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Critical Analysis of Picking and Putaway Strategies in a Warehouse Using SAP System

Dow Corning Seneffe - Case Study

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Abstract

The aim of this thesis is to address the product allocation problem and more specifically stock placement (“putaway”) and stock removal (“picking”) strategies in a warehouse using SAP system. The problem under study denotes an important point for warehousing performance and logistics at large. The goal is to reduce time and transport inside the warehouse during the putaway and picking processes while avoiding any non-value-added activities.

Most of international companies need to use powerful and fully integrated systems to manage and align their activities inside the corporation and all along the supply chain. Nowadays enterprise resource planning (ERP) software has become increasingly popular to face this challenge. SAP is one of the leaders in this industry, but only few papers take this tool into account. That is why this thesis integrates the SAP theory in purely logistic concepts. It requires excellent analysis of the current situation in the warehouse.

Those concepts and information are applied to a real case study: Dow Corning Seneffe. This international company has been using the SAP software in its day-to-day activities for 15 years. No assessment has been processed since its implementation in order to ensure warehousing component is optimally set for current DC business. Hence the purpose of this paper is to combine a literature review with SAP basic proposals to improve the putaway and picking activities inside the warehouse of the Seneffe site while limiting investments. These improvements are based on a review of SAP organizational structure and parameters. The goal of this approach is to give DC managers and engineers well-documented advice but also to provide an analysis framework applicable to other contexts. This investigation results in reliable and profitable recommendations.

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Abbreviations

Abbreviation	Full name
DC	Dow Corning
EDC	European Distribution Center of Feluy
FG	Finished Good
IT	Information Technology
IM	Inventory Management
IPPO	Inter Plant Company Purchase Order
RW	Raw Material
S-loc	Storage Location
S-type	Storage Type
SUT	Storage Unit Type
TO	Transfer Order
WM	Warehouse Management
WMS	Warehouse Management System

1. Introduction

A warehouse is typically used for storing and buffering products (raw materials, goods-in-process, finished goods) at and between points of origin and points of consumption throughout the supply chain (Lambert, 2008). According to an A.T. Kearney survey (2009), warehousing contributed to about 24% of companies' logistics costs in 2008. Hence a well-managed warehouse is a key element to effective supply chain and may create its competitive advantage. In this sense, improving warehouse performance is a major challenge for all organizations. For a business as important, a more scientific approach to those problems must be adopted.

Warehouse managers have to overcome problems that can be divided into two broad categories: warehouse management and inventory management (Pochet and Strack, 2008). Inventory issues deal with strategic choices such as "which products to place in the warehouse and in what amount" whereas warehouse issues concern the locations of products inside the building while managing all incoming flows, optimizing storage space, the paths of preparation, assignments and visibility of inventory levels, and improving compliance with the order and fluctuations of activity. This study will specifically focus on those warehousing challenges but, both subjects being closely related, inventory issues will also be discussed.

Stock placement and stock removal processes constitute two of the most important warehousing activities. On the one hand, after receiving products, putaway process concerns the selection of the best storage location in which the material will be stored on the basis of the product's characteristics. On the other hand, picking consists in retrieving articles from the storage locations in a specified quantity before shipment to satisfy customer orders. Although they are tightly linked, the two concepts have generally been studied and analyzed separately. Since the methodology used to assign products to storage locations has a significant impact on the efficiency to retrieve the items needed to fill an order, we want to study both strategies and integrate them in the same work.

In today's highly competitive global economic and financial situation, many companies automate their warehousing functions to achieve the best costs and performances. The technology enables to computerize and harmonize processes and procedures through a single computer tool such as an ERP (Enterprise Resource Planning). To provide an accurate analysis of warehouse activities, it is therefore important to integrate such a tool in the work. The system and the associated data-capture equipment are at the basis of the warehouse and inventory management. In addition to

basic functions, companies have to manage parameters and important information flows required to run the system. However, most of the time, when the system is implemented, they do not take the required step back to review this powerful tool and adapt its structure to the changing business strategies. The originality of the thesis lies in studying concurrently basic putaway and picking strategy with one of the most popular ERP, SAP system.

Dow Corning Company has implemented the SAP software 15 years ago. The way the stock is managed inside the warehouse widely depends on this system. In other words, SAP parameters are the fundamental basis of putaway and picking strategies. However, those parameters have not been reviewed since the implementation. SAP and Dow Corning business processes have been evolved and the current system is therefore not optimally used. Our objective is thus to set the system in order to improve warehousing processes and remove non-value-added activities.

The scope here is well to challenge SAP utilization in order to optimize the putaway and picking strategies at Dow Corning Seneffe. It provides a wide range of benefits: improvement of space utilization, removal non-value-added activities, saving time for logistic operator and employee, reduction of errors... We do not reconsider the physical layout of the building or the planning and scheduling activities (lot size, purchase order, safety stock...). Warehouse and inventory applications are reviewed and integrated with the general theory to generate accurate recommendations about a realistic case. The approach also a methodology and advices applicable in other cases.

Collecting data and understand Dow Corning system is a complex task since Dow Corning Seneffe keeps hardly any document or procedure about its SAP structure, its picking/putaway processes and it does not always keep tracks of previous decisions or errors. Therefore, information presented in the thesis is widely based on theoretical researches, dialogues with Dow Corning workers and personal handlings of SAP system.

The document consists of four parts. The first section exposes logistics and warehouse theory to present the general framework and to make a brief review of the literature available on the subject. The second section explains SAP organizational structure with its parameters and some useful concepts. The next section deals with the current warehousing situation in Seneffe and more specifically the stock placement and stock removal activities. Finally, previous information is applied to real data to analyze and provide new SAP, resulting in improvements of stock placement and stock removal activities in the main warehouse of Dow Corning Seneffe.

2. Logistic and Warehouse Theory

One of the objectives of this thesis is to make the link between logistics and SAP theory and apply them to a case study. To get off to the good start, this section presents the global interesting notions for stock placement and stock removal study. This starts with general explanations of logistic and warehouse concepts in order to put the topic into context. The next part deals with the subject under study by presenting theory about putaway and picking processes. It includes a mathematical model illustrating the storage assignment policy.

2.1 Logistics

The term “logistics” stands for “the systematic approach towards the comprehensive optimization of flow systems, e.g. material flow systems, beyond single system boundaries” (Ghiani et al., 2004). Hompel and Schmidt (2007) described the logistic targets as the “6Rs” involving the delivery of the Right goods, at the Right time, in the Right quantity, with the Right quality at the Right location and at the Right costs. In this perspective “right” stands for the fulfillment of the customer requirements at best costs. Maximizing value in a logistic system under those objectives is the key function of logistic managers. To do so, they make a variety of choices, ranging from the tactical-level decisions (e.g. the location of a new plant) to operational decisions (e.g. management of products places inside the warehouse). The latter allows introducing the thesis’ topic.

Lean tools and techniques are often used by managers to review their processes. As stated previously, we want to improve stock placement and stock removal processes by reviewing system’s parameters and avoiding non-added value activities. This kind of improvement project may be approached with the “Seven Wastes” of a lean project, known under “Muda”¹: over-production, inventory, over-processing, transportation, motion, defects, and waiting (Fouque, 2011). The “Seven Deadly Wastes” are originally intended in production industry field. However, the translation of those wastes of production in wastes of logistics as proposed by Sutherland and Bennet (2007) is interesting. It permits to highlight areas of improvement for the study of the putaway and picking.

¹ Japanese word that means "futility; uselessness; idleness; superfluity; waste; wastage" (Wikipedia).

² Cross-docking activity is when the received products (from an incoming semi-trailer truck or railroad car) are

1. Overproduction in a warehouse may correspond to the actions realized to deliver product before they are needed.
2. Inventory and the warehouse itself may be considered as a “muda” since it does not create any added value. Many firms have the objective of minimizing their inventory level. Clients do not pay for the storage of their products. In that way the only identified added value of warehouse operations is the order preparation (Harmapriya, 2011).
3. Unnecessary transports/conveyances are also a specific sort of waste. For example, it is the travel of an operator inside the warehouse without carrying out any material. It may also happen that the product is brought into an interim storage zone before being stored in the stockpile. This two-step manipulation is unnecessary transportation. This waste could also refer to unnecessary handling and moving of material.
4. Space: use of space inside a warehouse is an important performance indicator. Waste of space includes inefficient use of storage space, non-optimal trailer loads, pallets that are not fulfilled, etc.
5. Motion: waste of movements refers to all actions except transfers of products. These may be unnecessary movements of order pickers who are forced to go to the other end of the building to get their truck. This can be caused by unnecessary travel to computer that are poorly positioned ...
6. Mistakes/defects in any operations of logistic processes are important wastes. For example, picking mistakes (choose the wrong product, products at the wrong place...) is time-consuming and may generate other mistakes...
7. Standby time: a waste linked with waiting time. Examples include an order picker is waiting for a truck to be available, the time between the arrival of a truck for a pick-up and the loading of the trailer or waiting for a product to be replenished. Another kind of case would be a team of operator waiting because of a computer problem.

Finally, having an information system without using it (or under-use it) could also be perceived as a waste of opportunity. Companies should exploit their investment to their maximum. This concern occurs in many organizations using powerful and complex system such as SAP. The key point of the paper lies in minimizing this waste.

2.2 Warehouse

A warehouse is defined as a “structural unit” with all resources and organizational provisions necessary for the execution of processes connected to inventory and warehouse management, including the organizational units involved with goods receipt and shipping” (Kappauf et al., 2012). According to Ghiani, Laporte and Musmanno (2004), warehouses are facilities where inventories are sheltered. They are generally classified into production warehouses and distribution centers. The term ‘warehouse’ is used if the main function is buffering and storage. If distribution is the main activity, the term ‘distribution center’ is commonly used, whereas ‘transshipment’, ‘cross-dock’, or ‘platform’ center are often used if storage hardly plays a role. As we focus on products putaway and orders picking, we use the term ‘warehouse’ throughout the document. Similar to the “6R” of logistic, the proper objectives of warehousing lie in having the right product in the right place at the right time (Ghiani et al., 2004). Without a complete and accurate understanding of its value, companies have failed to give warehousing the same scientific scrutiny and strategic view as the other aspects of their business.

De Koster et al. (2007) say that the analysis of a warehouse largely depends on two broad criteria: the products and the processes. On the one hand, the number of different articles, packaging dimensions, weights and quantities of each article are basic data in warehouse analysis. On the other hand, storage/retrieval behavior strategies with the performance and throughput define the processes and the area to be improved. Rouwenhorst et al. (1999) keep the same features by proposing to study a warehouse through three angles: processes, resources and organization. This section follows their proposition by analyzing the warehouse with this approach.

Many papers make a distinction between a finished goods warehouse (FG) and a raw materials (RM) storeroom. The fact is however that the functions performed in the first one (receive-store-pick-ship) are identical to the functions performed in the second one (Tompkins and Smith, 1998). Consequently, both are warehouses. The only distinction that can be made from a logistic point of view is the end. Hence this study deals with FG and RM in the same way. Firstly it can be useful to clarify what “product” stands for. A *product* denotes a type of good, for example a drum of silicon. In this case, individual drums are called *items* (or Stock Keeping Units, SKU's) and the combination of several items of several products that are requested by a customer is called a *customer order* (Rouwenhorst et al., 1999).

2.2.1 Warehouse Processes

Even though warehouses can serve quite different ends, most warehousing activities consist of four major functions that also describe item's flow through this structure: *receiving* the goods from external sources and putting them away to a storage location, *storing* the goods, *picking* the goods from storage location to fulfill customer order and *shipping* them to the appropriate consumer/client. These steps subsequently followed by products in the warehouse are called "processes". Each of them refers to a specific cost displayed in Figure 2.1. Order picking has long been identified as the most labour-intensive and costly activity for almost every storeroom (de Koster et al., 2007).

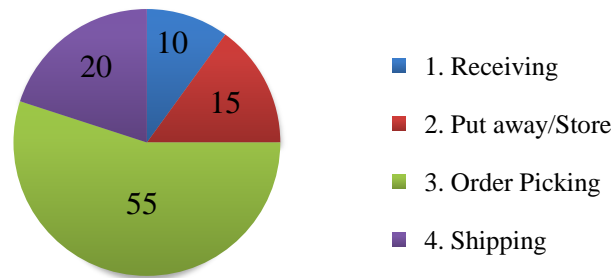


Figure 2.1 Common warehouse costs distribution (Ghiani et al., 2004)

The ERP system and the associated data-capture equipment introduce a fifth warehousing function: managing the information necessary to operate and coordinate WMS. Since higher levels of automation and computerization are required to stay competitive, managing the flow of information becomes just as important as managing the flow of materials (Tompkins and Smith, 1998). A widespread rule recommend that products should be scanned at all key stages to give "total visibility of assets" and ensure consistency, which enables quick and accurate response to customer demand.

Lambert (2008) states that warehouses often involve large investments and operating costs (e.g. cost of land, facility equipment, labour...). Even if storage is often seen as a non-value added activity, there are various reasons why a warehouse is an important component of a supply chain. It provides necessary services and may end up being the competitive advantage (Bartholdi and Hackman, 2002). According to Lambert (2008), they contribute to a wide range of the company's missions, such as:

- Consolidating products (achieving transportation economies by combining shipment and by using full-container load).

- Realizing economies of scale by taking advantage of purchase discounts and forward buying (e.g. make-to-stock production policy).
- Providing value added processing.
- Reducing respond time while meeting the changing market conditions and uncertainties (e.g. seasonality, demand fluctuations, competition).
- Supporting the firm's customer service policies and providing customers with a mix of products instead of a single product on each order (i.e. consolidation).

2.2.2 Warehouse Resources

Warehouse resources denote all tools, equipment and personnel required to operate a warehouse. Here are the main important ones:

The storage unit denotes all object in or on which products may be stored. It may be the packaging itself and the different types of pallets on which the items are placed. Examples of storage units are pallets, carton boxes and drums etc. (Rouwenhorst et al., 1999).

Rack storage is often one of the core elements in a warehouse. These large metallic shelves can contain hundreds of pallets. The width and the height of the slots inside the rack are adjustable depending on the type of packaging or the type of pallet. Aisle length between racks is also an important characteristic. The aisles in a standard warehouse layout are wide enough for a forklift to turn 90 degrees, take a pallet from the rack and turn again to continue down the aisle. With very narrow aisle racking, the passageways are only wide enough for a forklift to move in one direction. Truck must then come back backwards. It usually implies the use of special trucks (Roux, 2011).

A dock or door is a location in the warehouse complex where the goods arrive or leave and where the trucks are load or unload. Each door can have different functions including: goods receipt, goods issues, cross-docking², flow through...

Trolleys or trucks are used to move pallets inside the warehouse. "Pallet jacks" (or "trans pallets"), forklifts and high-rack forklifts are common handling equipment used to put away and pick the products from storage location. These equipment's specific features play a role in movements analysis since they define the time required to place and retrieve products in a

² Cross-docking activity is when the received products (from an incoming semi-trailer truck or railroad car) are directly transferred to shipping area with little or no storage in between (Tsige, 2013).

storage area. A pallet jack is a simple tool to lift and move pallets. The pallet is only lifted enough to clear the floor for subsequent travel. It is not possible to use this tool to move pallets upper than ground floor. Normal forklifts are used to move pallets from or to floor storage. They enable to stack the pallets one upon the other.

The *staging area* of the warehouse complex makes easier the goods flows. These areas are mainly intended to temporarily store items during goods receipts or goods issues. For receipt, unloaded goods are placed in the interim storage until they are put away in the specific bin. On the other hand, picked goods are placed in this zone before trailers arrive for goods issue.

In many organizations, the *warehouse management system (WMS)* is the cornerstone of each activities performed inside a complex warehouse. It permits to manage equipment, space and products through a single compute tool (Tompkins and Smith, 1998). WMS is among the most advanced of supply chain software application but also still among the most dynamic.

The use of a WMS is usually connected with the immediate *automatic identification of objects (auto-ID)* for the management and control of products in real-time. The tasks to be fulfilled in a warehouse put different requirements on the information technology (Hompel and Schmidt, 2007) such as ensuring reading reliability under the given conditions, sufficient reading speed for existing and planned conveyor techniques, a reading distance adjustable to the warehousing conditions, ensuring compatibility to other supply chain members, etc. Bar codes and terminal readers are nowadays the most common auto-ID technology in logistic area. The position of bar codes is somewhat important to ensure good performances. They do not require contact but do require line of sight (Tompkins and Smith, 2007).

Finally, *the workforce* constitutes one of the main warehouse resources since the performances largely depend on their efficiency. Personnel in charge of handling items are usually called “logistic operators” or “warehousemen”. Logistic operators team leader is commonly called a “supervisor”. He is in charge of taking day-to-day decisions concerning stock placement/removal strategies and oversees all warehousing activities. People management responsibilities are rather focused on operational task. Supply chain team leader and other managers operate tactical and strategic functions (Roux, 2011).

2.2.3 Warehouse Organization

Warehouse organization represents the final assessment of a complete warehouse analysis. It deals with all planning and control procedures used to run the business (Rouwenhorst et al., 1999). This includes organizational policies for assignment and picking of products. Those decisions are usually managed by a team leader logistic or by supply chain manager.

Organizational part also includes human resource management. Allocation of tasks to staff and equipment are addressed by several assignment policies, e.g. assignment of one warehouseman to one dock door. The way warehouse operators are administered influences the whole doing.

2.3 Stocking Strategy

The stocking strategy is an important factor that defines the type of supply chain. The two main figures are the push and pull processes. Those strategies depend on the timing relative to customer demand (Tancrez, 2011). Companies might have a safety stock whose purpose is to satisfy unexpectedly high demand in the coverage period, depending on their strategy. Having a safety stock reduces the risk of shortfalls but imply additional cost: the right balance must be adopted.

In a make-to-stock-system (pull view), finished products are continuously manufactured. The push view is a speculative process executed in anticipation of a customer order. In that way, most classical products are available in the stock. This strategy has some disadvantages because it requires forecast and important inventory that generate costs. Moreover, a make-to-stock system is slower to react to market changes.

On the opposite, the push view is a reactive process in response to a customer order. The system fulfills the need of reactivity and reduces inventory. Hence, in principle, no inventory is needed if the goods are directly shipped (Gianni et al., 2004). However, there are many reasons why stock is required even in this stocking strategy (e.g. minimum lot size³ constraint). The drawback of this stocking choice is the longer lead-time implying that customers have to accept waiting. Nowadays, many firms (such as Dow Corning Seneffe) combine both methodologies dependent on tactical decisions in order to take the most of these advantages.

³ A measure or quantity increment acceptable to or specified by the party offering to buy or sell [www.businessdictionary.com].

2.4 Putaway and Picking Processes

As exposed in section 2.2.1, products putaway and picking constitute basic functions of a warehouse. Since the orders are not fully known in advance, operational decisions are affected by uncertainty and a dynamic process must be adopted. It is strongly related to warehouse management system (WMS). Figure 2.2 shows the four main functions of a warehouse previously cited (receive, store, pick and ship). The red shapes emphasize the points to be studied: picking and putaway.

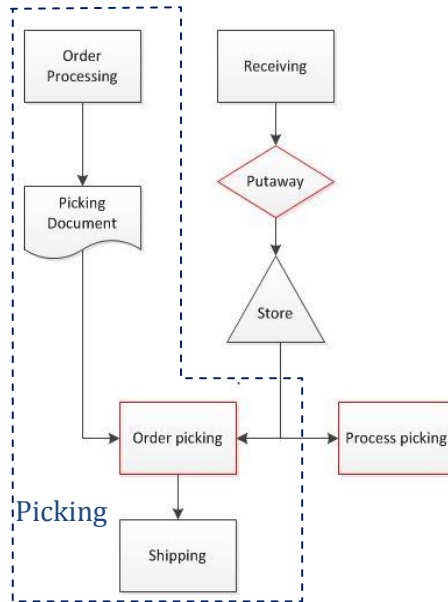


Figure 2.2 Putaway and picking flowchart (Tompkins and Smith, 1998)

Many papers address (e.g. Pochet and Strack, 2008) the problem of minimizing the average travel distance during the stock placement and removal. Other performance measures are related to the time or the effort required by products putaway or orders picking, i.e. retrieving items from the shelves and delivering them to expedition point (Kovacs, 2009). Here are common objectives in warehouse design and optimization studies (Tompkins and Smith, 1998):

- minimizing the total cost (that may include both investment and operational costs),
- minimizing the throughput time of an order,
- minimizing the overall throughput time (e.g. to complete a batch of orders),
- maximizing the use of space,
- maximizing the use of equipment,
- maximizing the use of labor,
- maximizing the accessibility to all items.

