehouse

A typical warehouse comprises supervisors, records clerks, and floor personnel. Figure 7 is a suggested management/supervisory structure of personnel needed to operate a typical warehouse, with moderate to high output. Having a management structure displayed in your warehouse will help establish and ensure that everyone knows who is responsible and accountable to whom. Depending on the size of your warehouse, you may not need all the job functions listed below. Each job function is described below with the typical number of personnel for each function, job requirements, and related training requirements.

The total number of floor personnel will depend on the person-power needed for each activity. How to determine the number of people needed for each activity is described in the next section.

General Manager: Typically one

Job requirements: The manager is responsible and accountable for the overall performance of the warehouse, including customer service, warehouse operations, and information systems. The manager must also liaise with the procurement and transport sections of the organization—assuming these activities are managed elsewhere in the organization. This person manages and directs all activities related to the warehouse, including planning and scheduling all distribution services.

Training requirements: If the manager does not have significant experience in any area of warehouse management and/or warehouse operations, they must be trained in the deficient areas. They must also be trained in all aspects of supervision, motivation, interpersonal communications, and planning that are relevant to this position.

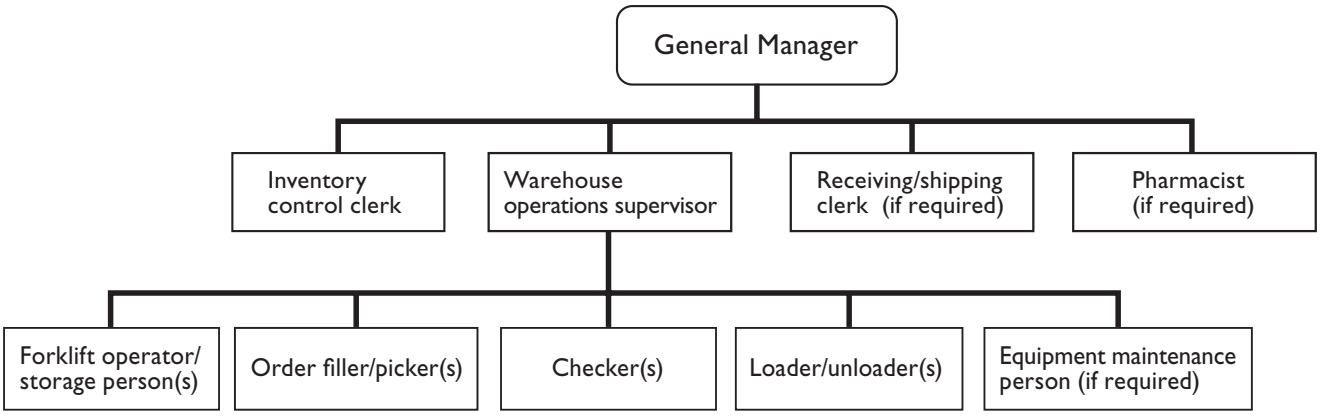
Inventory control clerk: Typically one. This clerk can also do shipping and receiving activities, if time requirements are acceptable.

Job requirements: The clerk's primary responsibility is to maintain and update inventory records, usually through an automated system. They also create inventory management procedures, when necessary, and coordinate the annual physical inventory. The clerk responds to information enquires from others, when necessary; and develop the necessary reports and documentation to facilitate accurate inventory control.

Training requirements: Must be trained in the inventory management methods being used at the warehouse. If the warehouse is automated, they must also be trained to use all, or most, parts of the system. Because the clerk must respond to information queries from management and staff, they must be trained in good interpersonal and communications skills.

Shipping and receiving clerk: Typically one, unless inventory control clerk assumes responsibility for shipping and receiving activities.

Figure 7. Suggested Management/Supervisory Structure for Warehouse Personnel



Job requirements: This clerk ensures that all shipping and receiving documents and functions are complete. They also coordinate with customers and transport, as required.

Training requirements: Must be trained in the shipping and receiving methods being used at the warehouse. If the warehouse is automated, the clerk must also be trained to use the system to enter and retrieve supplier and customer orders and information. Because the clerk must respond to information queries from management and customers/suppliers, they must be trained in good interpersonal and communications skills.

Pharmacist: One, possibly

Job requirements: If medications and other medical supplies will be stored in the warehouse, a pharmacist may be needed to ensure the quality of products received, stored, and issued.

Warehouse operations supervisor: One

Job requirements: This manager has general managerial responsibility for all routine warehousing activities and for all floor personnel, including forklift operators, order-fillers and order-pickers, checkers, loaders/unloaders, and equipment maintenance and repair staff. Typically, this person sits within the warehouse and is directly accountable for the day-to-day floor personnel and activities. This person maintains the product locator system and coordinates the picking and put-away operations, and all routine physical inventories.

Training Requirements: Must be trained in all aspects of supervision, including, but not limited to, setting targets, assigning and directing staff to perform tasks, developing good staff relations, motivating and/or disciplining staff, preventing accidents and theft, and promoting productivity. If the warehouse is automated, the warehouse operations supervisor must be trained to use the system to locate empty storage locations, locate stored items, and generate picking lists. If not already knowledgeable, the warehouse operations supervisor should be trained to perform all functions done by the warehouse floor staff.

Forklift operator/Storage person: Number depends on estimated time requirements for storing/retrieving materials to/from pallet racks

Job Requirements: They operate a forklift to move, relocate, and stack materials. They do minor maintenance for the forklift and other related equipment, and may also assist in filling orders, if needed.

Training requirements: Must complete a forklift training program where they learn how to handle materials, correctly operate the forklift, and perform routine maintenance. They must also understand the warehouse locator system. If they will assist in filling orders, they should be given appropriate training in picking/filling orders.

Order-filler and Order-picker: Number depends on estimated time requirements for picking orders

Job requirements: They fill customer orders and deliver the items to a staging area or delivery platform. They also conduct physical inventories, as directed. They may also prepare packaging/assembling orders for shipment.

Training requirements: Must understand the warehouse locator system and the labeling on each product stored in the warehouse. They must be trained to pick the correct amount of each item on a pick-order and complete pick-order paperwork or use relevant technology. They must also be trained to count products in stock for physical inventories and to complete appropriate paperwork. If they will assist in packaging and assembling orders, they should be trained to properly package an order and sort orders by customer or carrier.

Checker: Number depends on estimated time requirements for checking picked orders.

Job requirements: They count all products for both inbound and outbound freight; and check the quantity, quality, labeling, and addressing of orders. Checkers may also package and assemble orders for shipment.

Training requirements: Must be trained to count orders correctly and complete pick-order paperwork. If checkers will assist in packaging and assembling orders, they should be trained to properly package an order and sort orders, by customer or carrier.

Loader/Unloader: Number depends on estimated time requirements for loading and unloading materials.

Job requirements: They move materials from vehicles to receiving area, and from shipping area to vehicles and may also assist in packaging, repairing pallets, cleaning, and other janitorial tasks.

Training Requirements: Must be trained to load and unload vehicles correctly. They must also be taught how to use materials handling equipment—e.g., hand trolleys. If they will assist in packaging and assembling orders, they should be trained to properly package an order and sort orders, by customer or carrier.

Equipment maintenance and repair person: One, if warranted

Job requirements: They keep equipment in good working order; includ-

ing, but not limited to, building generator, lighting, and materials handling equipment.

Estimating Number of Personnel Required

The warehouse planner's single most important activity is to determine the type and number of people needed to operate the warehouse. As stated previously, the number of floor personnel will depend on the person-power needed for each activity.

Estimating the human resource requirements to run a warehouse can be determined by—

1. Identifying the basic warehouse activities: receiving, storage, order-picking, etc.

2. Dividing each activity into component tasks: receiving tasks might include starting the lift-truck, unloading a pallet from the truck, filling out forms, etc.

3. Identifying the typical types of personnel that work in a warehouse, and associating these individuals with particular activities/tasks; determine if they have the requisite competencies and skills to accomplish the work effectively.

4. After completing these activities, identify a time requirement for each task: for example, it takes an average of 15 minutes each day to start the lift-truck.

5. Determine how much time is required to perform each task and who should perform the task.

6. Using this information, calculate the number of personnel needed for all activities.

IDENTIFY BASIC WAREHOUSING ACTIVITIES AND ACTIVITY TASKS

There are usually 10 types of basic warehousing activities:

1. receiving/unloading

2. inspection

3. inventory control

4. storage

5. replenishment (possibly)

6. order-picking

7. checking

8. packing

9. staging (possibly)

10. shipping/loading.

Each activity has one or more tasks. Although the number of times the tasks are performed will vary, all warehouses have a common set of tasks, including—

Receiving: Unload supplier vehicles; move materials to inspection area.

Inspection: Draw sample from shipment and inspect—or arrange for inspection—to ensure compliance with specifications on purchase orders; report on status of inspection to purchasing and inventory control; count material and check against shipping invoice; report on status of count to inventory control. Note any discrepancies.

Inventory control: Operate manual or automated inventory control system; provide directions for moving supplies to/from storage; give information to management on receipts, issues, and stock balances; reconcile inventories to book or automated records; coordinate physical inventories.

Storage: Move incoming supplies to special picking location—if one exists—and/or storage location; confirm movement of supplies with inventory control.

Replenishment (assumes there is a special picking location): Move supplies from storage location to special picking location; confirm movement of supplies with inventory control.

Order picking: Select items from special picking location or storage, based on the pick list; confirm selection of items with inventory control; perform physical inventories.

Checking: Check picked orders for accuracy of item, quantity, and condition; to ensure compliance, compare quantity, quality, labeling, and address with customer's order.

Packaging: Package orders for customers; mark or label containers that hold customer orders.

Staging: Arrange orders according to customer and/or carrier that will transport products.

Shipping: Load outbound carrier, complete necessary paperwork, and report to inventory control.

