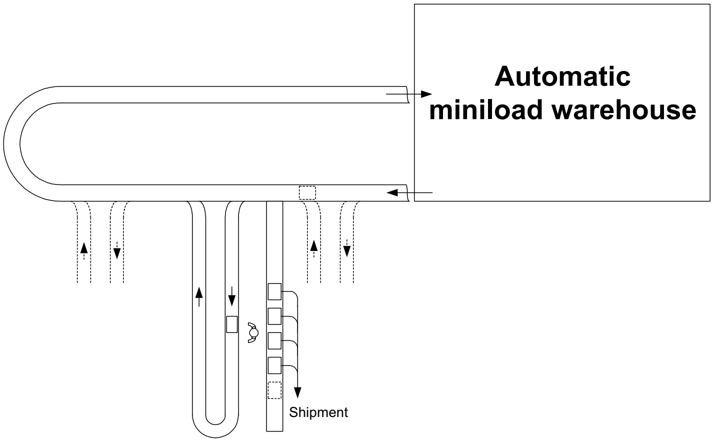


**Figure 2.9.** Inverse order-picking

While the upstream storage and order-picking area is generally marked by a continuous performance the loading into transport means often takes place within a relatively small time slot, e.g., because of the downstream consolidation of loads in hubs. This leads to receipt and issue peaks which have to be *buffered* in the shipping zones. For this purpose, the shipping units have to be consolidated prior to the loading and provided for loading. When palletized or other larger units are shipped the loads usually are provided in floor storage zones in front of the shipping gate. In addition to this, highly dynamical storage technologies are used to ship smaller units and single items (cf. e.g., section 4.1.3). In practice, the limited space at the shipping gates leads to bottlenecks so that the organization of the shipping zone has to be optimized continuously.

Finally, the transport/shipping documents (freight data, tour-related loading bills) have to be prepared for the shipment of goods. The supply chain can be made transparent by scanning the loaded units. Thus, the finished order is acknowledged and a feedback is given to the order management.

## 2.3 Warehouse management system

### 2.3.1 Warehouse management

The management of a warehouse is the main function of a warehouse management system. On the one hand, these systems keep record of the storage capacity, i.e., the specification of the existing storage bins (location management). On the other hand, of the stored units (inventory management). In addition to this, it should also include several control functions to optimize the storage activities.

**Table 2.10.** Definition of warehouse types

| Description | Parameters |
|---|---|
| Storage bin | Bins, shelves, channels, ... |
| Access to single locations | Random, stack, LIFO, FIFO ... |
| Execution | Automatically – manually |
| Storage operation | Definition of suitable storage facilities (loading capacity, range, rights) |

**Warehouse type management** While the staff in a manually operated warehouse system is able to independently choose the right conveyor and storage facility owing to their knowledge and experience, in an automatic warehouse management system single elements have to be assigned according to their compatibility. Furthermore, the manual operator fulfills certain tasks intuitively while an automatic system is not able to derive the sequence of work steps, like the loading or unloading of the storage channel according to the FIFO principle, from the instructions. Some warehouse functions call for the independent generation of orders, e.g., to define restorage or to optimize the gripping time, and thus for the knowledge of the right storage and retrieval operations.

The basis for such optimizations, thus are the stringent classification of the storage and conveyor technology from the *informational* point of view. For this purpose the warehouse types listed in Table 2.10 should be defined.

**Management of storage bins** At first, the management of storage bins represents the technical warehouse structure, i.e., the specification of the storage bin based on the storage technique (e.g., shelf racks) including the description of the dimensions, loading capacity and position (e.g., shelf coordinates). Some strategies for the assignment of storage bins (cf. section 2.2.2) require such a precise description of storage locations. More flexible storage methods (e.g., floor storage areas) may only need the specification of the areas and coordinates.

The management of storage bins also includes the management of units stored at a certain location. This includes the entry of goods-specific data such as article specifications (article number or number of the unit load) as well as the registration and update of the quantities stored in each location.