2.4.1 Putaway

Stock placement inside a warehouse is also known under “putaway” process. After reception of the incoming goods, an appropriate storage location must be determined. Then, an operator moves the goods from the receipt lane to the designated storage location (Kappauf et al., 2012). The objective here is to minimize the time of placing it and hence to optimize the future retrieval.

The determination of a storage slot may follow different rules according to criteria such as physical dimensions and operational warehouse methods. For example, a bin cannot store any type of product because of the length, the weight or the hazardousness. Stock placement has to attend to storage rules of products e.g. some items must be stored near sprinklers while others require floor storage. Taking into account the operational criteria, different strategies are implemented to identify the best location for an item.

In a warehouse using WMS and automatic identification of object, the products and the corresponding storage location should be scanned to record the new position of an item. This kind of information may subsequently be used to construct efficient pick-lists to guide the order-pickers in retrieving the product for customers (Bartholdi and Hackman, 2002).

2.4.2 Picking

In the context of warehousing, the broad definition of stock removal is the activity of retrieving stock (raw materials or finished goods) from storage location for two main reasons (Tompkins and Smith, 1998). On the one hand, order picking is the process of retrieving from warehouse storage locations in response to specific customer orders. On the other hand, stock removal also occurs to fulfill the production need of raw materials in a production site. There are five levels of order picking activities according to the size of the unit that is being picked: pallet picking, layer picking, case picking, split case picking and broken case picking (retrieval of individual items from storage). Figure 2.2 displays the main steps involved in the order picking process (the red dotted shape). “Order processing” stage represents the data processing function that supports customer requirements (Tompkins et al., 1998). Then, the picking documents are created to indicate which product/batch is to be picked.

The order picking/selection is the major activity in most warehouses. It involves the procedure of obtaining a right amount of the right products for a set of customer orders. Companies make decisions on design and control of order picking systems at tactical or operational level, with a

different time horizon (Rouwenhorst et al. 1999). Some policies suggest removing stock per batches in order to minimize movement (batching) instead of making one return trip for each item. Thus, the logistic operator picks a group of orders (batch) at the same time and dispatches them afterwards. Order picker routing is also a classic operational decision and a widely discussed issue. All of them are various concepts and methods of order picking that will not be addressed in this thesis. Hence, batch picking and routing problem are only relevant for “small” packaging (e.g. cartons) that can be retrieved per groups (e.g. one pallet store four cartons).

2.5 Storage Assignment Policies

The allocation of products within a warehouse is a critical activity as it impacts productivity of other processes performance. Even if storage assignment policies are part of the stock placement subject (section 2.4.1), it is presented in a distinct section since this is an important point of the thesis. The storage assignment problem involves deciding where and how to store a set of items in order to ensure optimal operations of the logistic system (de Koster et al., 2007). Warehouse strategies are based on the principle that fast-moving products must be placed closer to the in/out ports in order to minimize the overall handling time (Ghiani et al., 2004). In case of multi-buildings sites, the problem can be extended to decide the best warehouse for the storage of an item. The allocation problem consists therefore of assigning each material to a storage location. The literature (de Koster et al., 2007, Ghiani et al., 2004, Kovacs, 2009) usually speaks about three fundamental storage policies: dedicated storage, randomized storage and class-based storage.

In a *dedicated storage* policy, every product/SKU⁴ gets a fix number of storage locations that are exclusively allocated to it. This number represents the maximum storage needs in terms of space. This approach is one of the easiest to implement but several problems may obviously occur. Dedicated strategies always store the same item in the same group of slot (Kovacs, 2009). The variability of the demand progressively makes the initial allocation less accurate resulting in suboptimal situation, e.g. 100 storage locations are allocated to product X which has a high demand in December. Six months later, the demand is divided by two but the product X is still blocking 100 storage locations unusable for other products. This strategy may result in a suboptimal use of space.

⁴ A “SKU” is a distinct product as it is offered for sale that embodies all attributes associated with the item and that distinguish it from all other items [www.freedictionary.com].

Assuming that n is the number of products and $I_j(t)$, $j = 1, \dots, n$, is the inventory level of item j at time t , the number of required storage locations m_d in this policy results in equation 2.1.

$$m_d = \sum_{j=1}^n \max I_j(t) \quad (2.1)$$

The *random storage* policy (or shared storage strategy) is a dynamic decision based on the current warehouse situation. Therefore, the positions assigned to a product are variable in time. Each unit from any SKU can be stored in any available location. Shared storage strategies, in contrast, do not reserve slots for specific items, which makes them more convenient when stock levels change over time. This policy allows a higher utilization rate of the space but requires technology of identification. The number of required storage location is therefore equal to equation 2.2.

$$m_r = \max \sum_{j=1}^n I_j(t) \leq m_d \quad (2.2)$$

In between random and dedicated storage policies, many firms opt for a *class-based storage* policy. A reserved storage area is assigned to each class, SKU's within a class are randomly stored (de Koster et al., 2007). It assigns the most frequently requested SKUs to the best locations. This strategy comes from ABC classification. Items are categorized into classes based on several parameters: e.g. the number of times they appear in an order set. Class A items are relatively few in numbers but account for a large amount of the activity, while class C items are relatively large in numbers but account for a relatively small amount of the activity. Items between the above two classes constitute class B. Each class is then assigned to a dedicated area of the warehouse. Fast-moving products are stored close to the I/O-point (Tsiges, 2013). The main objective of this method is to state fast and slow access zones in the warehouse complex and to classify each product according to their turnover level. In this way, goods with high rotation level are to be placed in the easy and fast access zones.

This methodology will be useful for the reorganization of the warehouse. It can be divided into three steps:

1. The first step consists in the identification of fast/slow access zone of the warehouse complex, e.g. it is faster to pick a pallet on the ground than on shelves at 10 meters from the ground.

2. The second step is the identification of the products turnover. The main principle is to gather articles on basis of their movements, e.g. class A aggregates items accumulating 80% of the effect. Class B contains items accumulating the next 15%. Class C contains items accumulating the last 5%.
3. Finally, the tricky point is to assign a zone for each category of products. This step includes the warehouse setting in the system which allows recording a storage zone for each article. In this way, during the receipt of a product, the system indicates an appropriate warehouse zone according to the type of product.

An alternative to this policy is to base the classification on the duration of stay of the product in the warehouse (Kovacs, 2009). Storage locations are allocated to a product according to its average slot space occupation time. The main disadvantage is that demand and thus the average time in warehouse of a product vary constantly and the product assortment changes frequently. Each change would require a new ordering of products in the warehouse resulting in a large amount of reshuffling of stock. A solution might be to carry out the restocking once per period.

There are various possibilities for positioning the A-, B- and C-zones within the warehouse and among the racks. The two fundamental philosophies are within and across aisle storage policies. Jarvis and McDowell (1991) recommend that each aisle must represent only one class. This layout called “the within-aisle storage” is depicted in Figure 2.3.

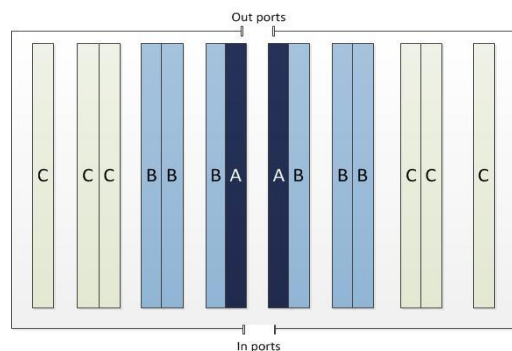


Figure 2.3 Within aisle storage (de Koster et al., 2007)

However, this disposition is not optimal for a warehouse in which the dock doors are on the same side of the building. In this vision, de Koster, Le-Duc, and Roodbergen (2007) optimize the storage-class positioning and proposed to divide a single aisle into three zones. They claim that the across-aisle storage method is close to optimal.

Petersen et al. (2004) compare multiple configurations among which across-aisles storage (depicted in Figure 2.4).

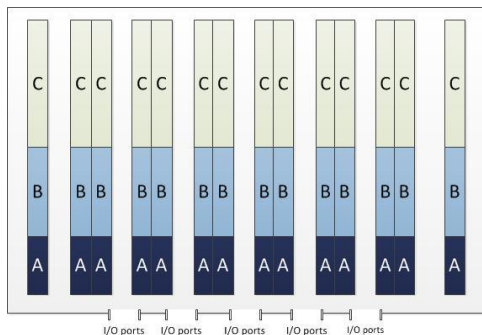


Figure 2.4 Across aisle storage (de Koster et al., 2007)

The choice between both configurations depends on the routing policy but also on the warehousing procedures.

Warehouses are highly dynamic environment where products have to be allocated in real-time in order to optimize the global space distribution. This is why the aim of the study is to avoid static and dedicated storage policies that do not take into account unpredictable and volatile parameters such as the place needed for each material, number of products, etc.

2.5.1 Mathematical Model

Several papers (Kovacs, 2009; Ghiani et al., 2004) suggest mathematical models about product allocation problem. It aims to assign each storage locations available to products. Most of these models propose optimization based on the cost of assigning a specific storage location to a specific product, e.g. mathematical model proposed by Ghiani et al. (2004). The rationale behind the following notation is quite different. Since the objective here is to apply and compare the theory to a practical case, it is important to consider real assets and variables. The objective function is based on the travel time which is an easy data to assess. In order to present the mathematical model, it is useful to introduce the following definitions and notations:

- n : number of products.
- m_d : number of storage locations available (example: a bin).
- m_j : $j=1, \dots, n$, the number of storage location required for product j .
- D : number of doors.
- t_{dk} : $d= 1, \dots, D$; $k=1, \dots, m_d$; travel time from door d and storage location k .

- p_{jd} : $j= 1, \dots, n$, $d = 1, \dots, D$, the average number of handling operations on product throughout I/O door d .

These variables allow to denote $(p_{jd}/m_j) t_{rk}$: the average number of handling operations per time period on product j between I/O door and the storage locations assigned to the product.

- x_{jk} : $j= 1, \dots, n$, $k=1, \dots, m_d$, the binary decision variable, equal to 1 if storage location k is assigned to produce j , 0 otherwise.

Assuming that all storage locations have an identical utilization rate, $(p_{jr}/m_j)t_{dk}$ is the average travel time due to storage location k if it is assigned to product j . The general problem of seeking the optimal product allocation to the storage locations can then be modeled as follows:

Minimize

$$\sum_{j=1}^n \sum_{k=1}^{m_d} \sum_{d=1}^D \frac{p_{jd}}{m_j} t_{dk} x_{j k} \quad (2.4)$$

Subject to

$$\sum_{k=1}^{m_d} x_{jk} = m_j, \quad j = 1, \dots, n \quad (2.5)$$

$$x_{jk} \in \{0,1\}, \quad j = 1, \dots, n; k = 1, \dots, m_d \quad (2.6)$$

Equation 2.5 states that each item at stock must be allocated to a storage location. In a dedicated storage policy, constraint 2.6 may be added to ensure that a storage location k can only be assigned to at most one product.

$$\sum_{k=1}^n x_{jk} \leq 1, \quad k_1, \dots, m_d \quad (2.7)$$

The model permits to illustrate the variables and constraints at the basis of the whole project. SAP strategy inserts much more variables into the problem but the basic scheme is the same.

3. SAP System

The previous chapter makes a review of useful logistic notions and more specifically, the products storage and retrieval activities. This section will be dedicated to explain fundamental SAP concepts and theory to making the reader familiar with this powerful tool. All the content is widely based on the Figure 3.1 that represents the organizational structure of *Inventory Management* (IM) and *Warehouse Management* modules (WM). Indeed warehousing study cannot exclusively focus on WMS since WM is implemented on IM and both parts are interrelated. This chapter provides detailed explanations of standard parameters with regard to picking and putaway.

IM organizational units are essential for the understanding of the stock removal (picking) at Dow Corning while WM is involved in stock placement. Several explanations in this section are illustrated with convincing examples derived from Seneffe case. Papers dealing with SAP IM-WM theory are very few in number (e.g. Kappauf et al., 2012). Although SAP documentation is useful for global understanding, it does not provide accurate information to analyze real case and it is sometimes difficult to study this guide without a previous experience in the field. Therefore this part is also the summary of the knowledge resulting from daily manipulation of SAP. Only a small piece of information is presented here in order to focus on parameters useful in our review of putaway and picking strategies at Dow Corning Seneffe.

3.1 SAP ERP Presentation

Before entering straight to the core operations of the system, this section will present the ERP SAP in general. This name stands for *Systems, Applications and Products for data processing*. As a reminder, Enterprise Resource Planning (ERP) software “integrates management of information across an entire organization-embracing finance/accounting, manufacturing, sales, logistic, customer relationship management, etc.” (Bidgoli, 2004). ERP systems automate company’s activities with an integrated software application. An ERP such as SAP “facilitates information flow between all business functions inside the organization, and manages connections to outside stakeholders” (Bidgoli, 2004). SAP is commonly divided into “modules”: they are the functional component of the system. Many international and national firms around the world use this system to optimize their processes and activities (Szwec, 2009).

In many cases (such as Dow Corning corporation), SAP replaces existing stand-alone systems and introduces a single point of data entry impacting an entire business.

In contrast with early software of warehouse and inventory management, modern warehouse management systems (WMS) such as SAP are able not only to supervise complex warehouses and distribution centers, but also to control and optimize them (Kappauf et al., 2012); putaway and picking strategy is a perfect example of that. The system provides multi dimensional and flexible reporting possibilities. These reports will be used to analyze material flows in section 5.1.3 in order to optimize the storage assignment policy.

3.2 Organizational Structure

Warehouse management with SAP is clearly based on two important components: inventory management (IM) and warehouse management (WM). However the distinction between both modules is clear and must be well understood. Figure 3.1 exposes basic organization structure of IM and WM SAP modules. This hierarchical diagram is essential for the understanding of picking and putaway processes with SAP systems. Each level is explained in details in the following subsections.

IM provides information on the total quantity of a material. Stock is expressed in term of quantity and dollars and is managed at storage location level. Beside this module, the firm may implement WMS to manage exact position of products inside a complex warehouse. In addition to the elementary functionality of an inventory management like the management of quantities and storage locations, warehouse management includes methods and means to control accurate placement of inventory (Hompel and Schmidt, 2007). Those two components are the foundation of picking and putaway analysis.

One of the tricky points of this project is to understand the scope of IM and WM respectively. The most important point to be aware of is that WM component looms into IM component. Most activities that take place within WM are initiated in IM. WM is implemented when a more sophisticated system is needed. In other words, each storage location can be divided into storage types and storage bins (see Figure 3.1) using the WMS to reflect the complex warehouses that are typical in retailing (e.g. position in the rack). Large distribution center or warehouses usually implement WM for general stock to keep track and record the exact place of an item inside the warehouse. Although it is possible to manage warehouse inventories using the inventory

management (IM) application component, the primary difference between is that in IM, the system can only display the total stock of a material for a storage location without providing accurate information about the place (ex: rack 32, row 17, level 3).

The link from IM to WM is made by the assignment of storage location(s) (IM) to the warehouse number (WM) (see red dotted line on Figure 3.1). In most of the cases, companies use a mix of WM and “purely” IM managed storage locations. For example, Dc Seneffe use IM managed storage locations for the Shuttle between Seneffe and Feluy. When a good is manufactured, instead of storing it in the warehouse, it is directly put in the trailer to be shipped to Feluy Distribution Center. This trailer is loaded in the system as a single storage location without WMS. In that way, the transaction is made easier.

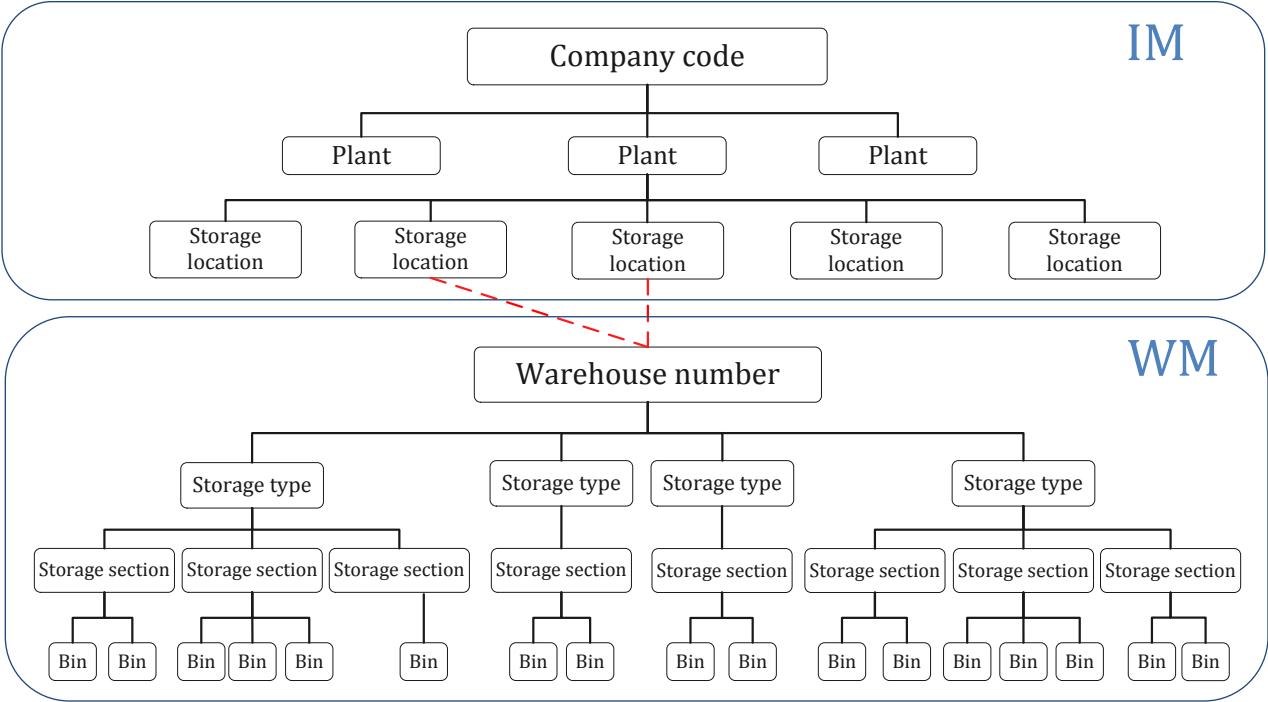


Figure 3.1 IM-WM organizational structure

Each individual element of the organizational structure is used to map an enterprise and its components in SAP system (Kappauf et al., 2012). This structure settles on the operational framework in which all sequences and functions of logistics occur. This architecture also reflects the legal and organizational structure of a company. It is obviously the basis for data organization in SAP business. The corporate functions can be allocated to a different level of this structure.

3.3 Inventory Management

The primary task of IM module is the management of stock with regards to quantity and value. This module executes its activities regardless of the exact location of items inside the plant. Basically, IM is used by many other components of the system, i.e. delivery, purchasing, quality management, production, maintenance, etc. (Kappauf et al., 2012).

The module consists of four basic organizational units: client, company code, plant and storage location. Client level is simply the element indicating the global company (e.g. Dow Corning) but is not an interesting element for the study. It is not represented in Figure 3.1 to keep the diagram as clear as possible. The other units are explained in following subsections.

3.3.1 Company Code

The company code is the smallest organizational unit of external accounting for which a complete, self-contained set of accounts can be created. This includes the entry of all transactions that must be posted and the creation of all items for legal individual financial statements, such as the balance sheet and the profit and loss statement. The primary purpose of a company code is to map individual companies or self-contained accounting divisions. A company code in the SAP system shows a legally independent organization (SAP documentation, 2011). A company code is usually divided into several plants.

3.3.2 Plant

A plant embodies the areas of a company in which materials are physically located. This level serves to subdivide an organization according to production, procurement, maintenance, and materials planning aspects. A plant must be defined to exactly one company code. From a logistic standpoint, a plant may correspond to a distribution center or manufacture and can produce goods for direct sale to client or for distribution (Kappauf et al, 2012).