ESTIMATING TIME REQUIREMENTS FOR ACTIVITIES AND TASKS

To estimate the number of staff required to operate a warehouse, you must establish the time requirements or standards for all tasks related to each activity. Generally, two ways are used to determine time requirements: (1) observe how long it takes the staff to do each task, or (2) use a predetermined time standard.

Estimating the time requirements for activities/tasks can be difficult. Table 8 displays the weekly time requirements, for a fictional warehouse, for all tasks related to the activity

Table 8. Sample Time Requirements for the Receiving Activity

Task (type of task)	Formula for Calculating Time Requirement	Weekly Time Requirement	Responsible Staff
Unload materials from vehicles (repetitive).	Unload 1,000 boxes (1 cubic meter each) to pallet @ 3 minutes a box.	50 hours	Loader/unloader
Move materials to receiving or inspection area (repetitive).	Move 1,000 pallets to receiving area @ 1.5 minute a pallet.	25 hours	Loader/unloader
Take receiving documentation to shipping/receiving clerk and fill out necessary paperwork (repetitive).	Task takes approximately 30 minutes per day.	3 hours	Loader/unloader
Obtain new pallets and other operating supplies (non-repetitive).	Task is usually done quarterly @ 2 days each time.	2 hours	Loader/unloader
Maintain/repair materials handling equipment (non-repetitive).	Task is usually done twice yearly @ one week each time.	2 hours	Equipment maintenance person

of *receiving*. Note that the example includes both repetitive and non-repetitive tasks. In this example, the warehouse used a stopwatch to determine how much time it took to complete a typical repetitive task; then, they multiplied the resulting number by the number of times the task was repeated each week. For non-repetitive tasks, the warehouse estimated how much time was required for these tasks, per week.

It should be mentioned that time requirements calculated this way do not include allowances for personnel fatigue and routine delays/breaks. You must make adjustments to the total time requirements to account for restroom breaks, coffee or tea breaks, personnel visits, machine malfunctions, etc. The warehouse may know what these adjustment factors are, or they may use standard factors, such as 5 percent for light work and 15 percent for heavy work.

If, in the previous example, an adjustment of 10 percent was assumed for personnel fatigue and delay, then only 36 hours per week (40– (.1 × 40)) would be available for productive work, per person. Although the time requirements would remain the same in the previous example, the staff requirements would change as follows:

Total time requirements for receiving activity:
Loader/unloader: *80 hours required per week*
Equipment main, person: *2 hours required per week*

Total staff requirements for receiving activity:
Loader/unloader: *80 hours weekly workload/40 hours per week per person - 2 loaders/unloaders required.*
Equipment maintenance person: *2 hours weekly workload/40 hours per week per person - 0.05 equipment maintenance persons required.*

(Note: this assumes a 40-hour work week.)

Total staff requirements for receiving activity:
Loader/unloader: *80 hours weekly workload/36 hours per week per person - 2.22 loaders/unloaders required.*
Equipment maintenance person: *2 hours weekly workload/36 hours per week per person - 0.055 equipment maintenance persons required.*

Additional Tools for Warehouse Managers

Performance Measurement

To help show improvement in operations, many consider implementing supply chain performance indicators or metrics as one of the simplest, least expensive, and least time-consuming activities. It is a well-known fact that, "people behave based on the way they are measured." Public health warehouses are no different; unless clear measurable indicators are in place, staff may not completely understand what is expected of them; as a consequence, they may not carry out their tasks as well as they could.

Performance management should be a dynamic, continuous process, and should lead to the appropriate action to stimulate improvement.

Measuring the outcomes of processes is fundamental to—

- understanding the current level of performance
- gaining control by understanding capability and capacity
- determining opportunities for improvement
- making decisions
- using key performance indicators to set performance standards.

Regularly measuring these performance standards will help maintain control and work toward continuous improvement by removing the causes of poor performance or non-conformity.

To manage an optimally operating warehouse and maintain superior performance, the warehouse planner needs to establish realistic performance standards and develop a foundation and infrastructure for continuous improvement of the whole warehouse function.

Performance measurement of warehouse operations should include measures that reflect the desire to make these overall operations better, faster, and less expensive. Fundamentally, all measurements should be aligned toward customer satisfaction and the relevant performance standards imposed either by the customer or the managing organization—as measured via the agreed-upon performance indicators or metrics.

BALANCING BETTER METRICS VERSUS A BETTER OPERATING ENVIRONMENT

There is always a trade-off between the operating environment and actual performance in that environment, as measured by agreed-to metrics. For example, while you may be able to increase storage density by installing narrow aisle shelving, this may reduce productivity by making it more difficult to travel through aisles and store or pick commodities.

The organization is responsible for recognizing conflicting strengths and weaknesses between the operating environment and performance metrics and, more important, between service and cost. You should consider these two outputs of the warehousing function the dependent variables in any design and implementation of both the warehouse infrastructure and the operating systems.

METRICS USED TO MEASURE WAREHOUSE PERFORMANCE

The USAID | DELIVER PROJECT developed a comprehensive set of supply chain metrics of performance. See Guide to Key Performance Indicators for Public Health Managers (USAID | DELIVER PROJECT, Task Order 1 2011). The metrics are divided into four categories; quality, response time, cost, and productivity. For the warehousing guidelines as contained in this document, we organized these metrics according to the seven categories for the warehouse self-assessment.

See appendix 4—Warehouse Performance Metrics—for a list and a list of the metrics.

DATA COLLECTION AND PRESENTATION

Having defined what performance is to be measured, it is imperative to determine—

- data to be collected
- source of the data
- how and who will collect the data
- frequency of data collection and reporting
- data validation process
- data presentation.

You not only need to determine what is to be reported, but also the source of the data, frequency, and responsibility for collection. Also, how the performance measurement data can be validated for accuracy to ensure that the reported performance is useful for meaningful and timely decisionmaking. To begin, try selecting a few metrics you feel are most relevant and for which the data are available. After you establish a good process with a few metrics, expand the number of metrics and begin measuring a more comprehensive view of your warehouse.

Warehouse Budgeting

To manage and operate a successful warehouse, it is necessary to develop and actively track expenditures against a comprehensive budget. Setting up a budget will help you understand where money is being spent and how to most effectively manage it.

To begin setting up a budget, looking at historical information is the best way to estimate future expenses and areas of expense. If reliable and complete historical information is not available, keep a daily log of your expenses, by category; this will help determine most of your expenditures and will help create budgets for the following months or year.

Appendix 5—Warehouse Budget Considerations—provides typical categories and areas of potential expense in a public health warehouse; it can help you create a complete and comprehensive budget tool.

Case Studies

Examples of Layout and Organization Improvement

Improved Warehouse Management Supports Expanding Health Programs in Ethiopia

USAID | DELIVER PROJECT 2010

By training warehouse managers from zonal warehouses across Ethiopia to use their storage space more efficiently, the USAID | DELIVER PROJECT helped make room for additional products to support the country's expanding health programs.

The dejunking effort has already created additional storage space in most of the country's zonal warehouses, limiting the need for expensive new construction.

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In Ethiopia, much-needed health programs for family planning, HIV and AIDS, malaria, tuberculosis, and other critical drugs and supplies are expanding to reach more of the population. This increase in services is bringing larger quantities of drugs and contraceptives to the country each year—a trend that is expected to continue and even increase.

More products means more storage space. As supplies are shipped to regional and zonal warehouses, finding sufficient storage space is becoming increasingly difficult. To increase space in existing warehouses, the Ethiopian Ministry of Health partnered with the USAID | DELIVER PROJECT to begin a major overhaul of its storage facilities, a process known as *dejunking*.

Dejunking means removing all damaged and expired products, as well as other items that are cluttering the warehouse or storage room—sometimes for many years—to free up space and use best practices to organize the warehouse. The dejunking effort has already created additional storage space in most of the country's zonal warehouses, limiting the need for expensive new construction.

From December 2009–July 2010, the USAID | DELIVER PROJECT trained almost 100 warehouse managers from across the country in how to dejunk. Using a curriculum developed specifically for dejunking and stock reorganization training in Ethiopia, the participants learned how to systematically redesign their space, correctly dispose of damaged and expired products and other inappropriate items, rationalize product storage, and mobilize local resources.

Warehouse managers from 56 of Ethiopia's 68 zones attended the training. Highly motivated and with new skills, the trainees made a major impact when they returned home. Most have dejunked their facilities, and some even helped colleagues at lower levels of the supply chain dejunk smaller warehouses and storerooms.

Around the country, many thousands of units of damaged and expired products have been destroyed; in most cases, the newly available space is the equivalent of half their warehouse space. On average, each warehouse has gained an estimated 15 square meters of space—enough room to park a couple of minibuses. In some locations, space was taken up by broken furniture, truck parts, old file cabinets, and fuel barrels, in addition to expired products.

The dejunking process also included rationalizing the use of floor space and shelf space. Best practices for storage were applied to group products in logical order to ensure that a product was located in only one place, and to rotate products so the ones closest to expiry would be used first (first-to-expire, first-out). As a result, turnaround time is much shorter and shipments coming in can be unloaded and stocked quickly. Orders going out can be assembled and loaded faster and more efficiently. Recordkeeping is easier and more accurate, and it is easy to tell the quantity of each product in the warehouse or storeroom.

Warehouse managers used their local resource mobilization (REMO) training to gain support from their communities while they dejunked the storage facilities. They contacted nongovernmental organizations (NGOs) and other local organizations to help with major cleaning, improving air circulation and temperature control, locating ladders and hand carts, installing shelving, and fixing roofs, among other things.

REMO empowered the warehouse managers to find creative ways to get things done; it resulted in a wide and unexpected range of improvements. At some sites, the USAID | DELIVER PROJECT provided shelving, but, thanks to REMO, warehouse managers found new ways to obtain storage equipment, including locally produced pallets made from eucalyptus wood. REMO training encourages local leadership and initiative to find solutions, offering a way to sustain improvements for years to come.