Status data are required for the control of storages and retrievals. When the storage bin is registered at the identification point, on the one hand, its availability has to be sure, and on the other hand, it is has to be ensured that this location is not assigned twice. For this purpose, different states are assigned with regard to the storage bin which is then *blocked* or *reserved* for

**Table 2.11.** Status information for the control of storage and retrievals (excerpt)

| Description | As to location | As to unit load |
|---|---|---|
| Available | The storage bin is accessible. | The article is accessible at random. |
| Reserved | The storage bin is reserved for storage of a certain unit load | The article is reserved for an order which will be executed later. It is ideally reserved with a reference to the order. |
| Blocked | The storage bin is blocked for future storages (e.g., because of maintenance work). | For some reason (expiry date exceeded, article in quarantine) the article cannot be accessed or is blocked for certain operations (e.g., restorage). |

certain articles or orders. In case of a retrieval, it has to be known if a certain unit is available. To make sure that the chosen unit is assigned to the current order the article status has to be linked to the order. The most important states of storage bins and unit loads are listed in Table 2.11.

In addition to the storage and retrieval the *blocking of stocks* or the *setting of blocking indicators* are an elementary management function used for various operations. These are above all

- Blocking for storage and retrieval and
- Blocking for certain warehouse operations (e.g., avoid restorage of fragile goods).

The list of all occupied locations, i.e., the representation of the current warehouse status, is called *bin status report*. The bin status report may also include the type and quantity of articles stored in each bin.

**Quantity management (Inventory management)** Quantity and inventory management are another logical aspect which focusses on the registration and update of the quantities of each stored article, some times under consideration of the relevant states (cf. Table 2.12). The management of goods according to different criteria (min./max. stocks) should ensure the supply and avoid excess quantities. When fixed limits are exceeded or not achieved messages or actions (orders, restorage, etc.) have to be generated.

This function, however, requires a careful control of the stored goods including the allowed storage time and blocking of the article when a certain (expiration) date has been reached. Under certain conditions the respective goods have to be taken out of store to protect other goods.

The main difference to an *enterprise resource planning system* (ERP), which has similar functions, is the warehouse management, while an ERP

**Table 2.12.** Inventory categories

| Description | Meaning |
|---|---|
| Physical stocks | Units available in the storage system |
| Available stocks | Stocks under consideration of blocked or reserved quantities = inventory of available units |
| Reserved stocks | Inventory marked with a blocking indicator |
| Shortages | Open (outstanding) incoming deliveries for whichan order has already been submitted. |

system mainly focusses on customers and sales. For this reason, a warehouse management system generally does not contain customer data or prices. Nevertheless, a functioning overall system needs the continuous exchange between WMS and ERP.

**System control** The control of the warehouse condition (temperature and humidity) and security (access control) is a special function which is of vital importance only in a few cases.

**Groupings**

In a warehouse some regularly occurring tasks refer to a group of unit loads, articles, shelves, etc. Therefore, a warehouse management system allows for flexible groupings in order to avoid the labour-extensive handling of single elements. Such tasks occur, for example, during:

– the maintenance, repair or failure of single aisles in an automatic shelf system,
– the goods control (e.g., special measurements for hazardous or high-quality goods),
– the storage or blocked goods (e.g., quarantine storage),
– the choice of larger quantities or
– stocktaking.

Ideally, such groupings should be highly flexible, but in any case it should be possible to group

– storage locations (according to aisle, zone, etc.)
– article groups (according to type, article number, etc.)
– batches

As a consequence, it should also be possible to apply the management functions (blocking, reservation, storage/retrieval) to the complete group.

### 2.3.2 Reorganization

An active warehouse and distribution system should be checked regularly with regard to its efficiency and suitable steps should be taken for its optimization. This is called *warehouse reorganization.* This action can be initiated by:

– changed retrievals of certain articles, e.g., lower throughput or change of of the typical pick-up unit
– beginning or terminated campaigns
– changed product range
– growing number of partial storage units

As a result, storage areas are occupied faultily (e.g., wrong zone), the average transport routes increase and the utilization of space is reduced. For this reason, the corresponding parameter should be analyzed and controlled continuously. The suitable system control method is described in section 2.3.4.