3.3.3 Storage Location

A plant is divided into storage locations. Stocks are managed within a site through different storage locations to differentiate, for example, general stock, returns from customer, promotions or cross-docking. The optimal number of storage locations depends on various factors such as business processes, inventory management strategies, scope of operations etc. For a warehouse

structure without WMS, stocks are exclusively managed through this storage location and no further information about the position of an item is provided.

With previous SAP version, it was not possible to manage the inventory of several storage locations within a warehouse number. In that sense, only one link (see red dotted line in Figure 3.1) has been made between one storage location and the warehouse number. With Release 4.0, this limitation has been removed because the business implications of the organizational unit storage location have increased, and, increasingly, more than one storage location per plant has to be defined: either to represent the ownership status of companies, or to be able to make important planning decisions at this level. Each storage location is loaded in the system with an address, thus it can represent different building.

3.4 Warehouse Management

SAP WM is implemented by linking a storage location to a warehouse number. Unlike IM module, warehouse management (WM) does not only provide an overview of the quantity of a material, but also offers information on the location of a specific material (Kappauf et al., 2012). Warehouse management is about the spatial division and the physical position in a warehouse. WM is not a mandatory SAP module as IM is. WM is used when accurate information about position is required. When using SAP WM, firms have the ability to define storage types (areas of a warehouse) and bins beneath them, so this provides the granular detail used in a typical warehouse/distribution center to accurately manage stock placement/removal.

Warehouse management is not used by other department such as IM is. The management of a warehouse is almost the single function of a WMS. The warehouse management application of SAP supports the organization of warehousing complex by treating the physical goods movement in a flexible and automated way (SAP documentation, 2001). When a WMS is implemented, goods movements and stock changes are managed at storage bin level.

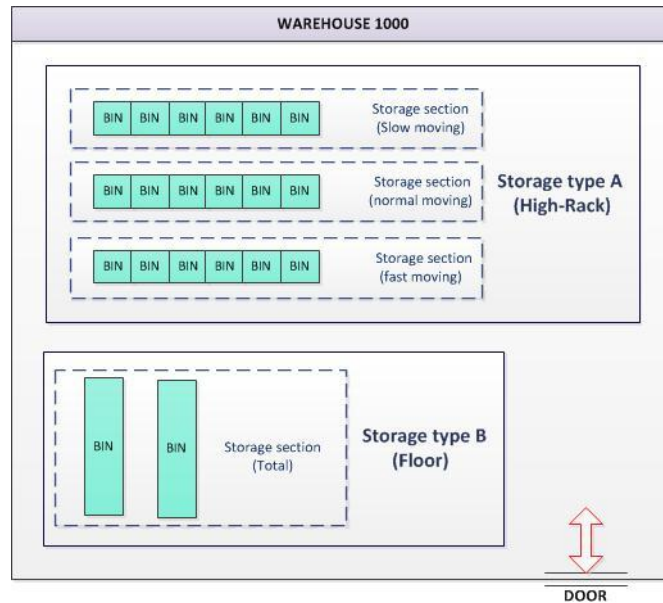


Figure 3.2 Storage type, storage section and storage bin

WM module contains four basic organizational units: warehouse number, storage type, storage section and storage bin illustrated in Figure 3.2. A mix up may occur between storage location and storage type. Attention on the naming, storage location is an IM concept while storage type is a WM concept. The best way to understand the warehouse management module and application is to analyze each level of the organizational structure one by one. The lower the level is, the more it precisely indicates the product position in the warehouse.

3.4.1 Warehouse Number

A single warehouse number is assigned for each warehouse complex. The warehouse number can be used to manage several storage types located in one or more buildings (SAP documentation, 2001). This three-digit number represents the organization and physical side (Fu and Fu, 2003). For example, the warehouse number of Dow Corning Seneffe is “041” and represents the whole group of storage areas and warehouse complex on this site.

Generally, this organizational unit is directly connected with one or several storage location(s) (see red dotted line in Figure 3.1). As presented in Figure 3.1, the warehouse number of WM level typically maps one storage location, although SAP new version allows mapping several S-locs to one warehouse number. In the example, WMS is implemented on those two S-locs but the three others are not WM managed.

3.4.2 Storage Type

The storage type represents the warehouse facilities that compose the warehouse complex. In other words, the storage types are a subdivision of a complex, physical warehouse. These storage types are classified by their spatial, technical and organizational characteristics (Kappauf et al., 2012). Each storage type belongs to one warehouse number. Appendix 2 gives an example of a “storage type view”. Basically a storage type is composed of one or several storage bins.

The storage type is a key level in the study of putaway and picking processes since the strategy are defined at this level (see sections 3.7.2 and 3.8.3). The way a material is placed in this S-type depends on the “putaway strategy” of this S-type. Each putaway strategies available are explained in details in section

The most frequently defined storage types are the bulk storage⁵, open storage, high rack storage, picking area and shelf storage (SAP documentation, 2001). There are also some “interim storage areas” that represent locations needed to make the link between IM and WM application component and so, keep the system consistent. There are 61 S-types in Seneffe including 16 interim storage areas. Figure 3.2 illustrates a simple warehouse layout with two storage types: high rack and floor.

3.4.3 Storage Section

Within a storage type, storage sections (S-section) combine all storage bins having the same homogenous features. This level is specifically used for the purpose of defining putaway strategy (Kappauf et al., 2012). The firm may define the criteria for such groups as required. S-sections usually organize fast, normal and slow moving materials. This case is actually an application of the ABC method explained in section 2.4.1.

However other classifications are allowed. One could also use the S-sections to organize materials placement differently, i.e.: sealants on one side of the building, medical material on the other. Such an organization can help with the receiving/placement operation as incoming trucks for one type of material can be allocated a door/staging area closer to these racks. In the example provided in Figure 3.2, the storage type “high rack” is subdivided into three storage sections according to their accessibility. Storage zone the closest to the door is fast moving.

⁵ Bulk storage: storage in a warehouse of supplies and equipment in large quantities, usually in original containers, as distinguished from bin storage. [www.thefreedictionary.com]

3.4.4 Storage Bin

A storage bin denotes a little storage space (or slots) in the warehouse. The stock is managed at this level. In this way, each storage type and each storage section gather a range of bins. In Figure 3.2, each storage section of the storage type “A” consists of 6 bins. Bin coordinates provide exact location of a material/pallet. Thus, every storage bin is mapped in the system and monitored at all time. The coordinate 01-02-03 for example, refers to a storage bin in row 1, stack 2, and level 3 (Mc Donald et al., 2002). The bins represent the smallest available unit of space in a warehouse. There are quite a lot of parameters that are defined at this level. Figure 3.3 is a print-screen of a storage bin view in SAP.

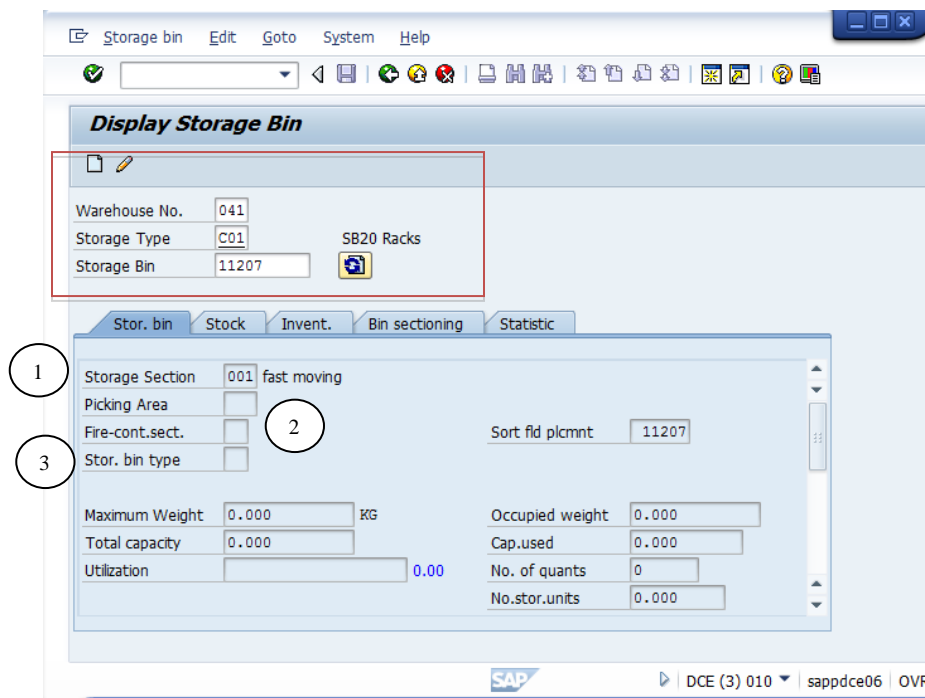


Figure 3.3 Storage bin view

The top of the print screen in Figure 3.3 (red rectangle) provides basic information about the bin: the warehouse number (041 stands for Seneffe), the storage type which the bin belongs to (C01) and the storage bin name/number (11207). Each storage bin is defined with a range of parameters. It is important to understand most of them to be able to make recommendation about the use of the system.

- *Storage Section*: each storage bin belongs to one storage section. A bin cannot belong to more than one storage section. On the figure, bin 11207 belongs to fast moving storage section (marker 1).

- *Storage bin type* is related to physical criteria of a bin. Bin types are used to subdivide storage bins into groups (e.g. large bins and small bins). Table 3.1 shows storage bin type recorded in SAP system of Seneffe. C1 denotes a chemical pallet (120*120) between 85cm and 1m high.

Code	Name	Height	Code	Name	Height
A2	All pallet	1.6m	E1	Euro-pallet	.85-1m
A3	All pallet	1.82-1.9m	E2	Euro-pallet	1.37m
A4	All pallet	2.2-2.35m	E6	Euro-pallet	2.87m
C1	Chemical pallet	.85-1m			
C2	Chemical pallet	1.37m			

Table 3.1 Storage bin type (DC Seneffe)

The storage bin type plays a significant role in optimizing the automatic putaway strategy. This parameter allows to find a bin in connection with the pallet type. For example, you can define the WM putaway strategy to place large industrial pallets into a specific large bin type and smaller pallets into small bins. Figure 3.3 shows that Dow Corning does not maintain this parameter for each bin (marker 3).

- *Maximum weight*: Maximum total weight allowed in the storage bin without affecting the stability of the shelving or rack assembly frames. During stock placements, the system calculates the difference between the maximum weight allowed and the weight already in the bin. If the weight of the material to be placed into stock is greater than the remaining capacity, the material cannot be placed into this storage bin.
- *Quant*: a “quant” is a quantity of any material with same features in a single storage bin. It depends on material number and the batch (a batch is a serial number that indicates the accurate information about process of production). If one of the two fields is different, the quant is different. If two pallets of material X with the same batch XYZ are stored in the same bin, the number of different quant in this bin is 1. However if there is a quantity of the same material in a bin that has two separate batch numbers, for example, there would be two quants in that bin (SAP documentation, 2001). This field helps to perform accurate inventory management of an item at the storage bin in regards to the batch of this item. The quant record contains several data such as: quant identification, plant, material number, batch number, stock category, special stock indicator and number.

Appendix 1 provides other bin parameters that are less important for picking and putaway study.

3.5 Material Master

Products information is centralized in SAP systems under the term “material master”. It records all required information regarding the materials that a firm produces, stores and sells (Kappauf et al., 2012). The warehouse management strategies work by relating the warehouse configuration, the bin master data and the material master data. The previous sections have already presented the warehouse configuration and also the bin parameters. Therefore, this section presents the material parameters

Data in material master is divided into individual areas called “*views*”. Information about material is grouped together according to respective department: e.g. accounting view, costing view, sales view, etc. The purpose of this section is to present useful parameters for the picking and putaway study. Thus it will specifically analyze the warehouse management view that will be useful for further investigations.

A material is recognized in the system with a unique seven-digit material number (e.g. 1919271) or its complete name (e.g. Q2-1353 6,000 CS, KG, 200 KG-DR). This name often describes also the type of packaging (e.g. 200KG-DR stands for drums of 200 kg). Most important information for putaway and picking activities is depicted in the general warehouse view data.

- *Base unit of Measure*: Unit of measure in which stocks of the material are managed. The system converts all the quantities you enter in other units of measure (alternative units of measure) to the base unit of measure, e.g. “Dr” indicates that the material is stored in drums (see Appendix 3).
- *Hazardous material number*: this number identifies the material as hazardous. It also indicates specific storage rules.

Companies often manage different category of products: good products, low quality product. In that purpose, a material is loaded under three statuses. Materials that have exceeded the “maximum storage date” are not classified as “unrestricted” but as “blocked”. Indeed, at Dow Corning, common products can be sold until 3 years. Products that have exceeded this date are classified as blocked.

- *Unrestricted*: this is the general status. When a material is referred as “unrestricted”, it can be used in production or sold to customers. In that way, we ensure that only good quality products are picked for delivery.

- *Blocked*: if a material is in “blocked” status, it cannot be used in production or for customer orders. When a material receives a poor quality rating, the team in charge of it will block the product so it cannot be used anymore.
- *Quality Inspection (QI)*: when a material is produced and a goods receipt is done it can be put in “QI” status until the quality test results are entered. When the test results are good, the status is changed to “unrestricted”. If they are bad the material status is changed to blocked (Kappauf et al., 2012).

SAP provides other not mandatory options to manage products according to batches. A batch is a serial number that indicates the accurate information about process of production (date, ingredient, quantity...). This field is important for chemical industry, as legislation requires this traceability. Further information about batch management for Seneffe is provided in section 4.2.3.

- *Batch management*: a batch in the materials management system is defined as a subset or partial quantity of a material that is managed separately from other subsets of the same material (Kappauf, 2012). Typical examples of batches include different production lots (such as pharmaceutical products), delivery lots, or quality grades of a material. This parameter is especially important in the study of stock removal policy (Landriani, 2012).

Finally material master records some “palletization” data interesting for storage constraints:

- *Loading Equipment (LE) quantity*: the system uses this field to make propositions on how to pack a quantity. It indicates how much quantity is allowed to put on a single pallet, e.g. if LE quantity is 4 drums then it means that maximum 4 drums can be placed on a pallet.
- *Storage Unit Type (SUT)*: this indicator allows to distinguish pallets of varying sizes. It checks if the specific packaging can be placed in the bin chosen for placement. Table 3.2 shows existing SUT in Seneffe. Similar to “bin type” parameter, SUT C2 denotes a bin that can store chemical pallets of 1.37 meter height.

Code	Name	Height
C1	Chemical pallet	.85-1m
C2	Chemical pallet	1.37m
C3	Chemical pallet	1.6m
C4	Chemical pallet	1.82-1.9m
C5	Chemical pallet	2.2-2.35m

Code	Name	Height
E1	Euro-pallet	.85-1m
E2	Euro-pallet	1.37m
E3	Euro-pallet	1.6m
E4	Euro-pallet	1.82-1.9m
E5	Euro-pallet	2.2-2.35m
E6	Euro-pallet	2.87m

Table 3.2 Storage unit type (DC Seneffe)

The storage unit type and storage bin type ensure the compatibility of a pallet with a bin. High rack storage is frequently designed in such a way that a storage bin can accommodate several storage unit types. In the opposite, some bins are smaller than other and may be not large enough to store chemical pallets (120*120 cm) which are larger than europallets (80*120cm). Smallest SUT can so be stored in all bin types while highest SUT can only be stored in the highest bin type.

A storage bin type must be assigned to each storage unit type. Table 3.3 depicts this relation. We can see that storage unit type is loaded on material master. Material “1” has a storage unit type “m1”. Bin “a” is classified as a bin type “ba”. Might material “1” be stored in bin “a”? Yes, since compatibility sets that SUT “m1” can be stored in the three types of bin (ba, bb, bc). However, material “3” might not be stored in bin “a” because it has to be exclusively stored in a bin type “bc”. The example of storage bin type indicator for Seneffe is given on Figure 3.6.

Material Master		Bins		Compatibility			
Material	SUT	Bin	BinType	SUT	BinType1	BinType2	BinType3
1	m1	a	ba	m1	ba	bb	bc
2	m1	b	ba	m2	bb	bc	
3	m3	c	bb	m3	bc		
4	m2	d	bc				
5	m3	e	bc				

Table 3.3 Link between storage unit type and bin type

These relations allow appropriate putaway strategy to be performed (see section 3.7.1 for further information).

3.6 Goods Movements and Documents

Each change in the inventory level or warehouse placement is initiated by a “goods movement” (Gu and FU, 2003). This section explains the most important ones. These goods movements are identified by a three-digit *movement number* in both interfaces: IM and WM. For instance, the key 101 describes a good receipt (for work or purchase order). The movement types provide information at different levels of the system.

- A *goods receipt* provokes automatically an increase in the stock. The respective functions of IM and WM are the following ones: goods receipt is posted in IM and WM distribute consequently the items from the interim storage area to a storage bin in the warehouse.
- A *goods issue* is recorded when a material is withdrawn, issued (when a shipment of goods to a customer takes place), consumed, or when materials are returned to the supplier. A goods issue leads to a decrease of the inventory level.
- A *transfer order (TO)* is the document created in the WMS that contains all the information needed to carry out the physical movement of material. It specifies the direction of the goods movements (for example: from one storage bin to another). A warehouseman executes a movement of goods within a warehouse on basis of this document. TO reporting keeps tracks of all movements performed inside the site. It will be very useful for our putaway analysis. Appendix 3 provides a print screen of a transfer order with its parameters. “TO Number” is the unique seven-digit code to identify a transfer order. Each “TO” indicates the material number and the batch of the item to be removed with the source/destination storage bin and storage type (see Appendix 3, figure 2).

3.7 Putaway

One of the trickiest points of this chapter is to understand where the stock placement and stock removal processes take place in the SAP organizational structure. Stock placement inside a warehouse is an important point for each company. This strategy is a key element because it influences the overall handling time to put and to retrieve the stock from the warehouse. Company has the choice to use SAP proposals to assign a product to a storage location or can do this manually.

In case of *manual stock placement*, there are two main ways to decide the position of a material. With random storage policy (see section 2.5), the operator decides where the product must be placed. If a dedicated storage policy is used, the operator knows in advance the area dedicated for the product. SAP system offers the possibility to find the optimal storage location automatically, it is *the stock placement control*. The purpose of this system is to efficiently find an optimal storage bin while utilizing available stock capacity and taking into account operational requirements (e.g. specific storage rules) (Kappauf et al., 2012).

3.7.1 Organizational Level

If the automatic stock placement policy is used, the stock placement strategy will take place on WM level. Indeed the material master contains information about the storage location (IM level) in which the material must be loaded and received. Beside this IM-specific element already known for each product, the tricky decision is to place the product in the most appropriate slot in the warehouse. This slot is actually the smallest organizational unit of the SAP structure: the bin.

The stock placement control is executed on three levels: store type, storage section and storage bin. Determination procedures are primarily based on search strategies that first attempt to find the best storage type. Appendix 6 shows the configuration of SAP warehouse strategy. The three can find those three levels on the print screen.

- **Storage Type Search:** the system determines in which storage type the material should be put away. Storage type determination is controlled by a search sequence. The storage type list is set up in a hierarchical form. First, the system searches for empty bins in the first storage type, then in the second storage type, etc. This storage type indicator depends on the status of the product (block...). Figure 3.4 gives an overview of some storage type indicator of Seneffe (configuration view). The first column gives the warehouse number: 041 for Seneffe (Figure 3.4, cursor 1). The third column is the name of the indicator: A01 (cursor 2). There are three indicators with the same name but a different sequence depending on the status of the product: fourth column. The last columns provide information about the storage type sequence (cursor 4). A product with the storage type indicator equals to A01 without any restriction (third column is empty) can be stored in any storage type. A product with the storage type indicator “A01” and status blocked for inspection quality (Q) is stored in storage type “A01” as a priority. If this zone is full, the product will be placed in S-type A02, then A0D.

Determine Stor.Ty.Search Sequence												
W..	Op...	TyIn...	S..	S	Stor...	W..	Re...	S..	1...	2...	3...	4...
041	A	A01				0	319	S1	***			
041	A	A01	Q			0	0		A01	A02	A0D	
041	A	A01	S			0	0		A01	A02	A0D	

Figure 3.4 Examples of storage type indicator

- Storage Section Search:** after the system has selected the S-type, storage section determination is performed inside the appropriate S-type on basis of the storage section indicator. Storage section indicator is the key used by the system to determine how a material is to be placed into a particular storage section rather than in another one. A classical case in which storage section search is used, is to ensure that frequently used materials ("fast-moving" items) are stored in the front of the warehouse while seldom-used materials ("slow-moving" items) are stored at the back of the warehouse. Figure 5.4 provides a configuration example. A material placed in storage type C21 (cursor 1) with storage section indicator (SA ID) 002 (cursor 2) will be placed in priority in section 002 (002 is the section normal moving in Seneffe), then in section 003 (slow moving in Seneffe) and if previous area are full, in section 001 (fast moving).