Dejunking helps improve the supply chain on multiple levels. It minimizes waste from expired products and, with more organized storage space, it improves the accuracy of logistics data, which informs critical procurement decisions. Better organization also helps warehouse staff complete their jobs more efficiently and helps boost employee morale.

The increased storage space and improved management of warehouses are crucial elements in meeting the demands of Ethiopia's expanding public health programs. With larger quantities of drugs and contraceptives coming from the central warehouses, the *new* storage space is already being put to good use.

Examples of Layout and Organization Improvement

Reorganization in Harari Region Increases Storage Capacity by 120 Percent

Located 565 kilometers east of Addis Ababa, the Harari Regional Health Bureau (HRHB) manages two regional warehouses.

These regional warehouses have become much easier to navigate. Storage areas are clearly marked on each aisle, shelf, and sub-shelf. By referencing storage locations on stock and bin cards, workers can quickly and easily ensure proper placement of each commodity.

With new racking systems in place, products are safely stored, which will help minimize the number of damaged products. Workers are also better positioned to reduce expiries by applying first-to-expire, first-out (FEFO).

Photo: Negash Milky, Warehouse and Distribution Specialist, USAID | DELIVER PROJECT

BEFORE The warehouses for HRHB's drugs and medical supplies appeared to be poorly managed. Improper storage and gaps in technical skills led to damaged and improperly managed health commodities. The Regional Health Bureau asked the USAID | DELIVER PROJECT to assess the situation and provide technical support to improve conditions.

Photo: Negash Milky, Warehouse and Distribution Specialist, USAID | DELIVER PROJECT

AFTER After careful reorganization, both warehouses were outfitted with standard storage shelving units. The USAID | DELIVER PROJECT (technical assistance), Managing Medical Injections Safer (MMIS) project, and MSH's RPM Plus (funding) collaborated on this initiative.

To strengthen capacity, the project also provided on-the-job training in storage management to stores and inventory management staff.

The region is pleased that they now have 120 percent additional storage capacity available as a direct result of this important initiative.

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Example of Warehouse Equipment Improvement

Heavy-Duty Shelves and Locators Dramatically Improve Warehouses in Bahir Dar

Bahir Dar, Ethiopia, located in Amhara—one of the largest regions in Ethiopia—has some of the largest warehouses in the country. Because the warehouses were full of unwanted items, the USAID | DELIVER PROJECT *provided technical assistance to improve the storage conditions in three of the warehouses.*

A dejunking operation increased the storage capacity of the warehouses by 200 percent; the capacity in efficiency of loading/unloading increased 100 percent.

The regional warehouses also received warehouse equipment, including ladders and trolleys. In addition, storekeepers received on-the-job training for stores management.

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Photo: Negash Milky, Warehouse and Distribution Specialist, USAID | DELIVER PROJECT

BEFORE The warehouses had several problems that made it difficult for the staff to manage poorly planned storage and expired and damaged commodities.

Photo: Negash Milky, Warehouse and Distribution Specialist, USAID | DELIVER PROJECT

AFTER The USAID | DELIVER PROJECT supervised the installation of heavy-duty shelves in the regional warehouses and the installation of different locators (a reference system to identify items) in the warehouse. They reorganized the space. Different types of locators were installed in all the warehouses for products, buildings, stores, shelves, and sub-shelves. Because of these improvements, the staff was able to control the storage management and control the expiry of products.

Example of Automated Data Collection

Barcoding: Modernizing Warehouses to Lighten the Workload

USAID | DELIVER PROJECT

Warehouse rehabilitation is essential for implementation of barcoding, but once this pre-requisite is in place, a barcode enabled warehouse management system can easily be replicated at the provincial level.

"USAID support for modernization and rehabilitation of the Central Warehouse, turning it into a center of excellence with automated warehouse management, will go a long way."

—Dr. Shafqat Jawaid, Director General, Population Program Wing, Planning & Development Division

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Until recently, Pakistan's Central Warehouse, which provides contraceptive supplies to the entire country, followed labor-intensive manual processes for all its transactions. A new automated warehouse management system is changing this and eliminating many of the problems that can arise from tracking commodities by hand, such as delays in reporting and distribution, wastage from expiries, and stock keeping errors.

This new innovative system is making it much easier for warehouse staff to manage the commodities. So far, the work load has been reduced by approximately 25-30 percent by introducing an automated system, and this percentage could increase to as much as 50 percent when everyone is fully trained, enabling the current staff to keep up with the growing demand for family planning products.

Additionally, the number of errors reported has decreased drastically, and the time it takes to produce reports has decreased by 40-50 percent. Previously, it was very difficult to track individual dispatch records, but now they are available at the click of a button. All of these changes have made a tremendous difference in the ability of the Central Warehouse to serve provincial warehouses and other clients.

The rehabilitation and automation of the Central Warehouse is one of the key interventions implemented by the USAID | DELIVER PROJECT, in partnership with the Government of Pakistan (GoP). To automate shipments, distribution, and inventory, the project developed a barcode enabled warehouse management system (WMS) in consultation with Central Warehouse management. This allows all transactions to be handled through barcode scanning.

A barcode is an optical machine-readable representation of data relating to the object to which it is attached. Barcodes are scanned by special optical scanners called barcode readers, and scanners and interpretive software are integrated into desktop computers and smartphones.

Barcode labels are printed using special barcode printers, and they contain all the information relevant to an item, including item name, lot number, manufacturing date, expiry date, and quantity per carton. This makes it easy for staff members to locate items in the warehouse, along with all the necessary information.

To implement a barcode enabled WMS, the project provided the Central Warehouse with new hardware and software, including servers, desktop computers, barcode scanners, and printers. The new system provides—

- improved management of the large volume of shipments received
- easier and faster distribution of commodities to the districts
- improved management of expiries
- improved location management of a large warehouse
- easier tracking of shipments and dispatches to various districts
- improved control of pilferage and theft
- faster reporting of logistics data to the federal level
- improved information visibility for all staff at the warehouse.

Inauguration of the rehabilitated Central Warehouse in Karachi. By introducing an automated system, the work load for staff at the Central Warehouse has been reduced by approximately 25-30 percent so far.

Key staff involved in warehouse operations received training on generating, printing, and scanning barcodes, as well as on how to receive, issue, and adjust stock, and create invoices using barcodes. Motivating staff to embrace the changes and experience the benefits of the new system is critical for successful implementation of barcoding. Ongoing staff training with standard operating procedures, job aids, and supportive supervision and monitoring have a positive impact on system implementation and can counter the challenges of moving existing staff to a new system, as well as staff turnover and other changes.

Warehouse rehabilitation and computer literate human resources are essential for implementation of barcoding at the provincial level. Rehabilitation requirements include installation of warehouse equipment, such as a pallet racking system; a stacker or lifter; and trolleys. Once this pre-requisite is in place, barcode enabled WMS can easily be replicated from the Central Warehouse system.

The USAID | DELIVER PROJECT and the GoP are encouraging the provinces to rehabilitate and integrate their warehouses. The project hopes to provide study tours for provincial warehouse staff to observe operations at the Central Warehouse and plans to help with rehabilitation assessments of provincial warehouses where needed.

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Appendix 1

Warehouse Self-Assessment Tool

The Warehouse Self-Assessment Tool has seven sections:

A. Warehouse Infrastructure Planning

B. Layout Planning and Operations Efficiency

C. Warehouse Equipment

D. Special Storage Requirements

E. Inventory Management

F. Security and Safety

G. Human Resources

Each section targets a specific and important aspect of warehousing. While this assessment is as comprehensive as possible, some areas may not apply, such as the cold chain. The point of this assessment is to understand what weaknesses are present so you can focus on improving those areas. It will also help you understand what areas you need to divert resources to or to ask for more resources. In addition, it can help highlight some strengths of your warehouse to help you and others understand what you are doing well.

Complete the assessment while you are physically located within the warehouse.

At the end of each section, you can add up and calculate a score. Divide the score by the total number of questions in the section to calculate a percentage.

At the end of the assessment, you will find a scoring sheet that you can use to compile scores for each section, as well as an area to summarize key strengths and weaknesses for each section.

SECTION A: WAREHOUSE INFRASTRUCTURE PLANNING			*Score*	*Maximum Score*
A1.	*Is the ceiling in good condition (not warped, free of holes)?*	❑ *Yes* ❑ *No*		*1*
A2.	*Do the ceiling or walls showing any staining indicating a leaking roof?*	❑ *Yes* ❑ *No*		*1*
A3.	*Is the floor in good condition, level, free of dust and free of holes?*	❑ *Yes* ❑ *No*		*1*
A4.	*Are the walls in good condition, clean and painted?*	❑ *Yes* ❑ *No*		*1*
A5.	*Is there adequate lighting throughout without too much direct sunlight?*	❑ *Yes* ❑ *No*		*1*
A6.	*Is the storeroom fitted with air-conditioners or ventilation /fans capable of maintaining a temperature of <24C at midday?*	❑ *Yes* ❑ *No*		*1*
A7.	*Is there a working thermometer and are temperature charts utilized?*	❑ *Yes* ❑ *No*		*1*
A8.	*Is the storage area visually free from harmful insects and rodents?*	❑ *Yes* ❑ *No*		*1*
A9.	*Are there frequent interruptions to the main electrical supply (more than 2 times a week)?*	❑ *Yes* ❑ *No* *(No = 1)*		*1*
A10.	*Does staff report breakers tripping when it rains or when the air-conditioners are on full load?*	❑ *Yes* ❑ *No* *(No = 1)*		*1*
A11.	*Does the warehouse have a generator?*	❑ *Yes* ❑ *No*		*1*
A12.	*Can the generator handle the full site load?*	❑ *Yes* ❑ *No*		*1*
A13.	*Is there an adequate budget for the purchase of generator fuel?*	❑ *Yes* ❑ *No*		*1*
A14.	*Is there a maintenance plan on file for the generator?*	❑ *Yes* ❑ *No*		*1*
TOTAL				___/14
SCORE FOR THE SECTION				____%