The resulting optimization of the system is achieved by some measures which logically should be supported by the warehouse management system:

– rebooking, i.e., reassignment of articles to suitable retrieval categories and storage zones
– restorage of already existing units in times with low retrieval rates (e.g., to reestablish an ABC zoning)
– densification of partial units or badly utilized mixed pallets (retrieval of relevant units, repackaging of units and restorage according to specifications)

### 2.3.3 Conveyor management and control systems

While automatic conveyors are controlled and supervised by a corresponding control (material flow controller, MFC), manual unsteady conveyors (stackers, etc.) are controlled by different systems from the manual management to the fully automatic system control.

Computer-aided control systems for the in-house transport are used in warehouse management for different reasons:

– To optimize the system performance (reduction of empty trips, larger handling volumes, higher system load)
– Flexibility of the system in case of short-term changes (quick reaction to transport requirements)
– Control of the system status (runtime of vehicles, operational costs per vehicle, etc.)

Systems for the deployment and control of vehicles are called *stacker control systems* or *transport control systems* [90]. These systems consist of a computer-aided control station or master computer, a wireless transfer medium (radio or infrared) and mobile terminals on the vehicles. Incoming transport orders or requests are handled, completed by relevant data (e.g., completion of article number or description, storage location (source), destination (sink)) and transmitted to the driver by certain procedures and strategies.

In all control systems first of all it has to be decided which conveyor has to be assigned to a certain kind of order because of its loading capacity, lifting height or other specifications. For this purpose, a classification of the existing conveyors has to be available in addition to the management of warehouse types (cf. section 2.10). Furthermore, the restrictions of other facilities like transfer points have to be recorded. There are two principle methods for the vehicle deployment:

**Dispatching** In dispatching a suitable vehicle is assigned to the current order according to different criteria and strategies. This may be, for example,
- the next free conveyor
- the nearest conveyor
- the conveyor with the shortest connection trip

Since the dispatching handles the currently incoming order the system reacts quickly and flexibly and the system can, thus, be used in dynamical environments.

**Scheduling** In scheduling, on the other hand, several orders and/or conveyors are assigned to an "ideal" schedule. This method thus aims at an optimal order sequence and system performance. The main condition for a scheduling is the collection of queued orders in an order pool from where they can be assigned optimally. In contrast to a manual scheduling, which can seldom be used in a warehouse, the scheduling is repeated in relatively short intervals.

In practice, mostly a mixed form of both methods is used where the most important requirements can be considered at any time. In addition to these extensive dispatching control systems there are simple conveyor management systems which focus on the recording of the system status and where no orders are assigned. This includes the recording of operating times or repair costs per vehicle, the supervision of the battery status and control of maintenance intervals for each vehicle. In systems where the vehicles are used by a large number of people it may be reasonable to also record and document the driver identification.

### 2.3.4 Data collection, processing and visualization

As already described in section 2.4 a warehouse and distribution system includes a variety of different data and key values for different purposes:

- Activity recording
  - Customer service
  - Documentation of shortages from stocktaking
  - Recording of picking errors, deviations at dispatch control
  - Efficiency of the staff (e.g., picks or orders per picker; storages per stacker driver; waiting times per vehicle)
- Overview
  - Bin status report (sorting according to storage bin, free/occupied, ...)
  - Stocks
  - Warehouse statistics (transshipping frequency, error times, filling level, ...)
  - Utilization of space
- Operating means statistics
  - Runtimes
  - Idle times
  - Maintenance and repair costs per unit
- and much more.

While the personal activity recording is not without legal problems and generally requires the admission of the works council it sometimes is the indispensable basis for the activity-based accounting especially with regard to

- the recording of piece rates
- the recording of contracted logistic services

The recording of significant status information is the elementary prerequisite for the control and optimization of the distribution system. Based on these data manpower requirements (e.g. in order-picking) or other resource requirements have to be determined and scheduled in the system control. The loading levels of conveyors show if parallel arranged systems are balanced. Waiting times at certain points may indicate bottlenecks and initiate a check of the operating strategies, system performances or personnel deployment.