Determine Stor. Sec. Search Sequence										
WNo	Typ	SA ID	Stora...	WPC	1...	2...	3...	4...	5...	
041	C21	002		0	002	003	001			
041	C21	003		0	003	002	001			
042	C01	001		0	001	002				
042	C01	002		0	002	001				

Figure 3.5 Examples of storage section indicator

- Storage Bin Search:** once the storage type has been determined, the system then searches within the storage type to find an appropriate storage bin in which the material can be put away. In order to find the destination storage bin, the system uses a search strategy that has been defined for the storage type: the putaway strategy (see section 5.8.3). For each storage type you can define this putaway strategy that will establish the sequence of searching a bin inside this S-type. Storage bin search indicator will indicate in which bin type the material can be stored. Figure 3.6 shows that in warehouse 041 (Seneffe), Storage unit type indicator C2 (see cursor 1) can be placed in storage bin type C2, A2, A3, A4, A1, E6 (cursor 2).

Assign storage bin types to storage unit type								
W...	SU...	1...	2...	3...	4...	5...	6...	7...
041	C2	C2	A2	A3	A4	A1	E6	
041	C3	A2	A3	A4				2
041	C4	A3	A4					

Figure 3.6 Examples of storage bin type indicator

In other words, actual selection of the storage bin is based on a sequential search strategy. If during this search, no free bin is found inside the first indicated storage section, the system checks inside the other storage sections. If no bin is found for the other storage section, the systems check for the other storage type indicated in the sequence (Kappauf, 2012). Our study of the putaway strategy must imply a review of those indicators.

3.7.2 S-type Putaway Strategies

SAP automatic stock placement is called “Putaway strategy”. When a transfer order is created, the system proposes the optimal storage bin in such a way that the operator does not interfere when it comes to find the storage bins. This guarantees that stock movements are processed quickly and consistently. We will see in the future section that even if the system proposes a powerful tool to automate processes, a central problem is that employees prefer to proceed manually and decide themselves the best slots for an item.

In the Warehouse Management (WM) application component, the putaway is used by the system to search for storage bins in the most expeditious manner. When the Storage type sequence has been defined, it is important to decide the strategy thoroughly. Table 3.1 depicts the strategies proposed by SAP:

Strategy code	Strategy name
	Manual stock placement
F	Fixed bins
C	Open Storage
B	Bulk Storage
L	Next empty bin
I	Addition to existing stock
K	Near Picking bin
P	Storage unit type
Q	Dynamic coordinate quant number

Table 3.1 Summary of the putaway strategies

Manual Entry: The system does not use a strategy to search for a storage bin. The user manually enters the destination storage bin when the transfer order is created.

Strategy F= Fixed Bin Storage. This putaway strategy is used when a material is to be stored in a fixed bin in a storage type. This strategy is used primarily in storage types from which picking is done manually. It is a dedicated storage policy (see section 4.6) where products have a specific location (see Appendix 4 for picture).

Strategy C= Open Storage. Open storage is a type of warehouse organization in which you define a single storage bin for a storage section. Therefore, materials are randomly stored inside this S-type (see Appendix 4 for picture).

Strategy B= Bulk Storage. Materials that occur in large quantities and generally take up a lot of space in the warehouse (for example large batch of big bag pallets) are often stored in bulk storage. Bulk storage strategy is appropriate for large quantities that take big place in storage bins. Stackable products are usually placed in a S-type defined with this strategy. The advantages of bulk storage include reducing need for physical storage bins, a fast access to the trading units and a clear structuring of the warehouse into rows. In practice, a row is treated as the control unit in bulk storage. In WMS a row is created and managed as a storage bin. The storage bins (rows) are classified according to storage bin types (see Appendix 4 for picture).

Strategy L= Next Empty Storage Bin. The system proposes the next empty bin according to bin number. This strategy is especially suited for high rack storage and shelf storage (E-university, 2012).

Strategy I= Addition to Existing Stock. When addition to existing stock has been defined as a putaway strategy, the system places goods in storage bins that already contain the same material. A prerequisite for addition to existing stock is that sufficient capacity still exists in the respective storage bin (see Appendix 4 for picture).

Strategy K= Near Picking Bin. This putaway strategy is used when a material is to be placed in a reserve storage area. The system does not search to see whether a fixed storage bin is available or not.

Strategy P= Storage Unit Type: Using this putaway strategy, the system processes different storage unit types (combination of loading equipment and packed material) and allocates them to the appropriate section. For example a storage bin can accommodate a number of pallets

depending on the size of the pallet, such as three standard pallets (80 x 120) or two industrial pallets (100 x 120). A storage bin may be able to accommodate a single oversized pallet or several very narrow pallets (see Appendix 4 for picture).

Strategy Q= Dynamic coordinate quant number: this putaway strategy is mainly for warehouse with high capacity utilization rate. If initial putaway is not possible at one point, a dynamic storage bin coordinate may be used to temporarily store the material that is to be put away in another location (such as the identification point, or ID point).

We can find those strategies at the storage type level in Appendix 2. The selection of the right strategy for a storage type depends on several elements: physical bin disposition inside the S-type, storage procedure, type of material store inside, etc.

3.8 Picking

In logistics, picking is the act of choosing and selecting a material or a group of material for shipment (Ghiani et al., 2004). SAP's definition says that picking process involves taking goods (pursuant to the respective delivery requirements) from a storage location, and staging the right quantity in a picking area, where the goods will be prepared for shipping (SAP documentation, 2001). This selection of required items over the warehouse has to be efficient to ensure optimal cost and time. During the delivery creation, the system or the person in charge of this task selects the right products to be delivered. When the correct batches are selected, a strategy can be used to decide which pallet must be taken in priority.

3.8.1 Organizational Level

SAP provides possibilities to execute stock removal control on both levels: inventory management and warehouse management. The first step is the selection of the right product/batch among the stock according to customer requirements. This is called the "batch search strategy". This material selection takes place on IM level.

In many situations, picking management can become a tricky task for large batches. For instance, if the same batch is dispatched among several locations on a site, it is important to decide which article/pallet is going to be selected first. It is possible to choose a stock removal strategy per S-type (WM level).

3.8.2 Batch Search Strategy

There are various materials that may no longer be used or sold after a certain time period. These products are normally assigned a “shelf life expiration date”. If the product is to be delivered in batches, the system should automatically determine the batches appropriately during the delivery. This concept of batch determination is primarily used in Pharmaceutical, Chemical and Food industries, where a batch closer to its expiration date must be delivered first to comply with the FIFO⁶ rules (Jain, 2010). Besides, important customers may also want only products which have a remaining shelf life of a certain number of days after it is being delivered. Plus, important customers may require additional specification. An example at Dow Corning is that the most important customers such as Procter and Gamble do not accept batches older than six months. The batch search strategy is used to check for these particular specifications and select the right batches.

Here is an overview of the batch search methodology. The system carries out the following steps in succession (SAP, 2001):

- It starts automatic batch determination according to the search strategy defined at different levels (customer level, material level...).
- It uses the characteristics from the selection class of the search strategy to look for batches with suitable specification.
- It checks whether the batches are available
- It sorts the batches that were found and are available according to the sort rule from the search strategy (e.g. FIFO) and proposes right batches to be picked.
- The system selects the right quantity in accordance with the requirement of the customer order.

3.8.3 S-type Picking Strategies

Once a batch is selected, the system may process a strategy in WM to choose which pallets of the selected batch should be retrieved first. In the same perspective as for putaway, it is the strategy implemented at storage type level. However this option is less important in that study because Dow Corning Seneffe has not implemented it. Since the chemical industry performs order

⁶ FIFO is an asset-management and valuation method, in which the assets produced or acquired first are sold, used or disposed of first. FIFO may be used by an individual or a corporation. Source: <http://www.investopedia.com>

picking on basis of the batch number, the place in the warehouse is less important. Picking strategies are presented in

3.9 Key Takeaways

SAP system is a very broad and difficult subject to present. Previous sections deal with a relatively complex organizational structure and parameters. The objective of this section is to understand how the system works and to highlight the parameters involved in the putaway and picking. This theoretical basis is absolutely necessary to accurately review the organizational structure and the parameters of Dow Corning Seneffe's ERP. In order to outline all this content, the following key points are taken into account in the analyzed case study:

- A storage section (IM concept) may be divided into storage type, storage section, and storage bins (WM concepts) to accurately manage the positions of the items inside a complex warehouse.
- Putaway strategy takes place at WM level while picking strategy may takes place at IM and WM level is the products are batch managed.
- Stock placement strategy is performed at three level of WM. First, the system searches for a storage type (s-type indicator), then a storage section (s-section indicator) and finally a bin within the indicated s-type and s-section.
- Storage Unit Type and Bin type are important parameters to ensure an appropriate putaway strategy (physical constraints).

4. Dow Corning Seneffe

In the previous chapters, an overview of the logistic theory and SAP warehouse components is given. This section provides the information needed to analyze the case while already identifying areas of improvement. A general presentation of the firm is given to provide the background. Furthermore the logistic flows inside the company are explained to illustrate the relationship between Feluy and Seneffe but also between the different buildings of the site. From a more specific standpoint, warehouse SB20 is described with the current putaway and picking activities performed inside it.

4.1 Company Presentation

This section is going to present the company to understand the context of research. Dow Corning Corporation (DC) is an international American company that develops its activities in the chemical industry. Dow Corning's core business is the production of silicone and silicon-based technology. It is the global leader in this branch. The firm offers more than 7,000 products and services all over the world for more than 25,000 clients. Dow Corning is also strong and healthy financially since it counts \$5.09 billion of sales in 2009 (Dow Corning presentation, 2010).

Historically, DC is the joint venture of Dow Chemical Company (leader in specialty chemicals products) and Corning Incorporated (manufacture of plastics, chemicals and agricultural products). In 1943, both firms decided to merge to explore the potential of the silicon. DC appeared in Belgium in 1970 with the first building of Seneffe site. The company is headquartered in Midland (USA) and owns manufacturing and distribution centers all around the world. The main countries in which Dow Corning is present are the USA, Brazil, Western Europe and India.

Dow Corning is very innovative. It owns approximately 5,000 active patents. More than 5 percent of its annual revenue is spent on R&D and between 10 and 15 percent of DC's silicone sales are from products and services less than five years old. Moreover, DC is strongly focusing on innovation to support sustainability and society's needs. Seneffe Site has recently opened a new building dedicated to research for sustainable development and clean energy. It is also a member of Responsible Care ® program that has the objective of improving the health, environmental performance and the security in chemical industries.

DC Seneffe is a production and partially storage site that comprises three buildings called SB20, SB02 and SB60. It manufactures mainly two lines of product: sealants (core) in building SB60 and advanced silicon (emulsions/ dispersions/ antifoams) in building SB02 and SB20. The topic is strongly devoted to SB20 analysis as this is the main warehouse. It stores raw materials and some finished goods are shipped directly to customers. SB20 also houses two production machines: EAF and SSAU that manufacture antifoam powder in “big bag”.

Dow Corning Europe has recently opened a new distribution center in Feluy that replaces the previous one in Houdeng. This point will be important in this research because loads of goods are transiting between both locations. Most of the production of SB02 and SB60 is directly shipped to Feluy.

The company actually owns two distinct brands: Dow Corning ® (innovative products) and Xiameter ® (functional products). Dow Corning ® represents 60% of the total sales (dollar amounts) while Xiameter ® 40% (Dow Corning Presentation, 2010). The Dow Corning ® is largely focusing on innovation and specialized silicone. The high-priced products are silicon-based material and technologies. The brand offers customized technical services and face-to-face visits due to the technical nature of the offer. Order entry is made by phone, fax, email, website (dowcorning.com). This part approximately contains 7,000 specialty products and services. In contrast, Xiameter ® proposes standard silicone products with a minimum, multiple and maximum order quantities. Xiameter ® proposes lower prices than Dow Corning ®. This is justified by a standard technical support via phone/ email and self-service order entry on the website of the brand. There are 2,100 products under the brand Xiameter.

4.2 Logistics

The objective of each company is to keep the supply chain and the processes optimal. Besides, the goals of a warehouse or a distribution center have been achieved when every customer order is completely ready for dispatch and when all involved activities are carried out within the shortest time (Hompele and Schmidt, 2007). This is the philosophy of DC logistics team. This section presents an overview of the logistic system.

4.2.1 Stocking Strategy Seneffe-Feluy

Dow Corning Seneffe has its own Distribution Center in Feluy. It is about 15 minutes drive from Seneffe. This building was created to replace the former warehouse in Houdeng. The site of Seneffe has a limited storage capacity (6,500 pallets) while Feluy site has a capacity of 42,000 pallets. Figure 4.1 shows the flows of RM and FG between external suppliers, Seneffe, Feluy and the customers. This chapter deals with the strategy to manage flows of product between Seneffe and Feluy. How do we decide to keep the production in Seneffe or to ship it directly to Feluy?

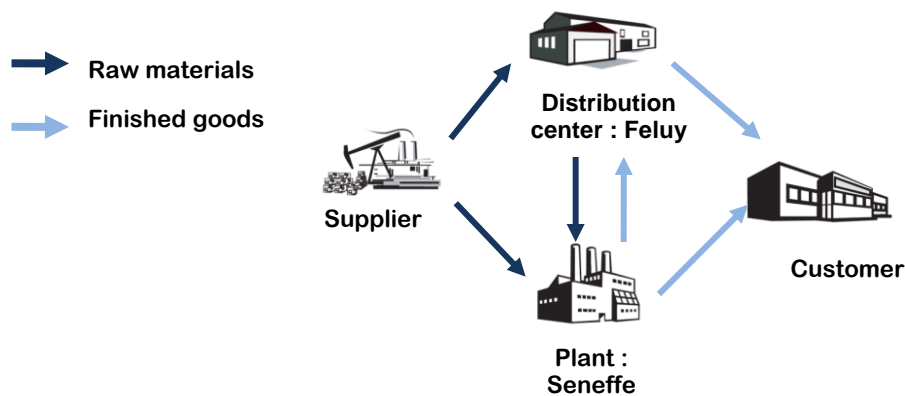


Figure 4.1 Materials flow Seneffe-Feluy

The basic rule is to keep in Seneffe products that are delivered directly to clients by full trucks and ship partial trailers to Feluy in order to consolidate⁷ them. Another reason to ship products to Feluy is to keep the “safety stock” and the “strategic stock” in two different facilities. The safety stock is compute by the system on the basis of sale history. Beside, a key client (e.g. P&G, Henkel...) may ask for a safety stock higher than the safety stock proposed by SAP: it is the strategic stock. Indeed, if DC is the only provider of an important raw material, key clients want to be supplied in any case. Hence, Dow Corning keeps a strategic stock to be sure to provide those clients. The rationale of the strategic stock is up to withstand long holdups or scarcity due to machine failures, strikes or other problems. Keeping the strategic stock or safety stock in Feluy protects the company in case of problems in the production site.

As explained in the first section, the type of logistic strategy is an important parameter to begin a warehouse analysis. Dow Corning Seneffe is mainly a “make-to-order” supply chain since 80.9%

⁷ Consolidate definition: combining several smaller shipments into a full container load or a large shipment to avail of better freight rates (also called “groupage”). [<http://www.businessdictionary.com>]

of the items from Seneffe and Feluy plant does not have a safety stock⁸. In theory, such a make-to-order strategy works with lower stock. However, some constraints such as the level of “rounding value” (this parameter is the multiple of which the system rounds up the procurement quantity) or “minimum lot size” imply to order a larger quantity than is required;

The coordination between both organizations and external stakeholders implies important flows of SAP information throughout the supply chain. Appendix 8 provides a schematic view of these information flows between Seneffe, Feluy, customers and other DC plants.

4.2.2 Intra-site Material Flows

Before going more into details, the aim of this subsection is to provide an overview of the whole materials flow of the site. It will allow having a global understanding of SB20 products’ source and destination zones.

Figure 4.2 shows the material flows inside Seneffe site (Appendix 9 provides a more complete figure). Light blue arrows denote bulk material and the dark blue pallets. Numbers above and under the arrows indicate the quantity (expressed in thousands of tons) that is flowing between the different buildings per month. Green squares indicate maximum storage capacity of the buildings (e.g. SB20 has a storage capacity of 5,500 tons). Seneffe receives intermediate material mainly from Antwerp port, Feluy distribution center and other Dow Corning sites (mainly Barry and Midland). Raw materials come from Feluy and other suppliers. Once a truck arrives at the gate, it is dispatched to the right building.

In order to focus on the scope of analysis, let’s describe the inbound and outbound flows of the SB20. As displayed in the Figure 4.2, the building receives raw materials and intermediate materials either pallets or bulk. The flows between SB20 and SB60 are important (in both directions). SB60 receives roughly 1,000 thousand of tons (intermediate and raw materials) per month from SB20 and ship 2,700 thousand of tones to SB20. Expeditions from SB02 and SB60 are typically shipped directly after production (no storage requires). It is not the case for SB20. For these reasons, the picking of pallets is exclusively performed in this building.

⁸ I have found this number by analysing material master report (see Appendix 7 for SAP report code). If the “safety stock” field is other than zero, this is a “just-in-time” production. Final results: 2,270 materials have a safety stock while the other 21,305 do not.

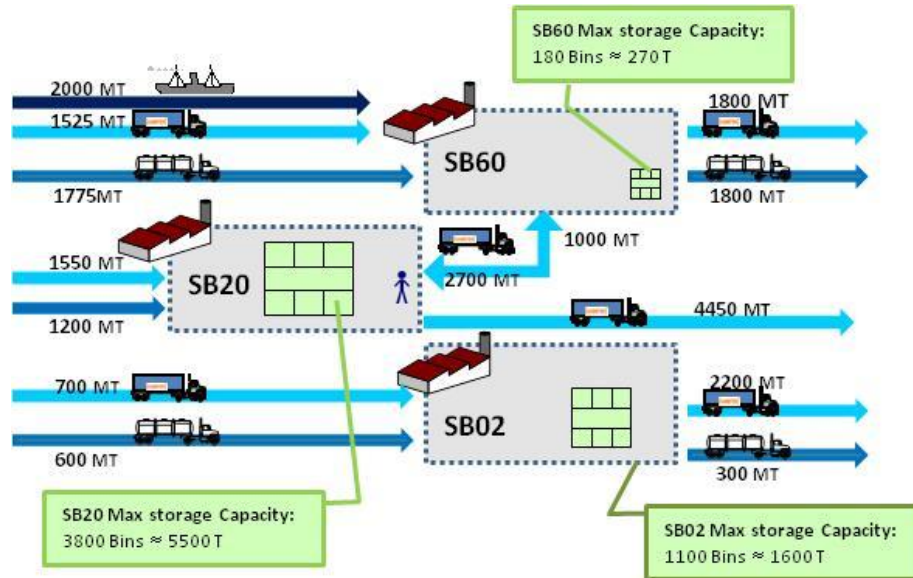


Figure 4.2 Intra-site material flows

4.2.3 Products, Storage Rules and Batch Management

As stated in Section 2.2, the warehouse analysis largely depends on the type of products and their characteristics. In that purpose, we are going to present DC products' characteristics. The company handles 4,602⁹ different items, which corresponds to the number of material loaded in the SAP system of Seneffe. As Regarding SB20, 518⁹ different products have been stored and handle inside the building. Dow Corning Seneffe manufactures three main classes of products: sealants, emulsions and antifoam products. The packaging of those products is numerous: drum, IBC¹⁰, pails, bottles. All these packaging's are placed on pallets. There are two types of pallets: euro- and chemical pallets.

It is important to define storage rules in a chemical company as Dow Corning that handles hazardous products. There are three main categories of products which require attention and for which Dow Corning has defined storage rules: corrosive products, toxic products and flammable products. They must exclusively be stored in a specific zone within the warehouse called "the red label". In SB20 and in many other DC buildings, the red label is a room with better safety systems such as fire extinguishers, alarms, lights, etc.