Additional Notes

SECTION B: LAYOUT PLANNING AND OPERATIONS EFFICIENCY			Score	Maximum Score
B1.	In an average week are there ever any days when orders are not processed?	❑ Yes ❑ No (No = 1)		1
B2.	In an average week are there ever any days when receipts are not processed?	❑ Yes ❑ No (No = 1)		1
B3.	Can delivery vehicles access loading/receiving bays?	❑ Yes ❑ No		1
B4.	Are receiving and dispatch areas separated?	❑ Yes ❑ No		1
B5.	In the receiving area is there sufficient secure space to arrange and sort an incoming delivery?	❑ Yes ❑ No		1
B6.	Is there a designated space for expired or damaged goods?	❑ Yes ❑ No		1
B7.	Is there sufficient secure space to assemble outgoing deliveries?	❑ Yes ❑ No		1
B8.	Is the existing floor space for pallet stacking, shelving or racking less than 75% full?	❑ Yes ❑ No		1
B9.	Are the aisles between the stacked pallets or racking clear of stored commodities?	❑ Yes ❑ No		1
TOTAL				___/9
SCORE FOR THE SECTION				____%

Additional Notes

SECTION C: WAREHOUSE EQUIPMENT			Score	Maximum Score
C1.	Are there sufficient pallets available?	❑ Yes ❑ No		1
C2.	Are there sufficient pallet jacks available?	❑ Yes ❑ No		1
C3.	If pallet racks are present, is there an operable fork truck with a maintenance schedule?	❑ Yes ❑ No		1
C4.	Is there a storage system utilized (shelving, racks or pallet stacking) and is it in good condition?	❑ Yes ❑ No		1
C5.	Is there adequate aisle space and clearance for material handling equipment?	❑ Yes ❑ No		1
C6.	Where commodities are stored on the floor are they stacked less than 2.5 meters high?	❑ Yes ❑ No		1
C7.	Are cartons in good condition, (not crushed due to mishandling or poor stacking.)?	❑ Yes ❑ No		1
C8.	Are cartons and products up off the floor and protected from water and dust?	❑ Yes ❑ No		1
TOTAL				___/8
SCORE FOR THE SECTION				____%

Additional Notes

SECTION D: SPECIAL STORAGE REQUIREMENTS			Score	Maximum Score
D1.	Does the location store cold chain required product and does it have designated cold chain facilities?	❑ Yes ❑ No		1
D2.	Is there sufficient capacity for cold chain product?	❑ Yes ❑ No		1
D3.	Are all fridges and cold rooms operational?	❑ Yes ❑ No		1
D4.	Are temperatures monitored for each discreet storage unit?	❑ Yes ❑ No		1
D5.	Do the refrigerators run on solar power?	❑ Yes ❑ No		1
D6.	If the cold chain facilities run on electricity, is there a back-up source of power? (ie. generator)	❑ Yes ❑ No		1
D7.	Is there funding for the back-up source of power?	❑ Yes ❑ No		1
D8.	Is there a designated area for flammable / hazardous items?	❑ Yes ❑ No		1
D9.	Are flammable/hazardous items kept in a separate area away from the main buildings?	❑ Yes ❑ No		1
D10.	Are high-value commodities kept in a locked or caged area?	❑ Yes ❑ No		1
TOTAL				___/10
SCORE FOR THE SECTION				____%

Additional Notes

SECTION E: INVENTORY MANAGEMENT			Score	Maximum Score
E1.	Are paper or electronic inventory records updated for each receipt and issue?	❑ Yes ❑ No		1
E2.	Are ledgers maintained and are corresponding bin cards maintained in the storerooms?	❑ Yes ❑ No		1
E3.	Are ledgers legibly and accurately maintained – audit a sample and cross check the same sample on the corresponding bin card?	❑ Yes ❑ No		1
E4.	Is there a process to investigate and resolve discrepancies on records?	❑ Yes ❑ No		1
E5.	Is there a system of rolling stock checks in place?	❑ Yes ❑ No		1
E6.	Are full physical inventory stock counts performed at least every 3 months?	❑ Yes ❑ No		1
E7.	Is the write off and destruction of damaged or expired stock processed regularly?	❑ Yes ❑ No		1
E8.	Are products organized according to FEFO?	❑ Yes ❑ No		1
TOTAL				___/8
SCORE FOR THE SECTION				____%

Additional Notes

SECTION F: SECURITY AND SAFETY			*Score*	*Maximum Score*
F1.	*Is the building perimeter surrounded by a high wall or fence, with entry guarded?*	❑ *Yes* ❑ *No*		*1*
F2.	*Is access to the warehouse limited to only designated staff?*	❑ *Yes* ❑ *No*		*1*
F3.	*Are windows intact and burglar proofed?*	❑ *Yes* ❑ *No*		*1*
F4.	*Are the doors and windows solid and well secured?*	❑ *Yes* ❑ *No*		*1*
F5.	*Is the store secured with a lock and key but accessible during normal working hours?*	❑ *Yes* ❑ *No*		*1*
F6.	*Is firefighting equipment available and do the labels on the firefighting equipment indicate that it has been serviced within the last year?*	❑ *Yes* ❑ *No*		*1*
F7.	*Are staff trained on how to use the firefighting equipment?*	❑ *Yes* ❑ *No*		*1*
F8.	*Are there items of personal protective equipment being used? (gloves, boots, etc?)*	❑ *Yes* ❑ *No*		*1*
TOTAL				___/8
SCORE FOR THE SECTION				____%

Additional Notes

SECTION G: HUMAN RESOURCES			*Score*	*Maximum Score*
G1.	*Does the facility have personnel responsible for warehouse management (supervisor) and are there present and accountable?*	❑ *Yes* ❑ *No*		*1*
G2.	*Is there an organizational structure and chart posted showing each warehouse-related post?*	❑ *Yes* ❑ *No*		*1*
G3.	*Is there sufficient staff capacity to run the warehouse and authority to oversee warehouse management?*	❑ *Yes* ❑ *No*		*1*
G4.	*Are there records of external visits or audits?*	❑ *Yes* ❑ *No*		*1*
G5.	*Are there posted job descriptions for all positions at the warehouse?*	❑ *Yes* ❑ *No*		*1*
G6.	*Are there up to date Standard Operating Procedures (SOPs) for all functions and processes posted on site?*	❑ *Yes* ❑ *No*		*1*
G7.	*Is there active on-the-job training for staff?*	❑ *Yes* ❑ *No*		*1*
G8.	*Is there a process for new hire orientation?*	❑ *Yes* ❑ *No*		*1*
TOTAL				___/8
SCORE FOR THE SECTION				____%

Additional Notes

Warehouse Assessment Questionnaire Scoring Sheet Results

SECTION	KEY STRENGTHS	KEY WEAKNESSES	SECTION SCORE
A. Warehouse Infrastructure Planning			
B. Layout Planning and Operations Efficiency			
C. Warehouse Equipment			
D. Special Storage Requirements			
E. Inventory Management			
F. Security and Safety			
G. Human Resources			

Appendix 2

Pallet Stacking, Shelving, and Pallet Racks

Storage Systems Selection

Types of storage systems:

- pallet stacking
- static shelving
- pallet racking.

Each storage system has advantages and disadvantages; the choice is usually based on storage capacity and the flexibility of each system, in relation to the cost of the system.

A thorough breakdown and analysis of the choices will help guide managers to select the most appropriate cost-effective storage system for their facility.

Keep in mind, before installing a storage system, the cost must also include other factors—required lift equipment, as well as any refurbishment needed for the existing conditions, including the floor.

In addition to cost factors, to select the storage system or combination of storage systems to maximize your storage space, you must understand the type of product that will be stored in your warehouse and the volume of the products. If you know what products you will be receiving, and the distribution plan for these products, you can categorize them to help you determine what kind of storage methods will maximize your space. Following are some general rules of product storage categorization.

Product Storage Categorization:

Slow moving or low volume products – placed on shelves

Examples: scalpels, venom, etc

Fast moving, high volume or heavy products– pallets on floor or racks

Examples: gloves, condoms, saline, etc.

Pallet Stacking

Advantages

- low cost
- flexible layout—can be moved
- expensive floor renovations not needed.

Disadvantages

- can become messy
- poor use of space if ceilings are higher than 4.5 meters.

Done properly, pallet stacking is one the simplest, most cost-effective storage methods. Using this method, boxes of products are stacked on top of a pallet. The product, its weight, and its dimensions will determine how high the stack can be and should be stacked. Always look at the packaging to see if the manufacturer has labeled the maximum height their boxes should be stacked, as well as for any arrow indicating the direction boxes should face. See the following general guidelines on stacking and the maximum height for common products.

Guidelines for Pallet Stacking

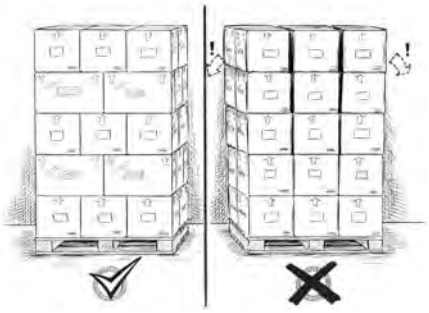
Figure 8. Standard Wood Pallet (1.22 by 1.02 Meters)

Stack the product on pallets off the floor to protect the product from dampness, dust, and pests. It also allows for ventilation. A standard wood pallet, shown in Figure 8, is commonly used.