The recording method is decisive for the use and successful evaluation of the data. There are two principle methods to record significant data and key values:

**Online recording** The database which is necessary to generate the required data is recorded in the process and automatically converted into the desired key value. Thus, the key values are directly available. The recording and evaluation focusses on the predefined problems. Other or similar data and key values cannot always be evaluated afterwards. The recording time is almost fixed and cannot be reset, for example to block out certain events or periods, because the results just are aggregated key values. Thus, this method represents a statical system.

**Time series recording** At first, only a *log file* is made out containing the events and the time of occurrence (time series). Here, it has to be ensured that the input data are determined purposefully. The required key values are then extracted from the database via a corresponding request. This method clearly offers much more possibilities and a better basis for the system planning and optimization. However, the data volume may increase continuously. It is advisable to book the following data:

- Documentation of requested and completed orders
  - Requests:
    - Request ID/demand ID
    - Source/sink
    - Date/time
    - Status (express-normal)
  - Fulfillment:
    - Person or operating means ID
    - Date/time
    - Termination
- Operating protocol
  - Start/end of operation
  - Error message and times
  - Warehouse movements
- Single information
  - article-related data (article no. stocks,...)
  - order-related data (order no., order item, dates...)
  - unit data (storage bin no., free/occupied, quantity ...)

In addition to this, delivery notes and goods issue protocols have to be recorded and documented for legal reasons.

### 2.3.5 Stocktaking

In most countries stocktaking is a legal obligation which has to be carried out by each businessman for each business year. For fixed assets and supplies, i.e., stocks, a *physical stocktaking* has to be made. This has the aim to check the inventories (booked stocks) and the reliability of the inventory management (warehouse accounting). All objects (storage units) have to be identified and classified by counting or measuring. The data have to be recorded in a protocol showing the following information:

- Voucher no. (check of completeness)
- Storage location and position
- Description of the object
- Recorded quantity and quantity unit
- Unit price and total value
- Optionally information about value-related influences (age, storage time)

– Date of recording and signature (or recording person)

This procedure is immensely labour-intensive and nearly impossible in very large warehouses. Furthermore, certain automatic warehouse techniques do not allow for direct personal checks and for the retrieval of all units for process-related or economical reasons. For this reason, different stocktaking methods have been developed which have to be cleared, however, with the respective auditors and financial authorities.

**Annual stocktaking** The classical form of stocktaking requires the physical check of all stocks at the accounting date. Since there is no business at this day there are no changes of the "assets". Such a method is only suitable for smaller systems. It is not necessary to finish the stocktaking within one day but as close to the accounting day as possible, i.e., 10 days prior or after the date, as far as inventory changes are recorded and considered in the stocktaking.
In a *forward or subsequent stocktaking* stocks can be taken at one day, three months prior to or two months after the accounting day and recalculated by a *special stock* . This requires the use of an updating or backward projection according to the *Generally Accepted Accounting Principles GAAP*.

**Permanent stocktaking** The permanent stocktaking is a suitable method in times of little business or low stocks. Stocks can be physically taken throughout the year if all inventories are booked continuously and all receipts and issues are booked separately mentioning the day, type and quantity. At the accounting day a (quantitative) inventory update is made — a so-called book inventory.
The counting may be related to the articles or the storage bins. For this purpose, all movements of the respective article or storage bin must be stopped. For an article-related stocktaking all free storage bins have to be checked separately. For this method the EDP-aided warehouse management system has to be able to assign article or bin-related counters.
Since in automatic warehouses the stocktaking cannot be performed at the storage bin for technical reasons the most suitable methods are the warehouse stocktaking and the zero-crossing stocktaking. During a warehouse stocktaking the items are counted at another location (usually at the identification point prior to the storage) where they are marked with the counter. In a zero-crossing stocktaking all storage bins are recorded at a zero-crossing (the stocks in the bins are completely removed). Differences are entered directly and the counter is updated[5].