⁹ I have found these numbers by analyzing material master record.

¹⁰ An Intermediate bulk container (IBC) is a container used for transport and storage of fluids and bulk materials. [<http://en.wikipedia.org>]

Dow Corning Seneffe is working batch-managed materials. This characteristic is very important in the review of picking and putaway study. A batch is the quantity or partial quantity of a certain material or product that has been produced according to the same recipe, and represents one homogenous, non-reproducible unit with unique Specifications¹¹. These batches are denoted by a seven-digit serial numbers. This batch is used in addition to a material number to allow differentiation between an individual item and other materials with the same material number. The batch management is very important for many industries (food, chemical, pharmaceutical...) to ensure the traceability of products among the supply chain stages. Based on the complexity of batch characteristic or shelf life issue, efficient approach of batch management is required.

4.3 Warehouse Characterizations (SB20)

SB20 building is the main warehouse of Seneffe site. This facility accommodates approximately 4,000 pallets. The goods are stored onto racks or on the floor. There are two production lines manufacturing antifoam powder: EAF and SSAU. Those machines use the same basic raw material (RM): cornstarch¹¹.

Appendix 3 is a picture of SB20 inside disposition. It displays floor storage area, rack storage area and one of the two production machines: EAF (red shape in the figure). There are actually three storage categories in the SB20 complex:

- *Floor storage area* is the fastest access zone of the warehouse (see blue shape in Appendix 10). The goods are stored directly on the floor. The stacking height depends on the characteristics of the goods (Hompel and Schmidt, 2007). The bins are drawn on the ground and can store large numbers of stackable pallets. The normal lift trucks (picture given in Appendix 11) can manage the storage in this section. In this way, it is faster to move products from and to this zone than from or to racks.
- *High-rack storage area* is the biggest area of the warehouse (green shape in Appendix 10). Because of very narrow aisle, special trucks are required to put a pallet onto racks. In that way, we can consider that this type of emplacement is not an easy access storage compared to ground storage. There are 24 racks in SB20 building, each of them has six levels/floors.

¹¹ Cornstarch is the starch derived from the corn (maize) grain [Wikipedia].

- *Red label* stores hazardous products. This area has sprinklers, air exhaust equipment, and is connected to a drainage system called “a spill-proof retention pond”. There is no floor storage but only rack storage. As a reminder, certain hazardous products must exclusively be stored in this area.

4.3.1 Warehouse Processes

As stated in Section 2.2, the four main functions processed inside a warehouse are receiving, putting away, order picking and shipping. As stock placement and order picking are the subjects of this thesis, they will be detailed in further section.

- *Receiving* process is not very specific or does not require special attention at SB20 building. Products arrive by truck from external supplier, from Feluy or from other buildings of Seneffe site (as shown in Figure 4.2). At this step, products, packaging and quantities are checked to ensure it is the right order. A warehousemen placed the products in an interim storage area in order to quickly unload the trailer.
- *Putaway and storage* processes include the selection of a storage location for an item. A logistic operator moves the items from the interim storage area to the final location. This decision is based on the storage assignment policy explained in details in section 4.5.1.
- *Order picking* is performed manually at Dow Corning (there is no automatic system to retrieve items from their storage locations). Each morning, the operators receive the list of the items that must be retrieved from stock to fulfill an order. Each element of this order is prepared in the expedition zone (expedition zones are the green hatched shapes in Figure 4.5) before trucks arrive. SB20 exclusively performs picking of full pallets.
- *Shipping* is the final function of SB20 warehouse. It includes checking of materials and loading of trucks.

4.3.2 Warehouse Resources

Pallet racks are the most common type of storage systems in SB20 and are designed for the use of a standardized loading aid. There is only one unit load between the rack supports so that this system is a single bin storage system.

The different types of *trucks* used to transport pallets are also an important point to analyze. “Transpallets” are mainly used in EAF/SSAU part to move product from storage to the production machine. Normal forklifts (example of forklift of SB20 is shown in Appendix 11) are

probably the most frequently used trucks. Operators drive those forklifts to unload and load trailers. Finally high rack forklifts (see Appendix 12 for picture) have specific function. Those trucks stay at the beginning of the high racks. They are exclusively intended to cross the narrow-aisles. They execute their movements in two steps: vertical and horizontal movements. High-rack forklifts slow down after third floor when they vertically move.

AIDC (Automatic Identification and Data Collection) at Dow Corning involves some of the most advanced technologies, applications and integration capability that keep pace with their flexible supply chains and efficient processes. There are three core components to AIDC at DC (see Appendix 21).

- Data Capture identifies objects and gathers data immediately from a physical process that is taking place. Data may be captured “manually” by an operator using a device or “automatically” by systems designed to monitor the process.
- Data Transport is how they move and qualify (or enrich) the data to back end systems waiting to receive it.
- Data Integration unifies the data with Sap system and controls it to make decisions and record business transactions.

The workforce in SB20 is made up of height workers. They are divided into two distinct teams managed by two supervisors: general products and EAF/SSAU products. Four warehousemen take care of loading and unloading trucks for general products, two for EAF/ SSAU parts and the two remaining take care of feeding the production machines.

4.3.3 Warehouse Organization

Organization of activities inside warehouse SB20 is an important criterion in the analysis of picking and putaway strategy. It will influence the way SAP organizational structure is set up. They are two supervisors managing different activities. It is important to take this constraint into account because each supervisor has his own operators team and uses separate doors.

Concerning products reception, there is no specific assignment policy concerning the allocation of trucks to a dock door. Regarding logistic operators, each team has dedicated dock doors. EAF/SSAU team receives and issues products through the two doors near production machines (see Figure 4.5, doors on the right-hand side). General products team manages the thirteen doors

on the left-hand side. When a truck arrives, any logistic operators available of the specific team unload the trailer.

The current storage policy is mainly a class-based and dedicated storage policy. Most groups of items have a dedicated area in the warehouse e.g. client return must be placed in rack 32. Inside these zones, products are randomly stored.

The picking policy adopted in SB20 is very simple since SB20 picks full pallet. They do the round trip for each element of an order. Routing strategy or batch picking policy are implemented. There is no specificity about the sequence to pick elements of orders. The order is not relevant.

4.4 Organizational Structure

This section seeks to present the current WM and IM architecture in Seneffe. Figure 4.3 provides an overview of the current SAP structure in Seneffe. It is the basis of the whole analysis. Only few organizational units are depicted to keep the diagram as clear as possible. It is important to note that from an IM point of view, each S-type is linked with a single storage location: SENF (red shape in Figure 4.3). As this thesis focus on SB20 processes, this section widely focuses on organizational units belonging to this building.

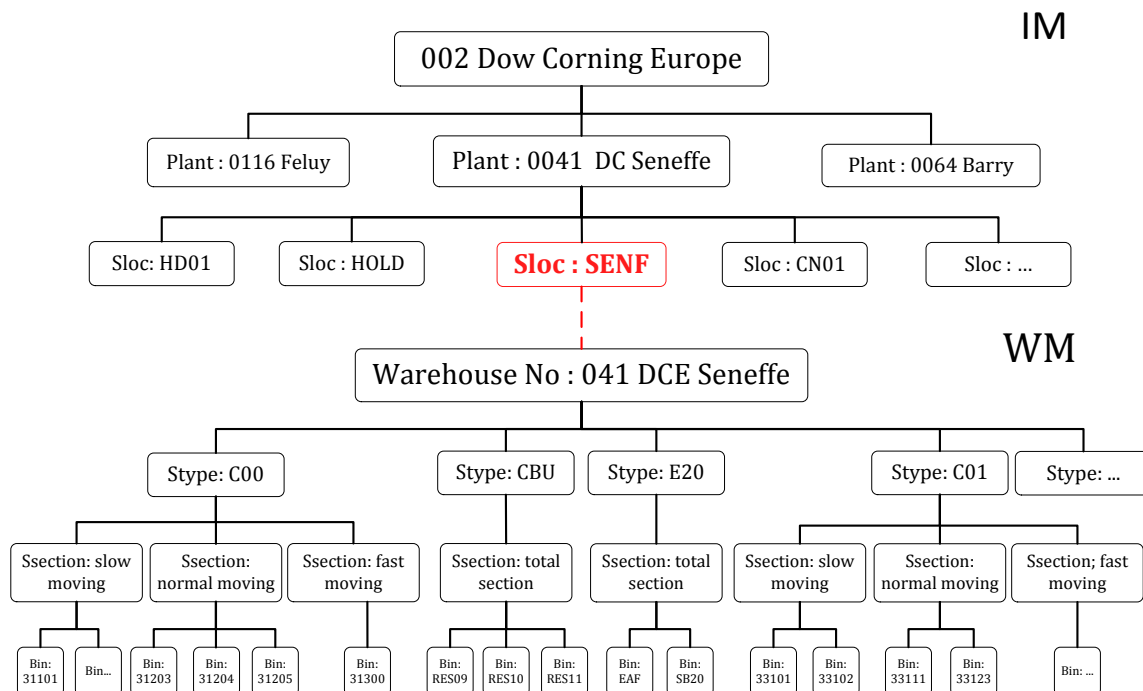


Figure 4.3 Organizational structure of SAP in Dow Corning Seneffe

4.4.1 IM Structure

IM analysis takes place at the storage location level. It is important to take into account the historical decisions about storage location to understand the rationale behind each element. The version of SAP software available upon the implementation was different from the current one. At that time, SAP allowed the WMS to be implemented on a single storage location. For these reasons, IT team and project managers decided to create the storage location SENF in order to manage the main inventory of Seneffe with WMS. At the beginning, there was a limited number of S-loc to manage tank storage (TK20, TK60, TK02), small pack area (SMPK) and so on. Appendix 13 gives the entire list of these S-loc with some words of explanations about their function.

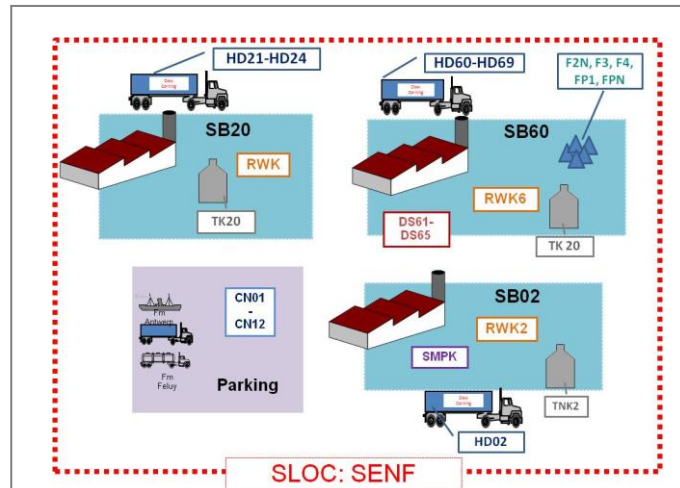


Figure 4.4 Storage location representation: as-is

Figure 4.4 offers a schematic representation of the main storage locations of Seneffe site. Each building is represented in blue and the parking in purple. The red square that surrounds the whole site represents the main storage location SENF. 97 percent of the materials in Seneffe are loaded on this S-loc. For this reason, the study of the storage locations cannot be limited to a single building but should involve the whole site. All storage locations (except SENF) on the figure are not WM managed. It means that it is not useful to have detailed information about the place of a product inside this S-loc. For example, S-locs “HDXX” represent trailers on the site (blue trucks in the figure). The trailers are filled as the products are manufactured. Once the trailer is full, it leaves the site. Hence precisions about pallets place are not useful.

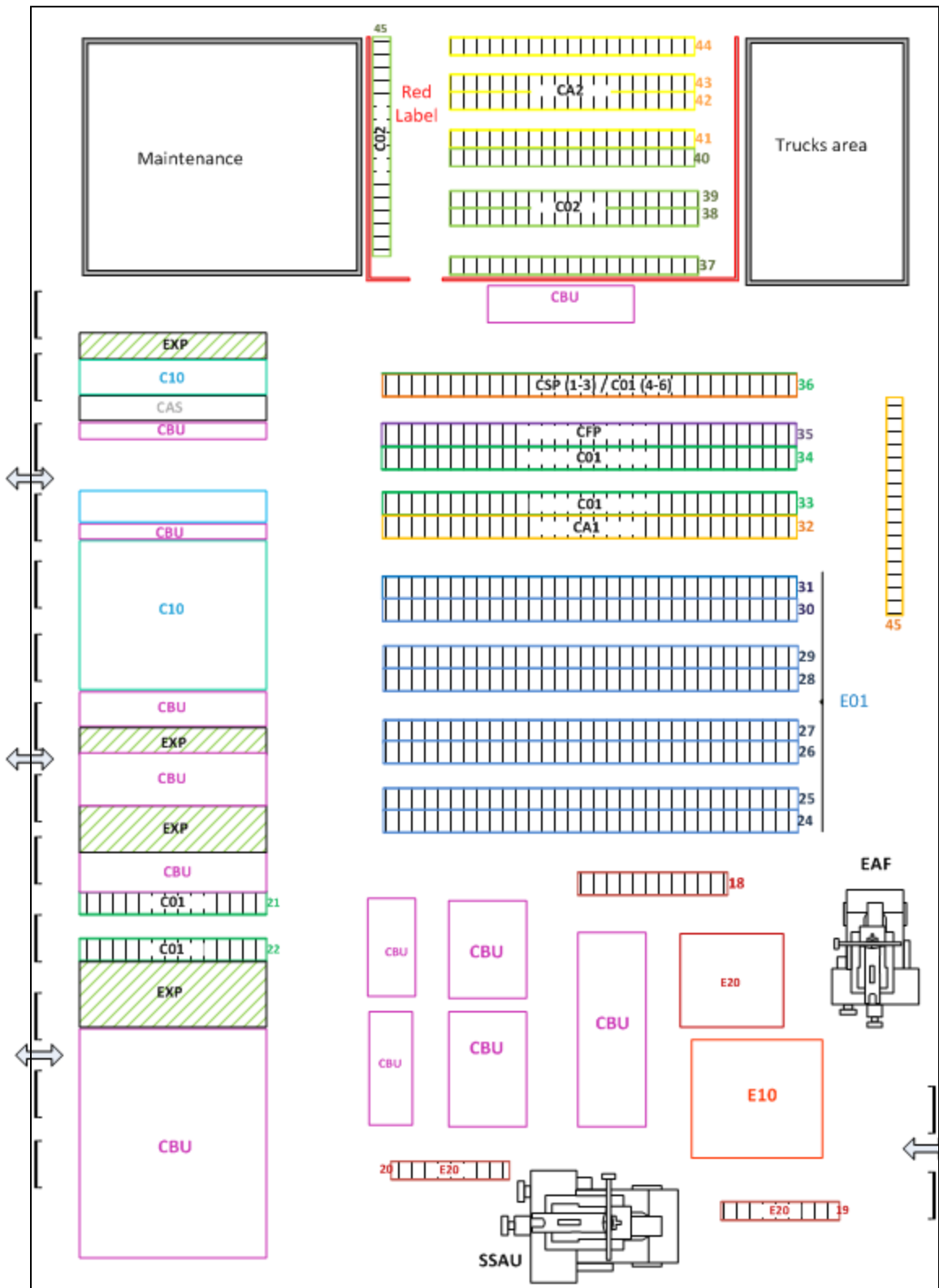


Figure 4.5 SB20 layout + S-types

4.4.1 WM Structure

As a reminder, we are focusing on SB20 building concerning the stock placement activity. Thus this subsection only presents organizational units linked with SB20. Warehouse number is not a challenging data and must remain the same.

4.4.1.1 Storage Type

The storage types of warehouse SB20 are represented in Figure 4.5 with different colors. Squared shapes represent the racks. The amount of S-types belonging to EAF/SSAU part is smaller than those belonging to the rest of the products. Indeed, the EAF/SSAU's supervisor philosophy is based on randomized storage policy while the general part philosophy is rather based on a dedicated storage policy, which requires a large amount of storage types. As stated above, those S-types belong to the S-loc "SENF": the only one managed by WMS.

- *CBU (pink shape)* in Figure 4.5): S-type CBU denotes a large part of the floor storage situated near the door. This S-type has a storage capacity of 776 pallets. Because it is easily accessible, we should store fast moving materials within it. This s-type largely stored Xiameter products since they have a high turnover rate and are produced in large quantity. The bins inside this area are designed in rows (width = width of one pallet). In that way, a bin is accessed via both sides (from the front or from the back of the bin).
- *C10 (turquoise)*: S-type C10 also represents ground storages. This S-type is dedicated to raw materials stored on the ground near the dock doors.
- *CA1 (yellow)*: it represents rack 32 and mainly stored customer returns.
- *CA2 (yellow)*: CA2 is the counterpart of CA1 for hazardous products in the red label. S-type CA2 includes 4 racks.
- *C01 (green)*: S-type C01 represents two locations in the warehouse. One part is situated in the rack area. It was initially created to store the cartons and empty cartridges since they are higher than general products. To allow the storage of this higher type of packaging, certain bins in this S-type are higher than the others. The other part is situated near the dock door side and denotes two racks.
- *C02 (green)*: S-type C02 is the counterpart of C02 in the Red Label. Rack 37 in the red label stores the product out of formulation. Rack 37 and 38 store premix and flammables. Finally, the rack 39 is reserved for toxic and retained sample products.

- *E01 (blue)*: E10 includes all EAF/SSAU racked area (8 racks). To allow the storage of some higher products, the first three levels are higher and can store big bags of 800/1.000 kg. The last two levels are smaller and are supposed to store big bags of 600 kg.
- *E10 (orange)*: it is located just next to the production lines EAF and SSAU. It is a ground floor storage zone. E10 is mainly a “transition” location to exclusively store finished goods of production SSAU and EAF. Therefore, the operator can transfer the finished goods directly from the production line to this zone with a pallet truck (transpallet).
- *E20 (orange)*: E20 contains only two bins that can store large quantities of materials. On the one hand, it represents floor storage near the production machines (bin= EAF). On the other hand, E20 contains all materials stored in a tank¹² located outside the building (bin = SB20TANK).
- *CAS (grey)*: this s-type was initially reserved for scrap but has now various functions.
- *CSP (brown)*: the S-type CSP was initially created to store sausage and cartridge finished goods. However it stores now large variety of products.

4.4.1.2 Storage Section

There is a real lack of consistency in storage section setting. Indeed, the system SAP is currently not used to decide the place of a material during stock placement. However storage sections are created to that purpose: implement an automatic putaway strategy. As stated in Figure 4.3, some S-types are divided into several storage sections (e.g. S-type C01) while some others are not (e.g. S-type CBU). However, this subdivision is not useful at all since they do not the automatic stock placement. The situation is really confusing.

4.4.1.3 Storage Bin

Storage bins in rack storage are physically limited. They allow the storage of only one pallet. Appendix 12 provides a view of SB20 racks. A bar code is placed under each slot. Thus the scanning of the material with the appropriate bin allows the record of the accurate material position.

Ground floor storage bins can store large numbers of pallets. Pallets are stackable in this area (see blue shape on Appendix 10). The bar code of each bin hangs above the zone (see the yellow

¹² A storage tank is a type of container, usually for holding liquids, sometimes for compressed gases (gas tank). The term can be used for reservoirs and for manufactured containers [Wikipedia].

arrows of Appendix 10). It is rather far from the floor. This disposition has caused problems in the past because terminal guns of AIDC technology were not powerful enough to scan the bar codes from this distance. It was one of the reasons why they have not been using SAP automatic putaway strategy that requires bar codes scanning.

4.5 Putaway and Picking Strategies

Finally, from a more specific point of view, this section presents the current putaway and picking processes performed in SB20. As previously explained, we are focusing on warehouse SB20 for the putaway strategy because procedures are not the same in each building and because SB20 is the most important warehouse of Seneffe with the largest capacity. Picking is also dealing with SB20 building because it only takes place in this building.

4.5.1 Putaway Strategy

As described in the previous sections, there are eleven storage types for SB20 building. Many S-types are intended to store specific products. A good example is the storage type CA1 that is supposed to exclusively store the returns (from customers). Therefore, storage assignment policy performed in SB20 is a sort of “dedicated storage policy” in which the place of a product is known in advance. The racks are organized by product families, which are palletized. However, occasionally some products are mixed in the shelves due to space problems. For example, a rack that should be dedicated for a specific item has sometimes a space temporarily assigned for another. For several products for which no position is assigned, the logistic operator makes the decision based on his experience.