Figure 9. Tipping Pallet Due to Un-level Floor

Place the product and then stack it on level and smooth floors to prevent the product from falling over.

Figure 10. Bonded Stacking vs. Unbonded Stacking

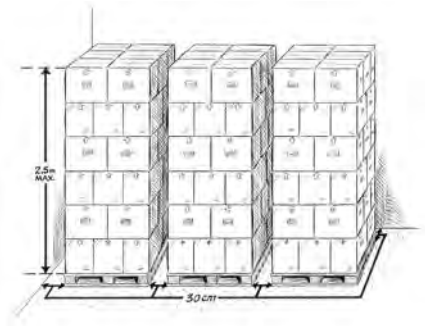


Stack the product up to the edge of the pallets and position it in bonded or interlocked stacks to increase stability of the product and prevent it from falling over.

Figure 11. Example of Crushed Boxes Due to High Stacking

Do not stack the product higher than 2.5 meters to protect the product. This is a general rule, but if you have very heavy products, like liquids, you may need to stack your boxes lower to prevent the weight from crushing or splitting the boxes the bottom of the stack. In addition, stacking higher than 2.5 meters is a safety concern.

Figure 12. Properly Stacked Pallet



Stack the product at least 30 centimeters from the wall and other stacks to allow for ventilation. (Show picture of properly stacked pallet 2.5m high, 30cm from wall and other pallets)

As a general rule, pallet racks that are three racks or less high require more square meters per pallet than bulk storage areas, because of the required aisle space and rack shelf clearances. If your ceiling height does not allow you to install pallet racks higher than three shelves, your return on investment may not be worthwhile—you will spend money and not gain any additional space. If a pallet racking system can be as high as four or five shelves, the use of the space is usually better than storing pallets on the floor.

However, racks do allow access to a specific pallet and they help keep warehouses neater. Again, however, the cost of the racking system is not the only expenditure; a lift truck and a suitable floor will also be required.

Recommendation

A good first step when determining if you need to buy a storage system is to do a baseline assessment of the storage density or available space utilization of the warehouse using only pallet stacking storage on the floor, then compare it to shelving or racking systems.

Static Shelving

Advantages

- medium cost
- flexible layout—can move it around
- expensive floor renovations not needed.

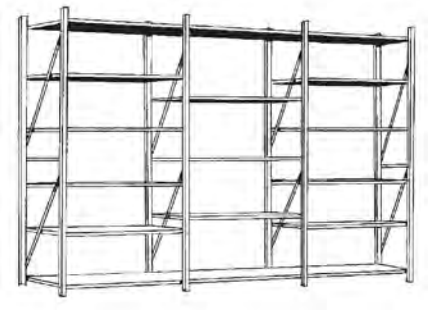
Disadvantages

- must hand carry all product on and off shelves
- poor use of space, if ceilings are higher than 4.5 meters.

Static shelving systems are one of the oldest and most popular forms of storage equipment for products. Small static shelving is usually constructed using light-gauge or heavy-gauge cold-rolled steel. Most static configurations have four vertical posts that support one or more horizontal shelves. They come in a range of depths and load capacities.

Figure 13 shows a common small load shelving rack. It is available in both light and heavy duty depending on the weight and size of product to be stored. This type of rack system is suitable for low volume and/or low quantity (e.g., scalpels, venom, etc.) warehouses that have many different stockkeeping units (SKUs). It is also appropriate for warehouses with many different SKUs of heavy products (e.g., saline), as well as lighter products that are difficult to stack on pallets.

Figure 13. Shelving Rack



However, no matter how simple this storage equipment appears to be, warehouse management must also do the same careful planning they use when preparing for pallet storage systems.

Pallet Racking

Advantages

- can be stacked very high
- can hold heavy loads and are durable.

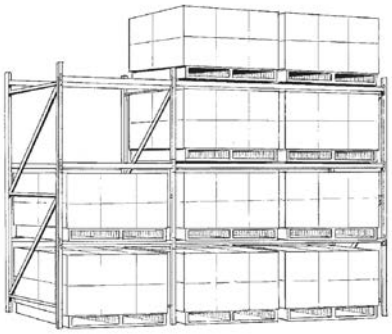
Disadvantages

- need strong, level floor
- most expensive option
- cannot be easily reconfigured.

Pallet racks, perhaps the most commonly used pallet storage equipment in the world, store products on pallets; they comprise various numbers of rack bays. A rack bay can be one or more shelves high; horizontal bars (beams) and vertical members (frames) suspend the horizontal members off the warehouse floor. When two or more rack bays are connected lengthwise, this represents a row of racks.

Each individual pallet is accessible from the aisle; to use floor space more efficiently; single rows can be placed against walls. The selective pallet rack is one of the most flexible types of racking system because pallets can be stored, retrieved, or picked without handling other pallets. This type of rack system has a simple construction of metal upright frames and a pair of load beams for each shelf elevation (see figure 14).

Figure 14. One Row of Connecting Racks (Two Bays) with Three Multi- Shelves



It is important for warehouse managers to remember that all loads are on an aisle when they use the selective rack configuration.

In addition, the pallet and the unit load—including the weight and overall dimensions, lift equipment, and building—determine the best type of rack design for an individual facility. By establishing the storage rack dimensions, you can correctly design your warehouse layout. It is of primary importance that you determine the type of lift truck equipment that will be used for rack storage—the different types of lift equipment are discussed in the following section.

PALLET RACK PARTS AND MATERIALS (METAL COMPOUNDS)

Most pallet racking systems are constructed of simple metal uprights and cross-members, which provide immediate access to each stored load. When a load is removed, a pallet space is created.

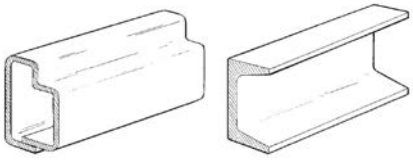
A rack system comprises rack frames with front and rear column sections, which are fixed firmly together by horizontal braces and diagonal struts. The struts and braces are important because they give the frame assembly strength and rigidity. The rack braces transfer the horizontally oriented forces between the front and rear column sections; the rack struts transfer the vertically oriented forces between columns. Of course, the larger the number of struts and braces on the rack structure itself, the more overall rack stability and long-term stability the structure will have.

When constructing a rack system, loads can have various heights and widths. However, whatever height or width the racks are designed to accommodate, ensure that the metallurgical compounds are consistent. Currently, the most common column materials are cold-rolled formed sections (steel) with a rectangular or square shape.

The horizontal metallurgical compounds are just as important. The horizontal load-bearing beams are also constructed of cold-rolled steel members or hot-rolled structural shapes. In addition, to facilitate the attachment because the beam must span a bay and be attached to the vertical columns, each end of the beam has an end plate or fitting (connector) welded or bolted to it.

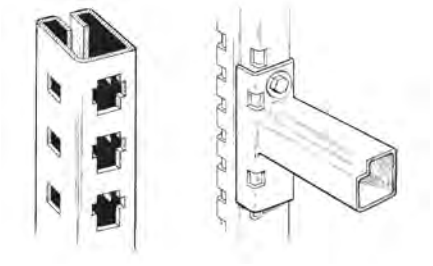
For various reasons—economic, engineering capacity, efficiency, safety, etc.—rack manufactures have standardized their column and beam section shapes. For reasons mentioned earlier, and because the height usually determines the beam capacity, most roll-formed beams are box-like structures, which efficiently use material (see figure 15).

Figure 15. Common Rack Beam Sections (Rolled-formed Left, Structural Right)



Rigid beam-to-column connections are a primary factor for ensuring the safety and long-term service life of a rack system. A racking system's rigidity depends on very rigid beam-to-column connections. The two common types of connections are teardrop—also called keystone-shaped keyhole (see figure 16)—and bolted connections. Bolted connections require more time to install and, to be effective, they must be inspected periodically and the fasteners must be tightened.

Figure 16. Common Rack Column Sections



PALLET RACK CONFIGURATIONS AND CLEARANCES

For standard U.S. pallets, which are 1.22 meters deep × 1.02 meters wide:

1. The standard depth of a pallet rack is usually 1.06 meters deep, or 0.16 meters less than the pallet depth. Using these dimensions, the pallet will have 0.08 meters of front and rear overhang over the shelf beams. Thus, a 1.22-meter deep pallet, for example, would require a 1.06-meter deep frame. This overhang will ensure the weight of the load is evenly distributed on the shelf.

2. The standard width of a pallet rack is 2.6 meters, which will accommodate two pallets side-by-side allowing for ample clearance between the pallets and the columns to move the pallets in and out safely.

3. The height of the storage rack is only limited to the ceiling height and the maximum lift height of any lift truck equipment. To allow for the height of a pallet, it is important for the top shelf to be at least 0.15 meters less than the maximum lifting height of the truck. This information may seem basic, or even intuitive, for most warehouse managers and staff; however, you must determine and apply this information to provide an economical, practical, and workable storage rack system.

PALLET RACKS AND LIFT TRUCKS

It is very important for you to determine the type of lift truck equipment that will be used in the warehouse before rack construction is started. During the rack design process, because each type of lift truck has different characteristics, these must be considered when determining the appropriate operational clearances.

The lifting height of the lift truck and the warehouse ceiling height determine the number of shelves that can be used for each rack bay. Most standard beam sections can handle two pallet loads—side-by-side—that range from 680 to 1,587 kilograms each. Two 1-meter-wide pallets may require a pair of 2.3-meters-long beams, if 0.10 meters is allowed on each side and between the pallets.

Depending on the type of lift truck used, minimum aisle widths must be followed. General aisle requirements are described later in the lift truck section. You should always consult the manufacturer of the specific lift truck to be purchased or the truck already on hand to determine the proper aisle width.

When operating lift trucks, allow at least 0.010 meters between upright frame columns and the load, and at least 0.010 meters between the loads. Additionally, you should allow at least 0.010 meters of operational clearance from the top of the load to the underside of the upper rack shelf.