**Inventory sampling** If an EDP-based warehouse management system is used and the Generally Accepted Accounting Principles are met an in-

[5] If shortages are recognized the warehouse management system has to initiate a replenishment independent of the requirement (inventory) or has to consider other retrieval points to fulfill the customer order correctly.

ventory sampling may also be used which requires considerably less expenditure. Samples are taken physically which are evaluated by means of proven mathematical statistical procedures, i.e., above all:

*Sequential test* The number of samples is unknown at the beginning and results from the repeated check of the test criterion. The test is repeated until the acceptance criterion is fulfilled (fall short of minimum error rate) or rejected (exceeding maximum error rate). To limit the testing period a stop criterion may be defined.

*Estimation* The basic total is estimated based on the frequency ratio of a sample. In case of *layered* estimations the basic total is splitted from which a sample each has to be taken. *Bound* estimations also use an auxiliary parameter, e.g., the booked inventory value, for the projection.

As already mentioned above, the chosen method has to be accepted by the auditor or financial authorities. The following parameters influence the suitability of a method:

- Use or existence of an EDP-aided inventory management system
- Accessibility of the shelves (freely accessible warehouse or closed area of an automatic warehouse)
- Value of the goods (The more valuable the goods the more exact the stocktaking. Sampling is unsuitable for "high-value goods")

Warehouse management systems should have at least the following stocktaking functions:

- Counting date for storage units and shelves
- Blocking of article groups or shelf areas for stocktaking purposes
- Permanent updating of counters considering the recording person, date and time
- Zero-crossing stocktaking

The rigid stocktaking requirements do not come up to the possibilities of modern warehouse management systems. A continuous counter booking and zero-crossing comparison allows for an extremely detailed stocktaking. And it should not be ignored that errors during the stocktaking process can hardly be avoided.

On the other hand, an exact inventory management offering safe data is of vital importance for the readiness to operate. The combination of a regular data update and a correct data management set the basis for a high readiness to deliver and short response times. Furthermore, negligence or thefts are detected only by a reliable stocktaking.

## 2.4 Basic data and key performance indicators of warehouse systems

The planning and design of warehouse and distribution systems is highly complex so that it is nearly impossible to describe all relevant system-related parameters. The major part of such key values has to be defined for a given problem. In the following the most elementary key values which are used in quite a number of systems are described. They are classified into *basic data* and *key values*

*Basic data* are also called absolute numbers and directly result from measurements, counts, summations or differences of certain units or they are recorded as master data. At the same time, they also represent the requirements and basic information to be provided by a system.

*Key values* should provide significant and densified information to evaluate and compare the efficiency of processes and systems. Here, absolute as well as relative numbers, i.e., proportionate values or data are used.

### 2.4.1 Basic data

**Master data**

Master data are statical data which are not changed over a longer period of time. The master data contain all important information about the basic characteristics of an article, loading aid, etc. The most important master data in a warehouse are the article master data because all main warehouse functions and control mechanisms are based thereon.

The article master contains a description of all articles independent of their current stock. The total number of articles represents the assortment although discontinued or *dead* articles result in differences to the actual stock. Table 2.13 gives an example of the most important elements of the article master data.

**Inventory data**

This data group informs about the quantities of articles stored or provided over a longer period of time. The up-to-dateness and accuracy of this kind of data collection is of special importance to ensure the readiness to deliver and to dimension the warehouse system. Since these data change continuously they are also called dynamical data.

**Movement data**

The second group of dynamical data are the movement data which represent all main physical warehouse processes. These are basic processes like goods receipt and issue and warehouse operations as well as order-picking processes and order execution.