Here is an overview of the different putaway steps. During goods receipts, an operator checks the delivered material to ensure that it complies with the delivery document and the CMR¹³. He checks the quantity (manual counting), the products (badges) and the packaging. Operator also checks if the order is intended for SB20 and not for another building of Seneffe site. If everything is fine, he unloads the truck and places the products in an interim storage area. Then, the operator places them in the definitive storage location. SB20 warehousemen do not use terminal to record the movement. At the end of the day or during his break, the operator records

¹³ CMR are a standardized document for cross-border transport of cargo by road, based on UN recommendations for uniform international rules and in force in the European Union. CMR stands for 'Convention relative au contrat de transport' is the bill of lading that contains information about the transport, the items and so on.

the movement in SAP system with the computer. This transaction/record is a key element for the accuracy of the stock and must be processed as soon as possible.

Putaway for incoming goods should happen in a timely fashion. There is a target of 90 % of all line items to be putaway within two hours. There are two drawbacks in such procedure: Instead of using SAP putaway strategy they use static allocation; instead of enjoying bar codes terminal allowing real-time records they use computer. This under-use of SAP for storage assignment and the AIDC for direct record is a waste of logistics (see section 4.1). DC has been making a lot of investment in technological tools but they don't take advantage of this system.

4.5.2 Picking Strategy

As already partially explained, SB20 building is the only one where picking takes place. Indeed, all productions of other buildings are directly shipped to Feluy while SB20 ships to customers. Thus picking activity is processed in response to a customer order.

Dow Corning Seneffe only allows picking of full pallets for orders while the distribution center of Feluy manages partial quantities. Hence, operators take the order elements (pallets) once at time and must always do the round-trip between the slot in which the products are stored and the expedition area (near door). It is not possible to pick several pallets at one time. For this reason, the methods exposed in section 2.4.2 (batch picking, routing optimization) are not worthwhile in our study. The potential of time optimization for single order picking essentially lies in putaway process. If a product is placed optimally, picking process will be less time-consuming.

SAP batch determination can be executed either exclusively at the IM level or firstly at the IM and then WM level with picking strategy. Seneffe is only processing batch determination on IM. The installation of the picking strategy on the WM module requires investment. The objective here is not to review the entire SAP implementation but rather optimize it. Regarding this context, the analysis will be based on the same configuration by keeping picking strategy only at IM level.

The process of picking is almost fully manual. When a delivery is created, the traffic employee has to select the items and the batches of this request. According to FIFO (first in first out) rule and other customer's specific requests, the system would automatically propose batches that fit with the order. The batch search strategy takes place within the S-loc "SENF" that does not make the distinction between the three buildings of the site (see organizational structure). Thus, this

process does not take into account all the constraints of the site. Due to storage locations set-up, the system often proposes batches whose pallets are located in another building (in SB02 or in SB60). In that case, the traffic employee manually chooses other batches than those automatically selected by SAP but he does not select the older batch. Therefore, the FIFO rule is not always respected. The consequences are an increase in scrap quantity due to out of storage life.

4.6 Key Takeaways

The background information discussed above is important to understand current situation and identify the gaps. Processes, products and warehouse layout must be taken into account when reviewing picking and putaway activities. In general, SB20 is not approached as a simple storage warehouse since it is also a production building. Quite a lot of information has been given; the purpose of this section is to summarize the most important one:

Regarding putaway strategy:

- Putaway process is made manually. The racks are generally assigned to a class of product (ex: customer returns, cartons, etc.). It takes place at WM level.
- Hazardous products must be stored in the red label.
- There are three types of storage (rack storage, floor storage and red label) and two logistic supervisors (one for EAF/SSAU product and the other for general products) in warehouse SB20.

Regarding picking strategy:

- Picking process is based on the batch search strategy. It exclusively takes place at IM level. We will not challenge this point because the implementation of picking at WM level would require investments and would not significantly improve the process.
- All materials for order picking are loaded on the S-loc “SENF”. Thus current storage locations layout (IM module) does not make the distinction between the stock SENF in SB20 and the stock SENF in SB02/SB60.
- Pallets for order picking must exclusively be located in warehouse SB20. We do not want to select a pallet in another building.
- If SAP selects a batch located in another building, the traffic employee selects manually another batch without always respecting FIFO rule.

5. Case Study Analysis

The company has been incurring important costs due to SAP implementation and maintenance. However, as discussed in the previous section, DC does not fully benefit from this advantage. There are two main side effects to the current situation. First, the current organizational structure does not allow putaway strategy to be performed in an appropriate way. In addition, operators do not use terminals, which allow direct recording of material position. They manually record movements with the computer. Second, batches for order picking are often manually selected. In fact, the system tends to suggest pallets located in another building than SB20, which is not allowed by the procedure. All of these non-value-added activities should therefore be removed. It is the objective of this analysis.

This chapter applies the previous information to the case study: Dow Corning Seneffe. The stock placement strategy implies the review of the WM module design while stock removal strategy implies the review of the IM module. This section deals with those two approaches separately. Firstly, a new WM structure (S-type, S-section, Bin) is suggested, allowing the automation of storage assignment policy. Afterwards, picking strategy is considered and storage sections are reviewed. Then, the accurate putaway and picking strategies will be described with regards to the new organizational structure. Each part discusses the implications and the expected outcomes of the proposed changes. Decisions and results are also justified with accurate arguments and computations. Finally, the global organizational structure is presented in the last subsection.

5.1 Putaway

The previous explanations and analysis emphasize that stock placement strategy in Seneffe takes place at WM level and implies a review of SB20 storage types and storage sections (application of the theory introduced in section 2.1). The bins are physically defined by rack disposition, lines on the ground and bar codes. As one of the constraints of this work is to keep the current physical disposition, bins are out of scope; only their parameters are challenged.

SAP stock placement control requires the recording of a sequential S-type list ranked by priority (mainly physical and organizational criteria) for each product. Then, inside each S-type, the best storage section is determined. This process has similarities with class-based storage except for the fact that products are not randomly stored inside a storage type. The putaway strategy (e.g.

“next empty bin” explained in section 3.7.2) defined for each S-type indicates the method to be used to place a material in this area. The best way to apply this relatively complex strategy is to follow a clear methodology in order to obtain reliable results. Here is my proposition:

1. Design new organizational areas (storage types and storage sections) and define storage bin parameters for warehouse SB20.
2. Assign a putaway strategy for each storage types.
3. Classify products and analyze their turnover into warehouse SB20.
4. Allocate storage type indicator and storage section indicator to each product category.

5.1.1 WM Structure

This section provides recommendations regarding warehouse management. It implies the review of almost each level of this module. Concerning the SAP configuration, our theoretical and practical research in the field allows us to well understand the system in order to analyze the current situation and give accurate propositions. For now on, only basic functionalities of the system are used for the stock placement strategy. As stated in the seven wastes of logistics (see section 2.1), it represents a shortfall for the firm. DC has made important investments in SAP technology but they do not use it optimally.

In a very simple warehouse, it is appropriate to organize the placement and removal strategies with only few storage types (Mc Donald et al., 2010). As the warehouse gets larger, it makes sense to add more storage types to separate the areas according to the warehouse techniques, the organizational form or the functions: i.e. different production buildings, the red label (for hazardous materials), normal storages, cool rooms, freezers, sample areas, etc. Moreover, these S-types are divided into storage sections and bin types to optimize the putaway strategies. Our methodology should follow the same rationale to obtain clear and consistent results. Today, DC has too much S-type, which almost results in a dedicated storage policy (see section 2.5). Each product has its own devoted area in the warehouse, e.g. S-type C01 that only contains empty cartridges. As the system was created 20 years ago, some S-types do not make sense anymore.

Warehouse “redesign” consists of three steps to divide the area in terms of storage types and storage sections. Then, important storage bin parameters are highlighted.

With the current organizational structure, the system cannot perform an appropriate putaway strategy. Moreover, product allocation to warehouse zones is not well distributed and the current layout (see Figure 4.5) subdividing the warehouse does not fit anymore. For example, an entire rack is reserved for sealant, even though SB20 rarely stores this type of chemical.

Here are some examples where the current stock placement process is problematic:

- The rack reserved for empty cartridges is full while the rack for cartoons is empty. In that case, fast moving access zones are not used resulting in suboptimal space utilization. As exposed in section 2.1, it represents a waste of space.
- Products are randomly stored inside a S-type. Fast moving material may be placed in slow moving access zone and vice versa.
- When the warehouse will get full, the dedicated storage policy will not work anymore, e.g. if the carton rack is full, how do we know where to place the next cartons?

5.1.1.1 Storage Type

The current S-type disposition does not allow an automatic putaway. Indeed, too much S-types have been created resulting in a dedicated storage policy.

As we have seen in the previous section, a complex warehouse must be subdivided into several storage types according to spatial or organizational features (SAP documentation, 2001). It seems pretty clear that the actual situation in the warehouse is not optimized. The existence of almost 15 storage types inside the warehouse SB20 creates too much rigidity in the system. However, a distinction between the different zones of the warehouse is necessary. S-types must therefore be used to separate areas according to organizational or operational criteria. The right balance must be found to avoid inefficiencies.

Section 4 has permits to understand the basic SB20 processes and procedure. With this information, we can layout the subdivisions necessary in the warehouse.

- From a technical and operational point of view, the red label should definitely be represented by a single storage type. This distinction will allow to allocate hazardous products to this area.
- For organizational reasons, the EAF/SSAU part is also to be distinguished from the rest of the products since they are managed by two distinct supervisors. EAF/SSAU part is surrounded with an orange shape on Figure 5.1.

- Floor storage space and rack area are to be distinguished since the procedures to place and remove a product are different. Rack-mount required special trucks.
- Within EAF/SSAU part, RM and FG should be distinguished for floor space in order to keep the current storage methodology and avoid confusion for operators.

Therefore, the creation of five S-types seems to be the minimum for an optimal stock management. Here is my naming proposal with the corresponding colors of Figure 5.1:

- *FLOOR*: this S-type identifies all floor bins of the general part. It replaces the previous CBU, C10 and CAS S-type → pink shapes.
- *EAF FG*: this storage type represents floor space near the production machines EAF and SSAU. It replaces S-type E10 where an important part of finished goods are stored → orange shapes.
- *EAF RM*: this storage type is dedicated to EAF/SSAU raw materials. It replaces S-type E20: the current area in which RM are stored → orange shapes.
- *RACK*: it is racked area for general products. This storage type stands for rack 32 to rack 36 → blue shapes.
- *EAF RACK*: this storage type stands for rack 24 to rack 31 → green shapes.
- *RED LABEL*: this S-type represents all the racks situated in the red label. It replace former S-type C02 and CA2 → red shapes.

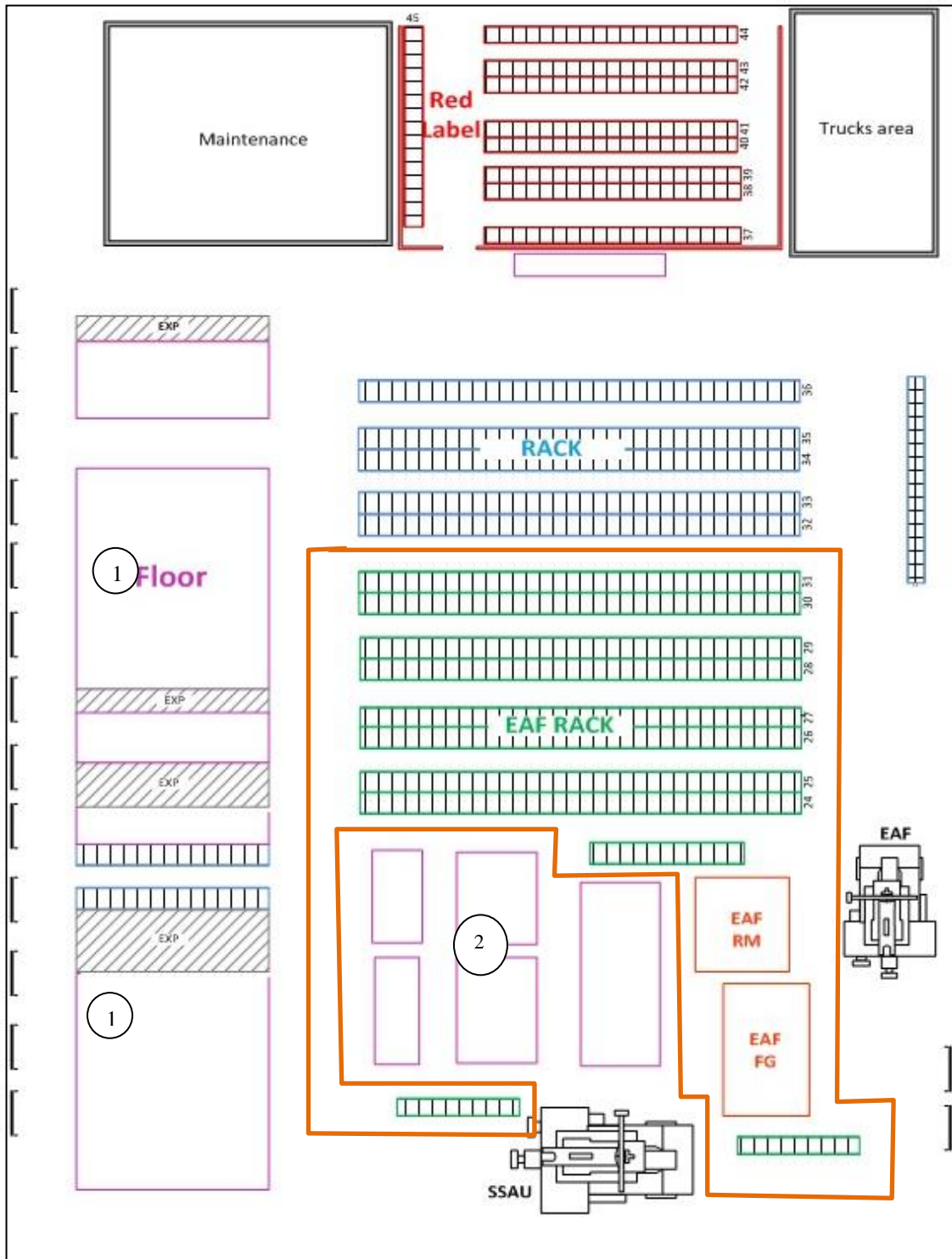


Figure 5.1 SB20 layout proposal

5.1.1.2 Storage Section

Storage sections are used to divide a storage type (see section 3.4.3 for explanations) for the purpose of stock placement strategy. The storage sections are not a mandatory level: if a subdivision is not required, the creation of only one “global storage section” may be sufficient. DC Seneffe subdivides only 16 % of its storage types into more than one storage section (see Appendix 15). This kind of strategy may not optimal since the fast and slow moving access zones are not distinguished. We propose a new storage section design for each type of storage one by one.

The design of *the floor storage* area is relatively simple. Regarding the previous explanation, it is not useful to set different storage sections for this space. The analysis of the time required to put a pallet in bin of the storage type “floor” revealed that it depends on the gates. Because DC Seneffe does not use “Yard Management¹⁴”, we don’t know in advance which door will be used to unload a trailer. For this reason, we suppose that the time to place or retrieve the stock from the floor storage locations near the doors (marker 1 on Figure 5.1) is not dependent on the location of the product inside this zone. With Yard Management, doors are allocated to the product and we know in advance from where it is to be arrived, but warehouse of Seneffe is not large enough to require this module. However, there is a significant difference (13.4 seconds on average) between the slots near the gates (marker 1) and the slots in the middle of the warehouse (marker 2). For this reason, it is better to create two separate storage sections: fast moving for marker 1 and slow moving for marker 2.

The design of storage sections for *pallet racks* requires a field investigation in order to collect information about rack-mount time. This is a demanding job since it has to reflect the reality accurately. It appears that the time required to put a product onto a rack varies substantially depending to the position of the bin (the row and the floor) in which the material is to be stored. The design of these storage sections for rack storage is based on the proposal of de Koster et al. (2004). As explained in section 3.4.3, the “across aisle storage” (see Figure 2.4) divides one rack into several zones (fast/normal/slow access zones) instead of being limited to a single one. It seems to be the most appropriate distribution since the main entry and exit gates are located on

¹⁴ Yard Management (YM) in SAP extends warehouse management beyond the physical walls of the warehouse, enabling management and control from the time that goods are planned to arrive at the warehouse. [<http://help.SAP.com>]

one side of the building. The two doors situated on the other side are exclusively intended to receive and dispatch EAF and SSAU products. Regarding this criteria, fast access slots (fast moving storage section) in the main storage area should be situated on the left (see Figure 4.2) while fast access slots in the EAF part should be located on the right part of the building.

For my research, I have followed logistic operators to discover which bins are to be classified as slow/normal/fast moving. The first important point is that rack-mount requires a specific type of trucks: a high-rack forklift. Because of that, stock placement into racks is made in two-steps. Firstly, an operator moves the pallet from the interim storage area (e.g. expedition zone) to a space at the beginning of the rack with a normal forklift. Secondly, the high-racks forklift moves this pallet from the floor space to the right slot in the rack. A high-rack forklift has the particularity to slow down after the third floor to minimize the risks. Horizontal and vertical movements of the high rack forklift are not simultaneously processed. The operator first moves until the right row and then moves up the pallet until the appropriate level. These data influence the design of the storage section.

Therefore, we carry out the analysis in four steps:

1. Collecting the data by computing the average time to put a pallet into the racks.
2. Drawing the function that expresses the time difference to put the pallet into the levels of the rack (horizontal movements).
3. Drawing the function that expresses the time difference to put pallet onto the rows of the rack (vertical movements).
4. Classify each bin as fast/normal/slow moving.

First of all, we realize a field study to compute the average time required to put pallets into slots. It requires several measures since the time significantly varies between operators. Table 5.1 gives the average time (in seconds) of the data collected with two operators of SB20. Timing starts when the forklift begins to cross the aisle.

Location :	Time in seconds		
	Row 1	Row 12	Row 35
1 ^{er} floor	3.6	11	28
2nd floor	5.3	12.2	30,1
3rd floor	7.1	14.9	32.7
4th floor	10.5	19.5	36
5th floor	14.1	23	37.5
6th floor	17	26.5	40.6

Table 5.1 Rack-mount time

Our objective is to estimate the rack-mount time of each bin in rack area ($35 \times 6 = 210$ bins per rack). To do so, we can split the high-rack forklift movements into two. first, we draw a function to express the time required to access the row of the bin (horizontal movement) and then, the time to access the level (vertical movement). We can admit that the function about the rows is linear since the speed of the machine is regular during the whole aisle crossing. Thus the time to cross the aisle can be directly derived from the data. The linear function is computed from the time to access the bin 1st floor/1st row and the bin 1st floor/35th row.

We can obtain a function such as: “ $y = ax + b$ ” by using the equation of a straight line with slope “a” ‘see equation 5.1) and y-intercept “b”:

$$a = \frac{f(x_2) - f(x_1)}{x_2 - x_1} = \frac{28 - 3.6}{35 - 1} = 0,717 \quad (5.1)$$

The constant term (b) is found by solving for $f(x_1)$: $f(x_1) = a \times x_1 + b$. It results in equation 7.2 that expresses the linear regression of the time of crossing the aisle until row “X”. It is assumed that this function is linear as the speed is constant during the travel.

$$\rightarrow \text{time to access row } X = 0.717 \times \text{row } X + 2.83 \quad (5.2)$$

Figure 5.2 shows the shape of this function.

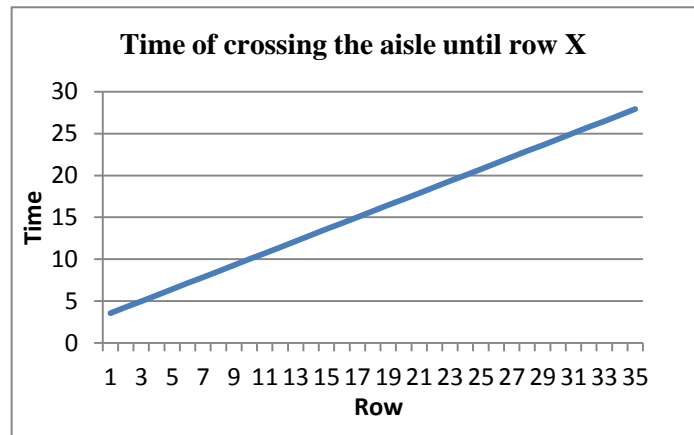


Figure 5.2 Difference in rack-mount time

Once the time to cross the aisle has been defined, the time to access the right level of the rack must be computed. Table 5.2 gives the time difference per level. For example, for row 1, the time to access 3rd level is 1.8 ($6.1 - 5.3$) second longer than the time to access 2nd floor. It is logical this number is not dependent on the row. The forth colon express the average of the three

previous columns. Finally, the last column of table 5.2 express the difference compared to first floor: the rack-mount time difference between fourth and second floor is 7.8 second.