Several key factors determine the number of shelves that can be used for each rack bay:

- lifting height of the lift equipment
- allowable ceiling height
- weight capacity limits of the frame for each rack bay.

Appendix 3

Material Handling Equipment

Pallet Lift Truck Types

Pallets lift trucks are available in many variations and configurations. However, to describe each type and classification is beyond the scope of this document. In the following section, you will learn more about a few of the more popular and practical types of material handling equipment—often called storage and pallet retrieval systems—used in public-health warehousing today.

Table 9 lists some general categories of pallet lift trucks, based on lifting height and aisle space availability:

Table 10 lists the typical trucks bought and used, including their capabilities. These trucks were specifically selected because they have all the capabilities required for public-health warehousing; they are also practical and widely available. If you already know the requirements and constraints of your warehouse, such as your aisle width and needed height lift, table 10 can help you decide which truck is the most suitable for your operation.

As with the aisle width and lift height, every decision must also include the cost element. While buying a narrow-aisle reach truck may seem like the best option, because it has the most flexibility, remember the cost of this truck is more than twice the cost for the medium-lift height equipment; and, exponentially, more than a simple hand pallet truck. In addition, the maintenance and upkeep required is more complex and expensive.

The maneuvering space needed to operate lift trucks effectively is critical when planning and designing warehouse operations. All trucks have two turning radii: outside and inside. The outside radius is measured by the overall swing of the truck frame to

Table 9. Lifting Height & Aisle Width

Lifting Height	*Aisle Width*
Low-lifts • Pallet can be lifted 0.10 to 0.18-plus meters above the floor	***Wide-aisle trucks*** • aisles 3.5m and up
Medium-lifts • Pallet can be lifted and stored on racks up to three shelves high	***Narrow-aisle trucks*** • aisles 2.5m – 3 m
High-lifts • Pallets can be lifted and stored on racks up to and greater than five shelves high.	***Very narrow–aisle truck*** • aisles 1.5m –2.5 m.

Table 10. Trucks Types and Their Capabilities

	Pallet Jack		*Walkie Stacker*	*Counterbalance Lift Truck*			*Narrow Aisle Reach Truck*
Capabilities	*Manual*	*Electric*	*Electric Only*	*Diesel*	*CNG*	*Electric*	*Electric Only*
Outdoor Only Use				X			
Indoor Only Use	X	X	X			X	X
Outdoor & Indoor Use					X		
High Lift Capabilities				X	X	X	X
Medium Lift Capabilities			X	X	X	X	X
Low Lift Only	X	X					
Wide Aisle	X	X	X	X	X	X	X
Narrow Aisle	X	X	X				X
Very-Narrow Aisle	X	X					
Average Cost Range (in US Dollars)	*$500*	*$2,000*	*$30,000*	*$30,000*	*$25,000*	*$40,000*	*$60,000*

*Costs are a sample, based on previous purchases. They will vary, depending on country and quantity purchased.

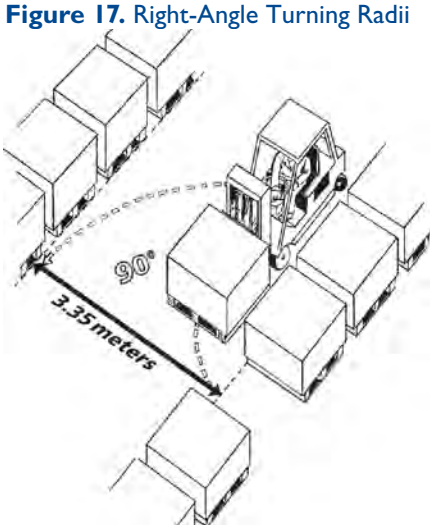
the furthest point of the rear frame. The inside radius, or the pivot point, is usually 0.08 to 0.10 meters outside the truck drive wheels (front wheels). Thus, this equipment cannot pivot within its own footprints.

To calculate the turning radii for a full right-turn angle (in metric) with a pallet using 0.15 meters for operating clearance, do the following:

1. Use manufacturer listed right-turn angle (forklift) + length of pallet + operating clearance (0.15 meters) = full right-turning radius, in meters.

2. Example: Lift truck right-angle turn (2 meters) + length of pallet (1.2 meters) + operating clearance (0.15 meters) = total (3.35 meters).

Figure 17. Right-Angle Turning Radii



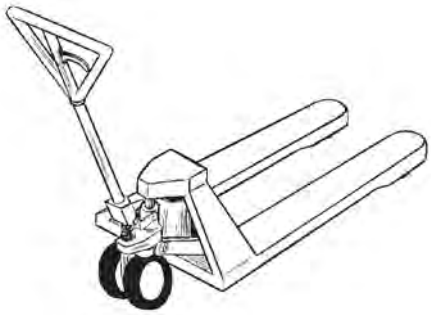
Every piece of equipment has different specifications. The equipment manufacturer should always be contacted to provide the exact dimensions of the truck you are interested in and to gather more detailed information about the turning radii. In general, managers need to plan for right-angle stacking and cross-aisle maneuvering calculations, based on truck turning radii, truck frame configuration, and unit load length and width.

Below pallet jacks, walkie stacker's, counterbalance lift trucks and narrow aisle reach trucks are described in further detail. Each has an illustration, pros and cons, as well as sample aisle width requirements for each type of equipment. At the end are links to manufacturer websites that can provide more specific detail on these pieces of equipment as well as others that have not been discussed.

Pallet Jacks

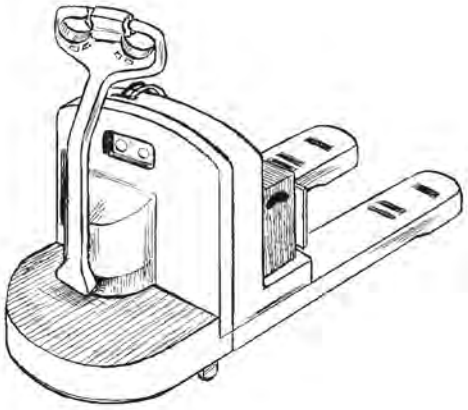
Pallet jacks are manual or use electricity (see figures 18 and 19). The manually operated low-lifts are usually called pallet jacks or hand pallet jacks. This type of low-lift is flexible; it can be a real workhorse for a facility. Both the manual and electric model low-lifts operate from the floor, are self-loading, and fit between the top and bottom boards of a double-faced pallet. The manual pallet jack is principally used whenever loads, grades, and distances are small enough that a forklift or another type of power truck–type equipment is not needed. It has a fully sealed, cast iron block hydraulic pump (self-contained). The forks (approximately 0.15 meters wide) come equipped with integral slides that offer rigidity and easy pallet entry and exit. It is user-friendly equipment that requires little training; it can be used throughout the warehouse, loading docks, or inside all kinds of trucks. It provides exceptional maneuverability and flexibility of operation, and is comparatively much lower in cost and maintenance expenses than any other pallet handling equipment.

Figure 18. Manual Low-Lift Pallet Jack



The electric-powered pallet jack, also called walkie low-lift truck, is a hybrid of pallet jacks. An on-board rechargeable battery (see figure 19) powers these trucks. The batteries provide the power for the lifting and powering and transporting motions. The speed and load capacity varies with each model. Average speed for this type of walkie is about 6 kilometer per hour (kph). Again, many different models and sizes are available. The powered walkie-type pallet jack is used in situations similar to the manual pallet jack. However, the basic difference is that the powered truck can transport heavier loads, over greater distances, and at faster speeds. The electric low-lift equipment provides great maneuverability and is able to make tight turns. Using a walkie-type, the operator can see the fork tips for pallet entry; the battery swings out for easy, quick maintenance checks.

Figure 19. Electric Low-Lift Truck



SAMPLE AISLE WIDTH REQUIREMENTS

The usual required dimensions of a right-angle turn for a low-lift hand pallet jack range from 1.5–2.1 meters and for low-lift electric pallet jack range from 2.0–2.5 meters. These types of trucks are in the very narrow–aisle width category. Again, these required dimensions will vary, depending on the type of pallet jack selected; it is essential to review all the required dimensions with the manufacturing representative or engineer during the planning and selection process.

Walkie Stackers

Walkie stackers are a walk-behind pallet truck with a mast for lifting pallets up to heights over 4.5 meters. They are used when lift heights do not exceed 4.5 meters and a larger, more expensive forklift is not needed. They are used indoors on flat concrete floors, but they can be ordered with larger wheels that can operate on more uneven floors.

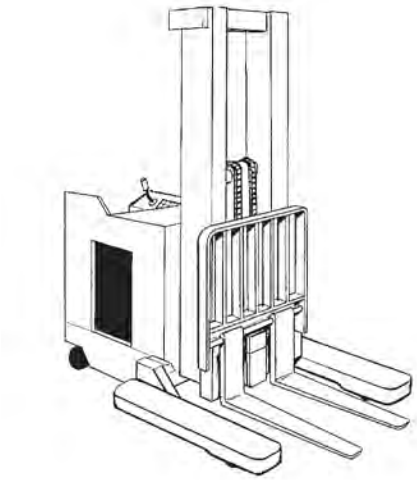
The two types of commonly used walkie stackers are the walkie straddle stacker and the walkie reach stacker, both electrically powered by batteries.

Unlike the counterbalance truck, the walkie straddle and walkie reach truck work within narrow stacking aisles. The efficiency and economy of these types of forklifts has been shown in actual field use for many years, under many different conditions.

WALKIE STRADDLE STACKER

Walkie straddle stackers use straddle legs to distribute the load weight. The legs allow the truck to straddle the pallet. These are good trucks to use for floor stacking, because the straddle legs allow closer pallet stacking (see figure 20). When they are used in conjunction with pallet racking, it is important to design the racks with enough space to allow for the wider straddle legs when loading pallets on and off the racks. Lifting heights start at 2.6 meters and go up to 4.8 meters.