**Table 2.13.** Elementary basic data

| Article master data | Inventory data | Movement data | Other System data |
|---|---|---|---|
| – Article number<br>– Description<br>– Article weight<br>– Article length<br>– Article width<br>– Article height<br>– Quantity unit<br>– Type unit load<br>– Loading factor (packaging quantity/unit load)<br>– Gripping unit (packaging quantity/retrieval unit)<br>– Blocking indicator<br>– ABC-classification<br>– Batch number<br>– Weight/retrieval unit<br>– Weight/unit load<br>– Client<br>– Best before date<br>– Remaining runtime<br>– Sorter capability | – No. articles<br>– Total stock<br>– Average stock<br>– Minimum stock/art.<br>– No.UL/art.<br>– Available stock<br>– Shortages | – Goods receipts/ day<br>– Goods issues/ day<br>– Storages/d<br>– Retrievals/d<br>– Quantity tranship./a<br>– Restorages/d<br>– Orders/d<br>– Orders per article<br>– Positions/order<br>– Positions/d<br>– Grips/ Pos.<br>– Incoming orders/h<br>– Order lead time<br>– Material lead time<br>– No. of orders/ order type<br>– Double cycles/d<br>– Complete units/d | – Order types<br>– Unit load master data<br>– Packaging master data<br>– Storage capacity<br>– Space restrictions<br>– Room restrictions<br>– Utilization space/volume<br>– No. UL/art.<br>– No. staff/dept.<br>– Sick days<br>– Operating costs (manpower, energy, maintenance)<br>– Investment costs (replacement)<br>– Value turnover/a<br>– Productivity |

**Other system data**

Other elementary system data are among others

– Structural space and room data
– Structural manpower data,
– Cost data
– Unit load and packaging master data, etc.

### 2.4.2 Logistic key performance indicators

As already described in the preceding section a variety of different information arise in warehouse and distribution systems in the form of data. Because of this abundance it is difficult to evaluate and optimize the system. Furthermore, some data may be misleading when taken out of their context. The *No.*

*orders/d*, for example, reveal very little when it is not seen in combination with *No. items/order*.

In a narrower sense key performance indicators are densified parameters, i.e., values calculated from data and other key performance indicators. On the other hand, all kinds of parameters with the following characteristics are summarized as key performance indicators:

> Logistic key performance indicators are numbers by which the quantitative aspects of logistics can be described in a concentrated form [66].

Accordingly, basic data also are key performance indicators. The specialization of logistic key performance indicators takes into consideration that key performance indicators are used in all areas of technology, economics, etc. Key performance indicators are used to give a quick overview over optimal costs and performances [66] and to evaluate the different variants.

Above all *efficiency/productivity values* (output/input) and *intensity values* (input/output) are built to derive relative key performance indicators. The generation of specific key performance indicators depends on whether the problem is of an operative or a strategic nature. Operative key performance indicators are first of all used to control efficient logistic processes while strategic key performance indicators are used to develop and design efficient goods flows [28]. Key performance indicators are often based on averaged and approximated values and provide no precise information but just a quick overview. Typical key performance indicators are shown in Table 2.14.

The key performance indicators "quantity turnover" and "inventory coverage" show that single key performance indicators may be defined differently what leads to considerable evaluation discrepancies. Therefore, it should be checked carefully if a key performance indicator relates to the value, quantity or performance.

Since single key performance indicators can represent only partial aspects and the variety of possible key performance indicators and their combinations make it difficult to use them targeted and systematically they are combined in *key performance indicator systems* [66]. Thus, the auxiliary key performance indicators which contain the necessary information for a management task are combined in a hierarchical structure of systematically linked single key performance indicators. According to Reichmann, the top key performance indicators of such a system are the transshipment frequency, the overall logistic costs and the readiness to deliver. The main problem, however, is to develop such a system for a special application.

While single key performance indicators can easily be used to analyze deviations and to reach certain goals in warehouse management extensive key performance indicator systems are a main tool of logistic controlling and will not be described here any further.