Time difference between floor X and floor X-1					
floor/Row	Row 1	Row 12	Row 35	Average	Additional time compared to 1 st floor
1 st floor	0	0	0	0	0
2 nd floor	1.7	1.2	2.1	1.7	1.7
3 rd floor	1.8	2.7	2.6	2.4	4.0
4 rd floor	3.4	4.6	3.3	3.8	7.8
5 rd floor	3.6	3.5	1.5	2.9	10.7
6 rd floor	2.9	3.6	2.8	3.1	13.8

Table 5.2 Difference in rack-mount time

Figure 5.3 displays this curve. We can observe a slight break (red circle) on the curve that indicates the forklift slows down after the third floor. This is not a significant change but it is interesting to take it into account in order to draw the sections as accurate as possible.

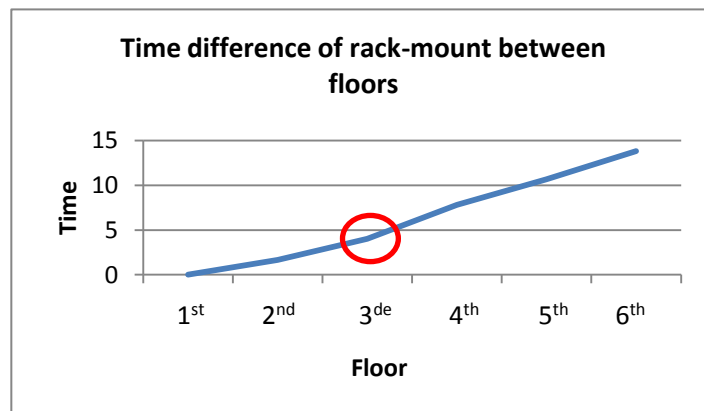


Figure 5.3 Additional rack-mount time

The previous functions allow to compute an estimation of the time required to put a pallet in each bin location of a rack. We use the following formula:

Parameters:

r_x , $x = 1, \dots, 35$, time of crossing the aisle until row x (see equation 7.2)

f_y , $y = 1, \dots, 6$, additional time to access floor y (see table 7.1)

Variables:

$t_{x,y}$ = time to access bin row x , floor y

$$t_{X,Y} = 0,717 * r_x + 2,83 + f_y \quad (7.5)$$

It is assumed that horizontal and vertical movements are not simultaneously executed. The results of time required to put a pallet for each bin (t_{xy}) are available in Appendix 17.

In order to have homogeneous number of bins into each section, bin access time lower than 17.8 seconds is classified in the fast moving storage section; bin access time above 26 seconds is in the slow moving section; in-between bins are normal moving sections. Figure 5.4 is a schematic representation of the storage sections distribution within a rack. Green zone represents fast moving section; orange zones represents the normal moving section and the red one the slow moving.

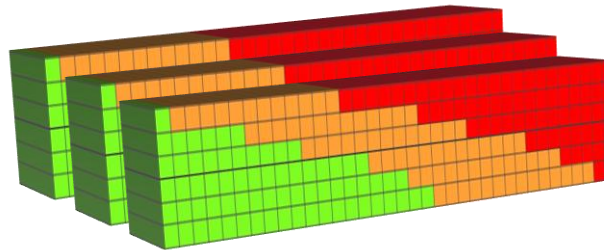


Figure 5.4 Storage section within rack

This sectioning is applied for each rack of the storage zone (except for red label area). However, rack 24 (see Figure 5.1) is situated on the edge of the rack zone and is accessible with normal trolley. Therefore the travel time to put the product onto rack 24 is significantly lower than to put it onto another rack. All bins of rack 24 are classified in fast moving section.

Red Label area requires specific attention in order to apply storage rules for hazardous products: corrosive, flammable and toxic. The high-racks situated in the red label are shorter and the area is smaller. Thus the rack-mount time between bins is not significantly different. If we keep this in mind, it is interesting to define storage section not according to fast/slow moving but rather according to specific storage rules.

As a reminder flammable and toxic products must be stored in the red label on any levels and corrosive materials must exclusively be placed on the ground floor in this area. So, one storage section should define all ground floor storage bins and another one should define the other storage. Figure 5.5 display the two storage section inside a rack of the red label. Corrosive (CORR) storage section is in blue and flammable + toxic (FLAM+TOX) storage section in yellow.

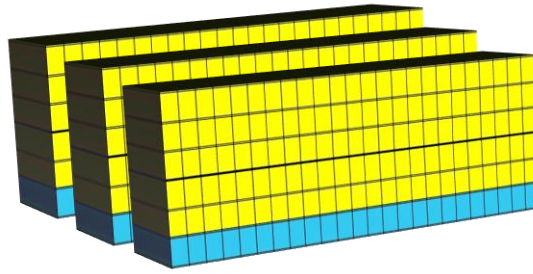


Figure 5.5 Storage section within a rack of red label area

Corrosive products should have a storage type indicator that specifies a single storage type: the Red Label, and storage section indicator that specifies a single storage section: first floor. Flammable and toxic products would have the same storage type but with both storage sections: firstly TOX+FLAM section and secondly COR since it can be stored on any level.

5.1.1.3 Storage Bin

As previously indicated, this study considers arrangement and management policies to improve putaway and picking activities with SAP system in the existing warehouse design. The optimization of the size of the bins is not the matter. However, as exposed in Section 3.4.4, many fields characterize storage bins in SAP system. Thus the storage bin search can be optimized by parameters handling.

First of all, storage unit type and storage bin type must be updated and loaded for each material and bin. At this time Dow Corning does maintain this data only for 67% of the items. Thus, it is not a reliable parameter. If we maintain this parameter up-to-date, the system would process an appropriate storage bin search taking into account the size of the bin and the material.

As explained by Kappauf (2012), “quant” parameter may be used to optimize association of product within a bin. The floor storage bins require special attention. Indeed, those areas are large and they can store until 44 pallets in the same bin. In that purpose, it would not be effective to store too many different batches inside the same bin. If the required batch is in the middle of the bin, the operator has to firstly move the pallets in front of the batch. Figure 5.6 exposes this problem. In this example, 9 pallets (see red drums in Figure 5.6) of the batch number “XYZ” are to be retrieved from the stock to fulfill a customer order. To access the six red drums, an operator has to process in three steps: to move the pallets in front of the required batch (on the left or on the right); to pick the 9 pallets; to put them back in their initial positions.

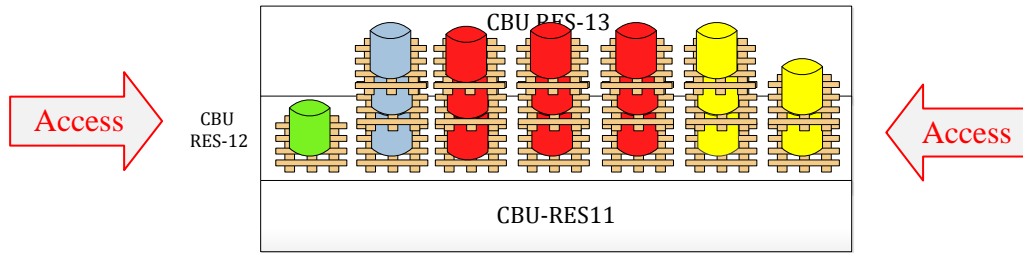


Figure 5.6 Bin with more than 2 different quants

The best solution to that problem is to set a number of *maximum quant* (see section 3.4.4). This parameter limits the number of different batches to only two per bin. If only two different batches are stored in a CBU bin as exposed in Figure 5.7. Red batch is accessible from the right and yellow batch from the left without moving any other pallets.

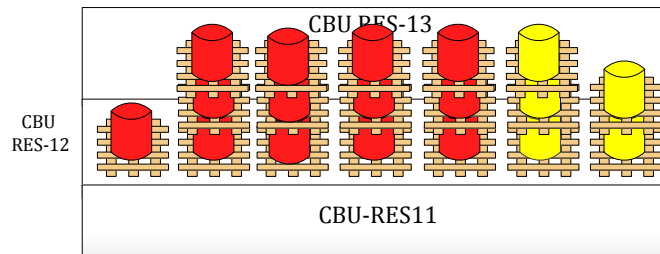


Figure 5.7 Bin with only 2 different quants

5.1.2 S-type Putaway Strategies

SAP storage assignment policy is an improvement of the methods exposed in Section 2.5. The theory about class based-storage policy implies to classify materials according to particular criteria, e.g. product turnover. The materials are randomly stored inside the area. SAP also works with classes and zones (storage types and sections) but it does not randomly place the products inside a zone. In this sense, a storage type indicator is assigned to each product and the putaway strategy indicates the way to fulfill the s-type (e.g. “next empty bin” fulfill the S-type next to rack space already used). This section assesses each S-type in order to choose the best putaway strategy:

- *Main floor*: this space will be dedicated to fast-moving materials in large quantities. In that purpose, the best strategy to manage products inside this S-type is “bulk storage”. The current bin disposition is adapted since the area is divided into rows. These rows represent the bins. It may store different unit types. “Addition to existing stock” option should be active in order to manage large capacity bin. Indeed, if this parameter is not

active, once a bin is occupied by a batch with one or several pallets, the system will record this bin as full.

- *EAF RM*: current S-type “E20” is divided into only two bins: bins for floor storage and one bin for the tank. This storage type only stores raw materials that do not stay more than 2 days in the warehouse. Stock removal from this bin to production machine is usually made by logistic operator with a transpallet machine. We don’t ware to choose one pallet or another since it is always the same raw material. For those reasons, the “open storage” strategy is the best solution. This strategy must be applied for S-type in which a single storage bin is defined for section. It is especially suitable for items that don’t require a specific bin assignment (Klaus, 2012).
- *EAF FG*: it is floor storage. It replaces the S-type E10 that currently stores FG. The new S-type also exclusively stores fast moving finished goods. It is a kind of interim storage area. Finished goods are stored there until the trailer arrives.
- *Racks*: as proposed by SAP theory, the most suitable putaway strategy for high rack storage is “Next empty storage bin”. According to Klaus (2012), it fits great for high rack storage. This policy is useful for storing pallets of material; one pallet per bin location.
- *EAF rack*: as the physical disposition of EAF racks is the same as the previous section, the same strategy must be selected: “Next empty storage bin”
- *Red label*: since this area is racked, the best putaway strategy inside it is also “Next empty storage bin”.

5.1.3 Product Turnover Analysis for SB20

This section analyzes the flows of materials in SB20 to determine which materials should be classified as fast or slow moving materials. The objective is to allocate the right storage sections indicator per product. The average time that a product stays inside the warehouse is a good parameter to classify them as fast or slow moving. The report output will be used to determine the best storage section for a material. The improvement of the product allocation policy is intended to minimize forklift travel time within the warehouse. Fast/slow moving analysis should be realized every 6 months or yearly.

This classification is based on “the average bin occupation time” per material, which is one of the best accurate. There are several reports on which this decision can be based. SAP provides a report containing all movements realized inside the plant. The tricky point is to detect useful

information and only analyze records that represent a real movement inside the warehouse SB20. SAP users must choose the accurate data among a large list. The unique key element of this report is the TO numbers. In this study, the required data are the following:

- Material numbers
- Batches
- Source storage types and source storage bins
- Destination storage types and destination storage bins
- Creation dates
- WM movement types

The first thing to do is exclusively to select the movement including SB20 building. Indeed, the objective is to find the turnover of a product. However, a material such as a sealant can be classified as fast moving in SB60 (sealant production building) but might be a slow moving in SB20. As explained in 4.2.1 (stocking strategy), SB20 might contain safety stock of different products which could be stay for quite a long time. To focus on SB20 building, we must therefore only select the s-types that refer to a location in this warehouse (C10, CBU, CA2, etc). We filter the data according to source storage types and destination storage types.

The time frame must be selected before running the report. In order to increase the relevance of the results, it is better to take a quite large time frame of the analyzed period. Suggestion is to use four months (since 1 December 2012 until 1 April 2013) in order to take into account the end of the year (with few demands), the beginning of the year (characterized by many orders) and the months February and March that have typical demand rates. It is not advocated to make the timeframe too long as sourcing strategy might happen as well.

It is important to exclude some movement types that do not reflect a physical movement but which could influence the results. Each of these movements is identified with a three-digit number (see section 3.6). Here are the main movement types that must be excluded from the analysis:

- The movements that indicate a decision in “Quality Management” module must be excluded. They typically represent a change in the material status, e.g. from “quality inspection” to “unrestricted”: (movement 321, 322 ...).
- Movement 309 also represents a sort of fictive movement. It is used to change material number, the bar code or the packaging.

- All movements for stock adjustment (701, 702, 707, 708, 712, 713, 718) can also be excluded because it does not reflect the real turnover of the product. Most of these movements are used during the cycle stock count. For example, when operator must physically check the stock inside a bin to evaluate the accuracy of WMS.

Building SB20 also stores some raw materials for production line in a tank. Moreover, it is not necessary to take them into account because they are stored in large tankers outside the building. It is not relevant to analyze their movements and optimize their placements. Fortunately, the tanks of SB20 are grouped together in the system in one bin (items 2424789, 2750180, 2898033, 2902524, 4057388, 4111764, 4014222).

As proposed by Kovacs (2009), classification of fast/slow moving material is based on the average bin space occupation time by material. The interpretation of these results is important. An example well illustrates the signification of this piece of data. If a full pallet is received and is depleted within two days the bin space occupation time for this one pallet is two days. Moreover, if for the same material but with a different batch arrives later another full pallet comes in and is depleted within 4 days the bin space occupation time for this pallet is four days. The average bins space occupation time for this material should be so: $\frac{2+4}{2} = 3$ days. In brief, we can say the smaller this figure is, the more likely it deserves a prime location.

Datasheet provided by SAP are manageable with Excel. In order to discover the average occupation time per material and per bin, the following steps are followed:

1. Discover if the movement is an entry (good receive) or an exit (good issue). To do so, I have used a formula that displays “in” if the destination storage type is a S-type of SB20 building and “out” if the source storage type is a S-type of SB20. Pallets that move inside the warehouse e.g. from S-type CBU to S-type C10 are neither an entry nor an exit. Thus this movement is not taking into account in the computation. This element is in the last column in Figure 5.8.
2. Display the date of entry per material and per bin. I have used a “V-look up” formula to display the PO creation date for each an entry (“in” in the last column in Figure 5.8).
3. Display the date of exit per material and per bin. I have used a “V-look up” formula to display the PO creation date for a good issue (“out” in the last column in Figure 5.8).

4. Compute the bin space occupation time for each item: date out - date in.
5. Make an average for each material number.

Compute the bin space occupation time for each material. Figure 5.8 provides simplified realistic examples of this method. Material 1919261 has 2 different batches that have been stored in SB20. Average bin space occupation time for each batch is:

- Batch 0007119182 = $\frac{(08/01/13 - 20/12/12) * 1 + (15/03/2013 - 20/12/2012) * 3}{4} = 63$ days
- Batch 0007138386 = 15/03/13 - 20/12/2013 = 85 days
- Average bin space occupation time = $\frac{63+85}{2} = 64$ days.

During the time period of this study (4 months) material 1919261 has only 8 movements which means that it is not an important product for warehouse SB20. However, a product that does not pass a lot throughout the warehouse may require an easy access storage if it does not stay a lot in the building. We have to use as much as possible fast access zones to minimize internal movement and so minimize access to slow moving section. It is better to place a material that stays only few days in the building because it will not blocked the slot a long time and the removal of this pallet will be fast. It is not the case here as this material has a bin space occupation equal to 64 days since December 2012.

Material 2086255 has also only 2 different batches that have been stored during the period under review.

- Batch 0007153342 = 19/17/2012 - 18/17/2012 = 1 day
- Batch 0007194903 = 09/01/2013 - 08/01/2013 = 1 day
- Average bin space occupation time = 1 day

This material is not regular but has an average bin space occupation time equal to 1 day. Hence it should be placed in an easy access zone in the warehouse but rather in rack because the material is not stored in large quantity.

Material 2370824 has 126 records during this period of three months. Figure 5.8 only provides a sample of those records. The average bin space occupation time of these materials is 9 days and is regularly stored in SB20.

Material	Material Description	Source SType	Source S. Bin	Dest. SType	Dest.S. Bin	Creation Date	Batch	Movement Type (WM)
1919261	Q2-1353 6,000 CS,KG,2(	904	8410088248	C10	Q0630	20/12/12	0007119182	651 IN
1919261	Q2-1353 6,000 CS,KG,2(	904	8410088248	C10	Q0630	20/12/12	0007119182	651 IN
1919261	Q2-1353 6,000 CS,KG,2(	904	8410088248	C10	Q0630	20/12/12	0007119182	651 IN
1919261	Q2-1353 6,000 CS,KG,2(	904	8410088248	C10	Q0630	20/12/12	0007138386	651 IN
1919261	Q2-1353 6,000 CS,KG,2(	C10	Q0630	REC	REC	8/01/13	0007119182	999 OUT
1919261	Q2-1353 6,000 CS,KG,2(	C10	Q0630	REC	REC	15/03/13	0007119182	999 OUT
1919261	Q2-1353 6,000 CS,KG,2(	C10	Q0630	REC	REC	15/03/13	0007119182	999 OUT
1919261	Q2-1353 6,000 CS,KG,2(	C10	Q0630	REC	REC	15/03/13	0007138386	999 OUT
2086255	3398 UNPIGMENTED ,K	C60	REM1	C01	11301	18/12/12	7153342	319 IN
2086256	3399 UNPIGMENTED ,K	C01	11301	C60	PCK	19/12/12	0007153342	319 OUT
2086257	3400 UNPIGMENTED ,K	C60	REM2	C01	12101	8/01/13	0007194903	319 IN
2086258	3401 UNPIGMENTED ,K	C01	12101	C62	62016	9/01/13	0007194903	319 OUT
2370824	MIKHART AC,KG	REC	REC	C01	33316 1	4/12/12	62W0109	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33417 1	4/12/12	62W0109	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33501 1	4/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33305 1	4/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33308 1	4/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33413 1	4/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33414 1	4/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33415 1	4/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33416 1	4/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33418 1	4/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33419 1	4/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33315 1	4/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	34303 1	10/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	34402 1	10/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	34306 1	10/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	34309 1	10/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	34411 1	10/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	C01	33303 1	C60	BLK	10/12/12	62W0109	319 OUT
2370824	MIKHART AC,KG	C01	33304 1	C60	BLK	10/12/12	62W0109	319 OUT
2370824	MIKHART AC,KG	C01	33316 1	C60	BLK	11/12/12	62W0109	319 OUT
2370824	MIKHART AC,KG	C01	33405 1	C60	BLK	11/12/12	62W0109	319 OUT
2370824	MIKHART AC,KG	C01	33410 1	C60	BLK	11/12/12	62W0109	319 OUT
2370824	MIKHART AC,KG	C01	33415 1	C60	BLK	13/12/12	62W0111	319 OUT
2370824	MIKHART AC,KG	C01	33416 1	C60	BLK	13/12/12	62W0111	319 OUT
2370824	MIKHART AC,KG	C01	33417 1	C60	BLK	13/12/12	62W0109	319 OUT
2370824	MIKHART AC,KG	C01	33413 1	C60	BLK	13/12/12	62W0111	319 OUT
2370824	MIKHART AC,KG	C01	33414 1	C60	BLK	13/12/12	62W0111	319 OUT
2370824	MIKHART AC,KG	C01	33418 1	C60	BLK	13/12/12	62W0111	319 OUT
2370824	MIKHART AC,KG	C01	33419 1	C60	BLK	13/12/12	62W0111	319 OUT
2370824	MIKHART AC,KG	C01	33501 1	C60	BLK	13/12/12	62W0111	319 OUT
2370824	MIKHART AC,KG	C60	BLK	C01	33103 1	18/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	C60	BLK	C01	33102 1	18/12/12	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33304 1	3/01/13	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33305 1	3/01/13	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33303 1	3/01/13	62W0111	999 IN
2370824	MIKHART AC,KG	REC	REC	C01	33307 1	3/01/13	62W0111	999 IN

Figure 5.8 TO's report sample

The limits of fast, normal and slow moving classes depend on the space dedicated to each class and how sections are distributed. A common suggestion is to group products into classes in such a way that the fastest moving class only contains about 15% of the products stored but contributes to about 85% of the turnover. However this decision is not that important since it is not a dedicated storage policy. Indeed, if there are too many materials in the fast moving category, SAP simply proposes a place in the normal moving section which does not significantly impact global storage assignment consistency.