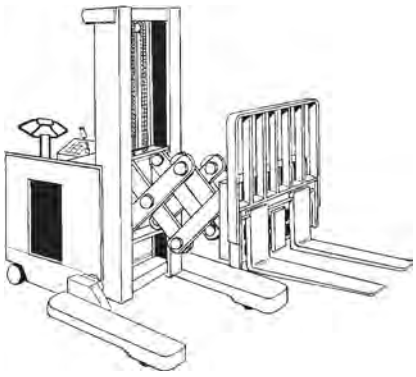
Figure 20. Walkie Straddle Stacker



Walkie Reach Stacker

Walkie reach stackers are a variation of the straddle truck. It is more maneuverable than the standard forklift trucks and can usually operate in smaller spaces. For operations that require more versatility because of different load sizes and challenges within the facility, the walkie reach stacker may be a better fit for the facility's needs. Reach trucks have a scissors-reach mechanism that moves the fork carriage forward into the load (see figure 21). Lifting heights start at 2.5 meters and can go as high as 4.54 meters.

Figure 21. Walkie Reach Stacker



SAMPLE AISLE WIDTH REQUIREMENTS

To complete a 90° turn within the aisle, with a 1.22 meter × 1.02 meter pallet, for either the standard walkie straddle stacker or walkie reach stacker, the right-angle stack dimension is 2.25 meters. If you add 0.15 meters for operating clearance, the total is aisle width requirements start at 2.5 meters. This assumes a 90° turn within the aisle with a load.

Counterbalance Lift Trucks

As the name implies, a counterbalance lift truck uses a counterbalance near the back of the truck to stabilize loads that are being transported or lifted to a storage area and retrieved. Counterbalanced lift trucks can be powered by either an internal combustion engine—gas, diesel, or liquefied petroleum gas (LP gas), or by a battery. With a capacity of 1,360-plus to 2,721-plus kilograms, counterbalance trucks work well for dock, cross-dock, and dock-to-stock applications.

Counterbalance lift trucks offer a wide range of masts and attachments to handle all types of loads (see figure 22). Today, most lift trucks accommodate ergonomic driver control and have relatively easy access for maintenance. Additionally, some trucks have a full driver cab. The counterbalance lift truck, a very flexible piece of equipment, is considered to be the backbone of the warehouse industry.

Figure 22. Counterbalance Lift Truck

SAMPLE AISLE WIDTH REQUIREMENTS

To complete a 90° turn within the aisle, with a 1.22-meter × 1.02-meter pallet, the most common counterbalanced lift truck requires approximately 3.35 meters plus .15 meters for clearance for a total of 3.5 meters.

Narrow-Aisle Reach Trucks

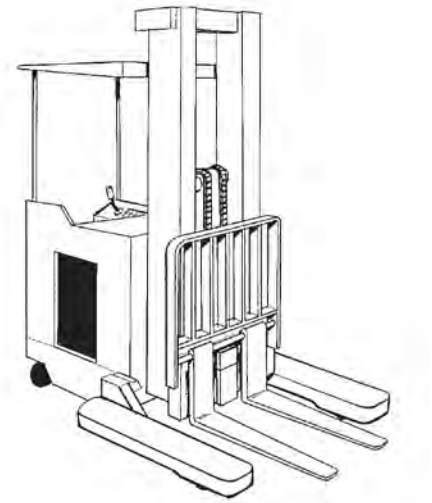
Lift truck manufactures have developed variations on lifts that can operate effectively in narrower aisles. The most commonly used narrow-aisle design is called a narrow-aisle reach truck. Narrow-aisle reach trucks are always battery operated, and many accept attachments to meet all types of special handling requirements.

Narrow-aisle reach trucks have forks that reach out beyond the stabilizing legs into the racking, which allow these trucks to lift to heights greater

than 10 meters, while still working in very tight aisles (see figure 23).

While these trucks are excellent for use indoors, reach trucks are not suitable for work outside because of their low clearance and electric power systems, which can be harmed if the truck is regularly shaken while operating on uneven surfaces.

Figure 23. Narrow-Aisle Reach Truck



SAMPLE AISLE WIDTH REQUIREMENTS

To complete a 90° turn within the aisle, with a 1.22 meter × 1.02 meter pallet, the narrow-aisle reach truck can operate in a 2.4 meter aisle plus .15 meters for clearance for a total of 2.54 meters. This is almost 1 meter less than the aisle space required for the counterbalance type.

GENERAL CONSIDERATIONS FOR ALL WALKIE STACKER'S OR REACH TRUCKS

Because the front wheels of the outrigger are much smaller than the other types of counterbalance equipment, they are not designed for crossing dock plates, or for jobs that require traveling over rough terrain: uneven cement floors, outside work with small stones on the surface, etc. For this type of equipment to function safely and productively, the surface for straddle trucks must be fairly smooth and free of debris and holes. Because of these limitations, the facility may need other types of equipment for a specific job such as—

- for loading and unloading trucks
- for outside jobs.

Rolling Warehouse Ladders

Rolling warehouse ladders provide a stable, transportable platform for maintenance, stock, and order picking; and for many other warehouse and non-warehouse functions. This equipment has features, such as adjustable floor levelers and anti-skid steps (see figure 24). Rolling warehouse ladder sizes can range from two steps to 15 steps; and 0.508 meters to 4.8006 meters in overall height. Additional key features include—

- Slip-resistant perforated tread: This surface has maximum slip resistance and comfort when sitting or kneeling on steps
- First-step actuated locking system: This feature locks the ladder in place when a person steps on the first step. The step-lock feature is standard on most models.
- Heavy 1 1/16 -inch diameter tubular construction: In harsh environments, the tubular construction provides superior strength, as well as being both durable and long lasting.
- Durable powder coated paint finish: This type of finish is baked on in colors, such as industrial gray or safety yellow. It provides a premium quality scratch-resistant finish that is both durable and long lasting.

In addition, warehouse ladders are available in steel or aluminum. They are also available in various degrees (48°–56°) of stairway slope for easy forward ascent or descent, commonly known as stairway slope warehouse ladders. One reason to use these ladders is that the ladder has the feel of a stairway, so the workers are comfortable and feel safe climbing up and down the ladder steps.

Figure 24. Warehouse Rolling Ladder

Some facilities can implement an effective rack or bin system by using only a rolling warehouse ladder. If the size of the facility, or the expense of certain material handling equipment, is a constraint and the warehouse cannot accommodate any type of pallet lift equipment for storage and retrieval activities, warehouse rolling ladders (see figure 24) may be adequate for actual storage and retrieval of small items. The rolling ladders can also be used for other essential warehouse requirements; managers may need to keep rolling ladders in the warehouse to supplement their day-to-day necessities. They are also useful as a backup if other material handling equipment is unavailable.

For additional information about to the equipment listed in this appendix, access the following web sites: http://www.yale.com/ (Yale Materials Handling Cooperation) or http://www.hyster.com/ (Hyster Forklifts), both with locations in several countries), and http://www.mit-lift.com/ (Mitsubishi Fork Lift Trucks).

Appendix 4

Warehouse Performance Metrics

The four categories of performance measurement include—

- quality
- response time
- cost
- productivity.

In each category, we defined the metrics, gave a formula, and described the purpose and issues related to the metric, as well as the sources to obtain data for the metric and requirements for the data.

To help relate the 13 metrics back to the Warehouse Self-Assessment, they have been organized to match the categories reviewed in the Self-Assessment. If there is a certain category from the assessment that scores low, the metrics listed here can be used to show how any interventions in this area have produced improvements on performance.

A. Infrastructure

a. Total Warehousing Cost

B. Layout & Operations Capacity

a. Warehouse Order Processing

b. Put-away Time

c. Put-away Accuracy

d. Picking Accuracy Rate

e. % of Storage Space Dedicated for Handling

C. Warehouse Equipme nt & Storage

a. Storage Space Utilization

b. Value of Product Damaged in the Warehouse

D. Special Storage

E. Inventory Management

a. Inventory Accuracy

F. Security & Safety

a. Warehouse Accident Rate

b. Defined Security Measures

G. Human Resources

a. Units Moved Per Person Per Hour

Warehousing/Storage

A. Inventory Accuracy Rate

This indicator measures the percentage of warehouse or storage locations that had no inventory discrepancies when stock cards were compared to a physical inventory count out of the total number of locations under review, during a defined period of time. Alternatively, this indicator can be calculated for a single facility as the percentage of months or quarters with no inventory discrepancies out of the total number of months or quarters in the review period (e.g., annual).

$$\frac{\text{number of storage locations with no inventory discrepancies}}{\text{total number of storage locations under review}} * 100$$

$$\frac{\text{number of months/quarters with no inventory discrepancies}}{\text{total number of months/quarters in review period}} * 100$$

The inventory accuracy rate can be used to assess overall inventory control performance for a group of storage facilities or for one storage facility over a set of review periods. Inventory accuracy is critical for managers to know how much they have in stock at any given point in time and to know when a new order must be placed to replenish stock. This discrepancy analysis can help managers identify storage locations that are having problems with inventory management; the analysis can lead to opportunities for improvement.

• Stock cards and inventory reports from information systems, etc. • Physical inventory report • Storage location listing.	• Inventory discrepancy calculations for each storage facility included in review • Total number of storage locations under review • Total number of months/quarters in review period.

B. Put-Away Accuracy

This indicator is the percentage of items placed in the correct location or bin in a warehouse or storage area.

$$\frac{\text{number of items in correct location}}{\text{total number of items}} * 100$$

This indicator measures a facility's ability to stock items in the correct location so they can be quickly and easily located. This can provide an indication of whether staff is practicing good warehousing practices and guidelines.