**Table 2.14.** Examples of logistic key performance indicators

| Key performance indicator | Definition | Objectives/ problems | Influencial variables |
|---|---|---|---|
| Readiness to deliver | $\frac{\text{no. of requests delivered in due time [pc]}}{\text{no. of requests [pc]}}$ | Delivery service, customer satisfaction | Order handling, throughput, capacity |
| Warehouse fill degree | $\frac{\text{number of occupied locations [pc]}}{\text{storage capacity [pc]}}$ | Utilization of storage capacity | Inventory management |
| Transshipment level quantitative | $\frac{\text{retrievals [pc/a]}}{\text{storage capacity [Stck]}}$ | Warehouse dynamics | Size of shipping units (because of customer orders) |
| value-based | $\frac{\text{total turnover [\$]}}{\text{Ø stored value [\$]}}$ | Inventory cost | Ordering system |
| Cost / storage location | $\frac{\text{total cost [\$]}}{\text{storage capacity [pc]}}$ | Choice of warehouse technology | Warehouse technology |
| Inventory coverage quantitative | $\frac{\text{current stocks [pc]}}{\text{wareh. turnover [pc/a]}}$ | Inventory costs, wareh. dynamics, service level | Ordering system |
| value based | $\frac{\text{stocks [\$]}}{\text{wareh. turnover [\$/a]}}$ | Inventory costs, service level | Ordering system |
| Picking way/item | $\frac{\text{average picking route [m]}}{\text{Ø line items [pc]}}$ | Choice of picking technique | Process control, picking principle, information management |
| Picking density | $\frac{\text{no. of line items [pc]}}{\text{gripping space}[m^2]}$ | avg. waytimes, picking performance | Supply management, rack technology |

## 2.5 Special procedures and methods

### 2.5.1 Cross docking

In cross docking goods receipts and dispatches are coordinated to such an extent that incoming goods are directly transferred to the shipping department without being put away. Thus, they are not entered into the warehouse system which is a pure transshipping system with the aim to:

– reduce stocks at certain points along the supply chain
– increase the efficiency by avoiding process steps
– reduce the throughput times of articles in the system
– improve the services by more frequent deliveries
– sort articles effectively according to destinations, e.g., for CEP

This method should not only minimize the stocks in the distribution system or at the *cross docking point* but also at the POS. This requires frequent deliveries what improves the services. There are two principle cross docking methods:

1. Cross docking with broken pallets
2. Cross docking as flow system

**Cross docking with broken pallets**

The incoming units are quasi single-item units and have to be distributed or picked according to the orders of the single subsidiaries. Palletized units are typically transshipped in roller containers, a principle which is also called *two-level* or *container cross docking*. A main feature of this method is an order-picking process.

**Cross docking as flow system**

Here, the supplier pre-sorts the incoming units according to the orders of the subsidiaries in such a way that the single units do not have to be broken and distributed but only have to be consolidated, i.e., combined with other single-order units. This principle is also called *one-level cross docking*. If only complete transport units (e.g., pallets) are handled this method is called *pallet cross docking*. If the pallets hold pre-sorted containers which have to be assigned to the single subsidiaries or tours this principle is called *pre-sorted store order*. In this case the goods are only transshipped without counting or direct picking processes.

**Prerequisites and fields of application** Many requirements have to be met before the cross docking principle can be used. One efficient way is to directly transfer incoming goods. However, this requires that the desired quantity is available on short notice so that the risk of shortages is very high due to lacking stocks. It is practically impossible to restore articles in case of an order cancellation. If the subsidiaries have similar order structures the tours are scheduled almost simultaneously. This may lead to bottlenecks at the goods issue and thus to several deliveries of single subsidiaries a day.

In practice this method is only suitable for systems with a relatively constant demand, similar quantities and articles, short replenishment times and

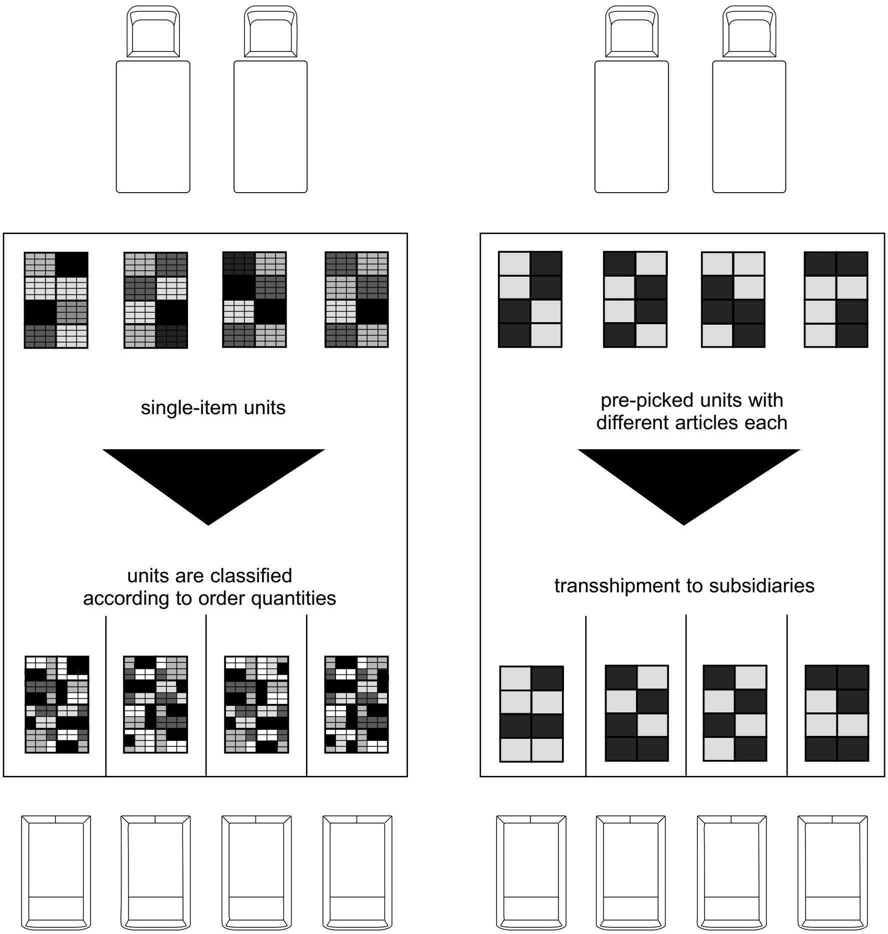


**Figure 2.10.** Cross docking principles

short distances to the subsidiaries, for example for fresh goods. Furthermore, these principles are used for certain groups of goods within existing goods distribution centers where corresponding processes have to be integrated into the warehouse management system. [11] gives recommendations for the realization of communication interfaces.

### 2.5.2 Outsourcing of the physical distribution and warehousing processes

The outsourcing of logistic services was already described earlier in this book (cf. p. 15). The warehouse management is influenced, among others, by connecting external systems to the own enterprise resource planning (cf. Chapter 7).

To be able to adjust the processes in multi-client outsourcing warehouses to the special requirements of the customers the processes, procedures and strategies have to consider not only the goods and customers but also the client. This feature has to be integrated into the WMS which is then called *multi-client enabled*.

Since provided services are often settled on the basis of performed activities single client-related services (e.g., stacker trips, picking positions) have to be recorded separately.

### 2.5.3 Application Service Providing

Similar to the outsourcing of physical warehouse processes to an external service provider in Application Service Providing (ASP) IT services and computer-aided control functions are outsourced to a service provider who controls the processes from a central computer center where he also carries out the necessary evaluations, processing, etc. Such services are successfully used in wage and financial accounting.

An advantage are not only direct cost savings, e.g., by a reduced EDP staff on the site, but above all the data security. A central service provider can afford other better possibilities than many companies at decentralized locations.

In logistics such solutions are used in the form of shop systems in e-commerce and ERP but also on WMS superordinate levels. An ASP solution where time-critical processes in a large distribution system are controlled from a central computer center is still unknown because the transmission security cannot be guaranteed and the response times may be too long. Breakdowns and failures would inevitably lead to process interruptions.

With regard to current developments in the information and communication technology such solutions are quite conceivable above all for smaller applications. The basic functions remain unchanged so that the special procedures will not be described here.

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