This indicator can be measured during a site visit or by making periodic checks at the facility over a specified length of time.

For example, during a quarterly period, the number of times items were found in the wrong location.

• Site visits for visual inspection of location of items • Map or guidelines of intended storage locations for products.	• Number of items in their correct location in the storage area • Total number of items in storage area under review.

$$\frac{\text{number of items in correct location and also in the correct quantities}}{\text{total number of items}} * 100$$

C. Picking Accuracy Rate

This indicator is defined as the percentage of items or lines picked accurately (i.e., the correct items and quantities) from storage based on a request or packing list, and then placed into the appropriate container.

$$\frac{\text{number of items of lines picked without errors with correct items and quantities}}{\text{total number of items or lines picked}} * 100$$

This indicator measures whether items are accurately selected from storage and placed into a container to be shipped to the requesting facility. It can reveal the ability of the facility to pick requests correctly in terms of quantity and item. Errors can result in stockouts or overstocks at the ordering facility. To collect data for this indicator, a review of items just before they are loaded for transporting can be conducted to determine the accuracy of picked items compared against an invoice or requisition form. It can be calculated for a single order or for all orders during a defined period of time.

• Order requests • Packing list • Physical count.	• Quantities ordered • Quantities picked.

D. Warehouse Accident Rate

This indicator measures the total number of accidents occurring in a warehouse or other storage facility during a defined period of time.

number of accidents occurring at the storage location per hour/day/week/month/quarter

This indicator can reveal poor warehouse management and practices, untrained staff, unclear safety guidelines, faulty

equipment, or poor conditions. It can help pinpoint areas needing improvement by determining the cause of the accidents—because of human error or other reasons. With intervention, accidents should decrease in frequency.

Data Sources	Data Requirements
• Interviews with warehouse staff • Incident reports • Visit of warehouses.	• All accident reports over a specified period of time.

Related Indicators

- Average number of accidents per hour/day/week/month/quarter

E. Defined Security Measures

Definition

This indicator measures whether there are guidelines or standard operating procedures (SOP) in place that provide instructions to prevent theft or leakage at a given storage location.

Formula

Are warehouse guidelines or standards in place that define the security measures? (yes/no)

Purpose and Issues

Implementing proper security measures at storage facilities will help prevent theft and leakage of products, thus saving money and increasing the availability of commodities. The program should have defined and detailed instructions for facilities to follow to ensure that the facility is secure and the products protected. Evaluators should also assess the quality or thoroughness of these guidelines or SOPs and the level of adherence by the facilities.

Data Sources	Data Requirements
• Security measures • Interviews with staff.	• Warehouse or storage location SOPs and/or security guidelines.

RESPONSE TIME

A. Warehouse Order Processing Time

Definition

This indicator measures the average amount of time (e.g., minutes, hours, days, weeks) from the moment an order is received at the storage facility until the time the order is actually shipped to the client. The order processing time can be calculated for a specific shipping facility averaged across orders or on average for orders to a specific client or for a specific product.

Formula

$$\frac{\sum (\text{date \& time order is shipped} - \text{date \& time shipping order was received})}{\text{total number of orders processed}}$$

Purpose and Issues
This indicator helps monitor the order processing performance and the efficiency of a shipping facility. It also helps identify opportunities for improving staff performance in order management and a facility's response time.

Data Sources	Data Requirements
• Order requests • Shipping log reports.	• Date and time shipping order was received • Date and time order is shipped • Total number of orders processed.

B. Customs Clearance Cycle

Definition
This indicator measures the amount of time (e.g., minutes, hours, days, weeks) from the moment the cargo arrives in the port or airport until the moment that it clears customs, arrives at the warehouse, and is ready to be put away. This indicator can be calculated by product or supplier, or the average across products or suppliers, during a specified period of time. If other factors affect getting the product from the port to the warehouse, such as a lack of equipment at the port facility, evaluators can scale this calculation down to the specific amount of time that the products were sent to the customs office until the customs office cleared and released them.

Formula
Warehouse arrival date & time – port/airport arrival date and time

Purpose and Issues
The indicator can help identify delays in customs clearance and, with additional research, the causes involved—such as incomplete paperwork, poor material description, missed certificate of origin, etc. Based on that, opportunities for improvement can be identified and actions taken to minimize the amount of time required for products to clear customs and to be made available at the warehouse.

Data Sources	Data Requirements
• Packing lists, invoices, entry notice • Receiving report • Customs reports.	• Cargo arrival date at the port/airport • Cargo arrival date at the warehouse.

Related Indicators
• Average customs clearance time per month/quarter/year • Average customs clearance time for a specific product per month/quarter/year

C. Put-Away Time

Definition
This indicator measures the amount of time it takes from when a product(s) has been unloaded from a truck after arriving at a warehouse or other storage location to when it is stored in its designated place and is ready for picking. This indicator can be calculated by product, or by shipment, or as an average across products or shipments, during a specified period of time.

Formula
Date and time product(s) unloaded – date and time product(s) stored in designated spot

Purpose and Issues

Measuring the put-away time can help improve productivity by monitoring the efficiency of the put-away processes and the staff responsible for the task. It can help managers identify work conditions or processes that need improvement, as well as the need for staff training.

Data Sources	Data Requirements
• Shipment receipt vouchers • Time sheet for put-away activity per employee • Number of employees.	• Put-away time in hours • Quantity of pallets or volume in cubic meters.

Related Indicators

- Average put-away time for all products per month/quarter/year
- Average put-away time for a specific product or shipment per month/quarter/year

COST/FINANCIAL

A. Total Warehousing Cost

Definition

The total warehousing costs collect all costs related to warehousing, such as labor costs and warehouse rent; or mortgage payments, utility bills, equipment, material- and information-handling systems, etc. It also includes costs related to systems, supplies, and any other material with specific use in warehousing. This indicator is usually measured annually.

This indicator can also be calculated as the total warehousing cost per piece/SKU/product/line by dividing the total warehousing cost by the quantity of stocked units or by the volume of stocked items in cubic meters (m^3), per storage area (m^2), or program.

Formula

Total warehousing cost = sum (labor, space, utilities, material, equipment, information systems, etc.)

$$\frac{\text{total warehousing cost}}{\text{quantities of stocked units or } m^3 \text{ or } m^2}$$

Purpose and Issues

Using this indicator, managers can monitor the costs of different components in a warehouse, as well as compare costs between different warehouses. It can help identify the most cost-effective warehouses, and can also lead to an analysis of best practices.

Dividing total warehousing costs by units or area can also indicate storage usage, cost-effectiveness, etc. By dividing the warehousing costs per SKU, this indicator provides the management team with excellent detailed cost visibility.

Data Sources	Data Requirements
• Yearly accounting sheets • Payroll.	• Labor cost • Warehousing space cost (per m^2) • Cost of warehousing material • Equipment costs • Total inventory on hand in units (or volume m^3).

Related Indicators

- Average inventory cost per storage point

B. Value of Product Damaged in the Warehouse

Definition

This indicator calculates the value of products damaged, during a defined period of time (usually one year), in the warehouse as a percentage of the value of all shipped products during that period.

Formula

$$\frac{\text{total value of damaged products}}{\text{value of shipped products}} * 100$$

Purpose and Issues

Inappropriate warehousing conditions or handling of products can lead to inventory damage. This indicator can help put the value of products damaged into perspective and can be used to help identify the causes, as well as, the actions needed to avoid such damages, including better infrastructure, manpower, training, etc.

Data Sources	Data Requirements
• Invoices from vendors • Inventory reports, issue vouchers • Stock records • Accident reports • Damage reports.	• Value of damaged products • Value of shipped products.

PRODUCTIVITY

A. Storage Space Utilization

Definition

Storage space utilization indicates the percentage of the total storage space actually being used out of the total storage space available.

Formula

$$\frac{\text{total storage space in use } (m^3)}{\text{total storage space available } (m^3)} * 100$$

Purpose and Issues

Based on this indicator, managers can monitor storage capacity and utilization at a warehouse. By assessing storage space utilization, managers can look for opportunities to improve storage capacity (e.g., remove expired products, dejunking, reorganizing) and maximize the use of the storage space, or request a re-evaluation of layout, material flow, shelves disposition, etc.

Data Sources	Data Requirements
• Inventory reports • Warehouse floor plan • Site visit.	• Total in use storage area: volume of inventory in stock (m^3) • Total storage space capacity (m^3).

B. Units Moved Per Person-Hour

Definition

This indicator measures the number of units (e.g., boxes, pallets) or weight moved during a defined period of time, per person-hour, for each person working during that period. It can be considered both when receiving and shipping inventory.

Formula

$$\frac{\text{total number of units moved (or weight)}}{\text{total number of person-hours}}$$

Purpose and Issues

This indicator helps measure material handling productivity for a period of time (hours, days, or months). It helps compare productivity levels in different working shifts or different warehousing locations. It can be a source for identifying needs for training and measuring its effectiveness.

Data Sources	Data Requirements
• Receiving reports, invoices, packing lists • Time sheets, punch cards.	• Number of units moved (receiving or shipping) during a specified time period, per person • Total persons and hours spent moving material during a specified time period.

C. Percentage of Storage Space Dedicated to Product Handling

Definition

This indicator measures the percentage of total storage area that is dedicated specifically to product handling (receiving, unloading, packing, loading, and dispatching).

Formula

$$\frac{\text{storage area dedicated to product handling } (m^2)}{\text{total storage area } (m^2)} * 100$$

Purpose and Issues

It is recommended that a certain percentage of the storage area be dedicated specifically to product handling for an average volume of products. The amount of handing space needed depends on the volume of product moved through the storage area and the equipment required to move those products. This dedicated area is critical for the efficient operations of the storage facility to allow for organized and efficient receiving, unloading, packing, loading, and dispatching of products; and to protect products from the elements during receiving and packing.

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