Here is our general recommendation to classify product in slow, normal and fast moving material. The most important parameter is the bin space occupation time. We can study the number of movements may help to clarify the results: fast moving zone should be allocated in priority to materials with many movements.

Average bin space occupation time	Number of movements	Section
< 10 days	High	Fast moving
< 10 days	Low	Fast/ normal moving
[10 ; 30 days]	High	Normal moving
[10 ; 30 days]	Low	Normal/slow moving
> 30 days	High	Slow moving
> 30 days	Low	Slow moving

Table 5.3 Fast/normal/slow moving classification example

5.1.4 Assignment of Products

The last step of the “putaway” analysis is to allocate for each category of products the right storage type indicator and storage section indicator taking into account previous choices. The most effective way to those hierarchical indicators is to work with categories of products. The previous section analyses material flows in order to define fast and slow moving materials. Storage bin search is not an element to be reviewed as it is defined in master data.

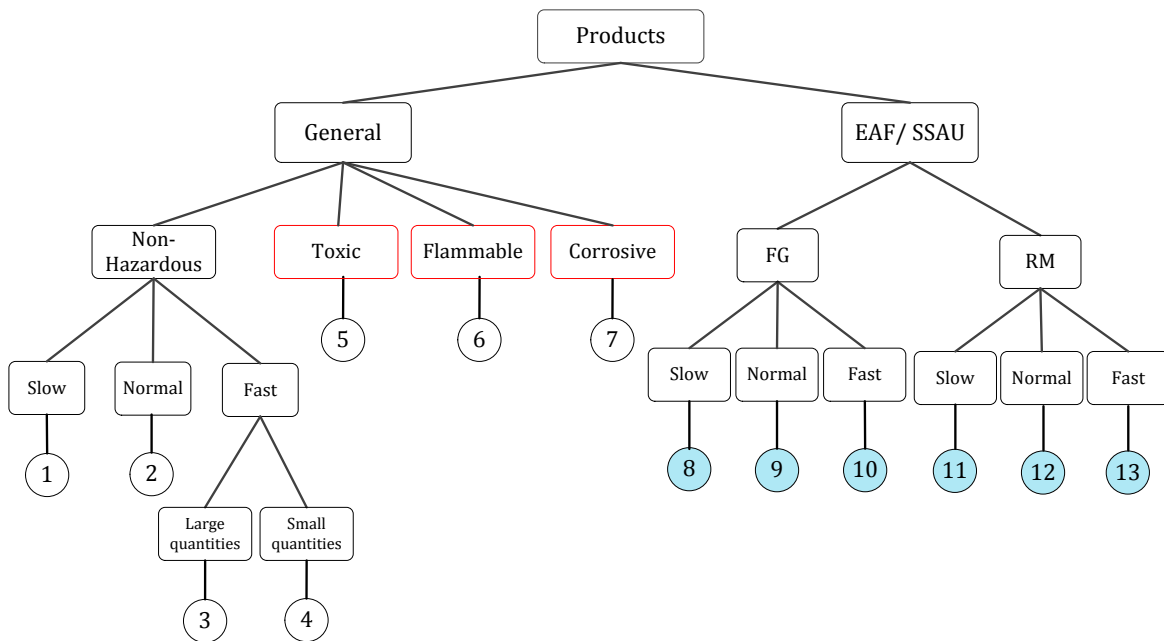


Figure 5.9 Product classification

A distinction must be made between EAF/SSAU products and the rest of the stock. As stated above, discrepancy is useful as there are different supervisors and the two classes passed through different doors. On the left sight of the tree (Figure 5.9), general products are firstly divided into four classes according to their hazardousness. Finally non-hazardous products are classified according to turnover analysis. The fast moving category is then subdivided into large and small quantities to dedicate the large quantity for floor area. On the right sight of the tree, EAF/SSAU products are divided in fast, normal and slow moving items. Fast moving items are then subdivided into raw materials and finished goods classes. Each number above the end of each tree branch indicates a different search sequence. A proposition of storage type search and storage section search is proposed above.

- Class 1 products are slow moving non-hazardous materials. Products that stay more than 3 weeks inside the warehouse could be classified as slow moving. Those products must then be placed in slow access part of the rack. This category may be stored in the red label. Indeed, if at any time, SB20 hardly stores hazardous products, this area can be used to complete lack of space in other zones/s-types. It is better to differentiate EAF and the rest of the products. However it is not mandatory. In case of limited capacity in s-type “rack”, class 1 should go to EAF racks, then floor and so on...

Class 1	1	2	3	4	5	6
Storage type indicator	Rack	EAF racks	Floor	Red label	EAF FG	EAF RM
Storage section indicator	Slow	Normal	Fast			

- Class 2 contains normal moving materials. The storage assignment policy is similar to slow moving materials. Instead of placing those materials in the slow sections, they must be placed in normal section. If this part of the rack is full, it will secondly be placed in fast moving access. Indeed, it is better to use easy access area in priority in order to reduce the total travel time. Finally, if those two sections are full, the material will be placed in the slow moving part.

Class 2	1	2	3	4	5	6
Storage type indicator	Racks	EAF racks	Floor	Red label	EAF FG	EAF RM
Storage section indicator	Normal	Fast	Slow			

- Class 3 contains all non-hazardous products that stay only a few days in the warehouse. Floor bins should be dedicated to large quantities (large batches) and stackable products. Storage type indicators must point in priority easy access areas such as FLOOR S-types.

This section contains mainly Xiameter products because they have a high turnover rate. Fast access bin of S-type “FLOOR” approximately store 1,200 pallets. General section (without counting red label and EAF/SSAU part) approximately stores 3,675 pallets.

Class 3	1	2	3	4	5	6
Storage type indicator	Floor	Racks	EAF racks	Red Label	EAF RM	EAF FG
Storage section indicator	Fast	Normal	Slow			

- Class 4 contains fast moving items that used to arrive in limited quantities, e.g. 4-5 pallets. It is not optimal to store small quantities on floor bins. It is better to devote those slots to large quantities to keep together the same batches in the same bins.

Class 4	1	2	3	4	5	
Storage type indicator	Floor	Racks	EAF racks	EAF RM	EAF GI	
Storage section indicator	Fast	Normal	Slow			

- Class 5 and 6 contains flammable and toxic products. The only rule concerning those products is that it must be stored in the red label area.

Class 5 and 6	1	2	3
Storage type indicator	Red label		
Storage section indicator	Tox + Flam	Corrosive	

- Class 7 exclusively includes corrosive products. They must absolutely respect the storage rules. Hence if the single storage type (red label) and storage section (corrosive) allocated to corrosive products are full, the system will not be able to indicate a storage bin and the putaway strategy would be blocked.

Class 7	1	2	3
Storage type indicator	Red label		
Storage section indicator	Corrosive		

- Class 8 contains all EAF/SSAU FG classified as slow moving material. As they do not move a lot, they should be in priority placed on the rack area. If this area is full, the products are placed in general rack area. Since it only contains FG, they can be placed in fast access zone “EAF FG”. However we do not want to mix RM and FG as it could lead to important errors.

Class 8	1	2	3	4	5	6
Storage type indicator	EAF racks	Racks	EAF FG	Floor	Red label	
Storage section indicator	Fast	Normal	Slow			

- Class 9 stands finished goods of EAF/SSAU classified as normal moving. There is no specificity about this class but the best area to store these products is in rack of EAF/SSAU part. Those products usually stay more than 5 days in the area. To do so, they will not be placed in easy access zone in priority. As they move faster than class 8, the second s-type is floor storage.

Class 9	1	2	3	4	5	6
Storage type indicator	EAF rack	EAF FG	Rack	Floor	Red label	
Storage section indicator	Normal	Slow	Fast			

- Class 10 denotes fast moving finished goods for EAF/SSAU production units. This class must be placed in floor storage such as the current situation. Indeed, operator must rapidly be able to transport those products with transpallets. Moreover, supervisors do not want to mix raw materials with finished goods on floor storage. This is why a storage type is dedicated for each class. S-type EAF FG is in the last position of the sequence to avoid mixing them with finished goods.

Class 10	1	2	3	4	5	6
Storage type indicator	EAF FG	EAF racks	Racks	Floor	Red label	
Storage section indicator	Fast	Normal	Slow			

- The same rationale is applied for class 11, 12 and 13 but for raw materials. Once again, we avoid mixing up raw materials and finished goods so the Stype EAF FG does not appear in the sequence.

Class 11	1	2	3	4	5	6
Storage type indicator	EAF rack	Rack	EAF RM	Floor	Red label	
Storage section indicator	Slow	Normal	Fast			

Class 12	1	2	3	4	5	6
Storage type indicator	EAF rack	EAF RM	Rack	Floor	Red label	
Storage section indicator	Normal	Fast	Slow			

Class 13	1	2	3	4	5	6
Storage type indicator	EAF RM	EAF Rack	Rack	Floor	Red label	
Storage section indicator	Fast	Normal	Slow			

5.1.5 Implications

When initiating any project, getting an understanding of the impact of its change is vital. This subsection analyzes the main impacts on the other departments. Modifications of WM level don't involve the complete organization. The changes made will impact only a restricted area and a restricted number of workers. However, the operators and the supervisors' daily work will significantly be impacted.

AIDC technology and gun utilization would become mandatory to record good receipt, good issue or movements inside the warehouse. In this way, each operator should learn to use the gun. Managers should administer these changes to ensure appropriate transition from previous operational method to new automatic processes. However, it is not an important investment for the company since each worker already possesses a terminal gun.

Every 6 months or yearly it is useful to review the fast/slow moving materials and the quantity of each material. There are several reports on which a decision can be based. It might also be useful to sometimes run the slow moving report to check for materials that don't move for a long time. Appendix 19 provides an overview of the trends in demand for EAF and SSAU products since January 2011 until now. The graphs display the number of sales in blue and the inventory level at the end of each month in green. The point we have to pay attention to is the inventory level which indicates the real stock level in warehouse SB20. We can see that EAF inventory level is rather constant over the time. A review of picking strategy should then occur every year. However SSAU inventory level reveals high variability between each month. For that reason, it should be better to review the putaway strategy more frequently.

5.1.6 Expected Outcomes

In order to conclude this part, this section provides estimations of the expected outcomes due to previous recommendations. However, putaway outcomes are quite difficult to evaluate: most of improvements are indirect.

Concerning putaway strategy, we can distinguish several types of outcomes. First of all, the processes that were fully manual would be replaced by automatic activity with the AIDC tools (see section 4.3.2). This technology would directly indicate on the screen (see appendix 21) the optimal location (on basis of the putaway strategy) to store the products. When the operator makes the movement, instead of recording the movement on the computer during his break or at

the end of the day, the system will automatically record the new position when the operator scan the bar code of the product and the bar code of the bin. All movements would be recorded in the system in real time. Thus, information about material's position would be more accurate by removing time inconsistency in the record.

Global average distance travelled is to decrease. If accurate putaway strategy is set up, fast moving item will be placed in fast moving access zone. This zone will be rapidly depleted and available for other item. In general, average time between movements for fast moving bins would be lower than average time between movement for slow moving bins resulting in a decrease of travel time and cost.

Report analysis indicates that 85 movements are linked with mismatch between system's indication and reality. For instance, in some cases SAP indicates that a material is stored in S-type XXX/bin YYY. However, when an operator has to pick this material, bin YYY is empty or stores the wrong product which means that an error has been made during the putaway processes. This kind of errors would significantly be reduced

Moreover, the movements report analysis reveals that 1,802 movements (over the 14,489 movements analyzed) are "intra-warehouse" movements. This means the pallet has been moved from one bin to another inside the warehouse for several reasons, e.g. there is only one pallet left on floor bin, the operator decides to move this pallet onto rack to avoid having too many batches on the same bin (problem exposed in section 5.1.1.3). It can be perceived as a "muda" of overproduction (see section 2.1) since it is a movement that could have been avoided and may refer to unnecessary handling of materials. Those movements may be scrapped with automatic putaway because the system would propose an appropriate position right the first time.

5.2 Picking

The main disadvantage of the current stock removal strategy is the gap between Inventory Management and Warehouse management. As explained previously, the order picking is processed on the plant level. The material is selected through the storage location SENF according to customer's specificities. However, at that organization level, no distinction is made between stock of one building or another. Even if the system proposes the batches that correspond to this requirement, an employee must double check every time if this SAP's proposition is situated on SB20 building. If it is not the case, the employee must select manually another batch that causes bypass of the FIFO rules.

In other words, SAP proposes efficient batch search strategy that allows automatic picking activities. However, due to lack of consistency on the storage type level, Dow Corning Seneffe must process each picking manually.

5.2.1 IM Structure: Storage Locations

The SAP definition of a storage section clearly proposes to set one storage section per building. The three buildings of Seneffe require undoubtedly a WMS in order to manage large quantities of raw materials and finished goods. With the new version of SAP, a storage section can be managed with WM module.

The main suggestion of the project is thus to create three new storage locations that would represent each building: SB20, SB60, SB02 to replace the main storage location SENF.

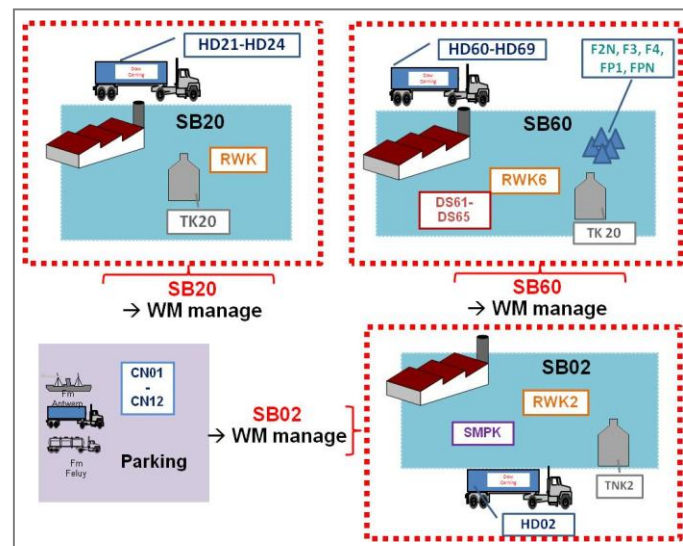


Figure 5.10 Storage section layout proposal

Figure 5.10 shows that each building is represented by a new storage location. This new structure allows the company to use automatic picking. The system is set to make the distinction between the stocks of one building and the stocks of another building on IM level. During batch determination process, SAP would therefore propose only batches and pallets located in the right building: SB20.

5.2.2 Implications

All changes made on the inventory level are obviously thornier than those made on the WM module. Storage locations are implicated on activities of many departments of the company (production, logistics, quality management etc.). The impact of those three new storage locations on the picking activities is positive by improving the batch search strategy. However, it is necessary to perform an in-depth impact analysis on the business activities concerned.

During my investigation at the distribution center of Feluy, I have discovered important problems concerning building visibility of Seneffe site, especially for the deliveries. Even if the primary objective of this thesis is not to resolve this problem, this study can permit to determine the global necessity to change the storage location setting. Here is the situation as it is today. When Seneffe needs materials from Feluy, an “Inter Plant Purchase Order”¹⁵ (IPPO) is created. This means that Seneffe (plant 0041, see organizational structure) calls for raw materials or intermediate materials require for production. Every day Feluy’ employees are looking at the IPPO list (see Appendix 18 for examples) in order to create the shuttle and bundle the different orders in one trailer. One important point is that Seneffe site does not accept a truck stopping at different buildings: one shuttle must be intended to one single building. Feluy must therefore gather the orders by building.

However, the IPPO list they are using does not provide any information about the destination building at that time. Indeed, it only provides the S-loc which doesn’t help to know the building since 89% of the orders are made on the SENF storage location (see Figure 5.11). Feluy’s employees actually must create the shuttle on the basis of the “Creator ID” (see Appendix 18, marker 2 “Created by”) to discover the destination. Based upon the experience, they know the building of the person who has made the purchase order and so, know where the order must be

¹⁵ When two plants of the same company make purchasing: Plant A buys from product Plant B [help.SAP.com].

shipped. However, this point is neither efficient nor reliable. Information asset management must be documented and based on concrete information.

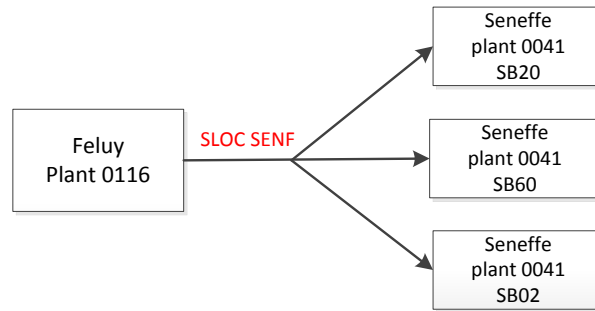


Figure 5.11 IPPO between Feluy and Seneffe: as-is

The creation of three S-locs to represent the three buildings of Seneffe would allow a significant improvement in the shipping activity. S-loc (SENF) parameter would be replaced by the appropriate building and therefore will be visible on the lost. Moreover, instead of manually creating the shuttle on the basis of creator name, SAP could automatically group together orders with the same destination building. This is depicted in Figure 5.12.



Figure 5.12 IPPO between Feluy and Seneffe: to be

The time –saving would be very important since a worker had to spend approximately 2 hours per day in this non-value added activity. If the objective is to estimate this value in Euro, we can approximately say that an employee is paid 18€/hour, this manual activity costs Dow Corning 720/€ a month. Concerning other impacts, the creation of three S-locs doesn't involve important disadvantages.

5.2.3 Expected Outcomes

From an IM point of view, the advantages of recommendations made for the picking are due to improvement of buildings visibility, the error rate will obviously go down and we can expect the number of shuttles between Feluy and Seneffe will be reduced too. It is quite difficult to put a figure to this gain but estimations can give us an idea. The non value-added activity performed by Feluy employees will almost be reduced to zero. The average wage of a traffic employee is

18€ per hour which means a benefit of 4,320 € per year. But this is not the most important advantage.

Automatic consolidation would reduce the number of errors. Operator estimates that 2 shuttles per month have mixed destination buildings or wrong information about the destination. In some of these cases, the shuttle comes back to Feluy without unloading any material.

Average cost per hour of a logistic operator	35€/h
Average transport cost for a shuttle per ton	8€/t
Average tons per shuttle	18
Average time per trip (travel time + waiting time)	30 m
Cost per shuttle for one trip	156.5€

Table 5.4 Cost of shuttle (internal information)

Assuming that “mix¹⁶” shuttles cannot be used, with an estimation of two per months, the firm loses 313€ per month (see Table 5.4) due to bad information management. This lost is avoided with the automatic consolidation of transports.

The improvement of the Batch Search strategy lowers the number of scrapped material due to out of storage life. Indeed, for now, if the system indicates a material which is located in another building, employees chooses manually another batch. However, during this manual choose, it is not guarantee that the employee chooses the older batch. He prefers to select pallets on the ground in order to facilitate the picking: warehousemen prefer to retrieve a pallet on ground storage than in the rack, even if the batch in the rack is older. In this case, the FIFO rule is not respected and may involve a greater number of scraps products.

This “automatic” batch selection is no longer a need if the system only proposes batches in SB20. Traffic employees must now exactly follow SAP proposal according to FIFO rule; resulting in a reduction of scrap due to out of storage life. As shown in Appendix 20, scrap due to out of storage life is the leading cause of scrap. Knowing that one tone of scrapped products cost approximately 400€ (internal DC information), it leaves the room for important opportunity to save money.

¹⁶ A shuttle intended to deliver to more than one building, e.g. SB20 and SB02.

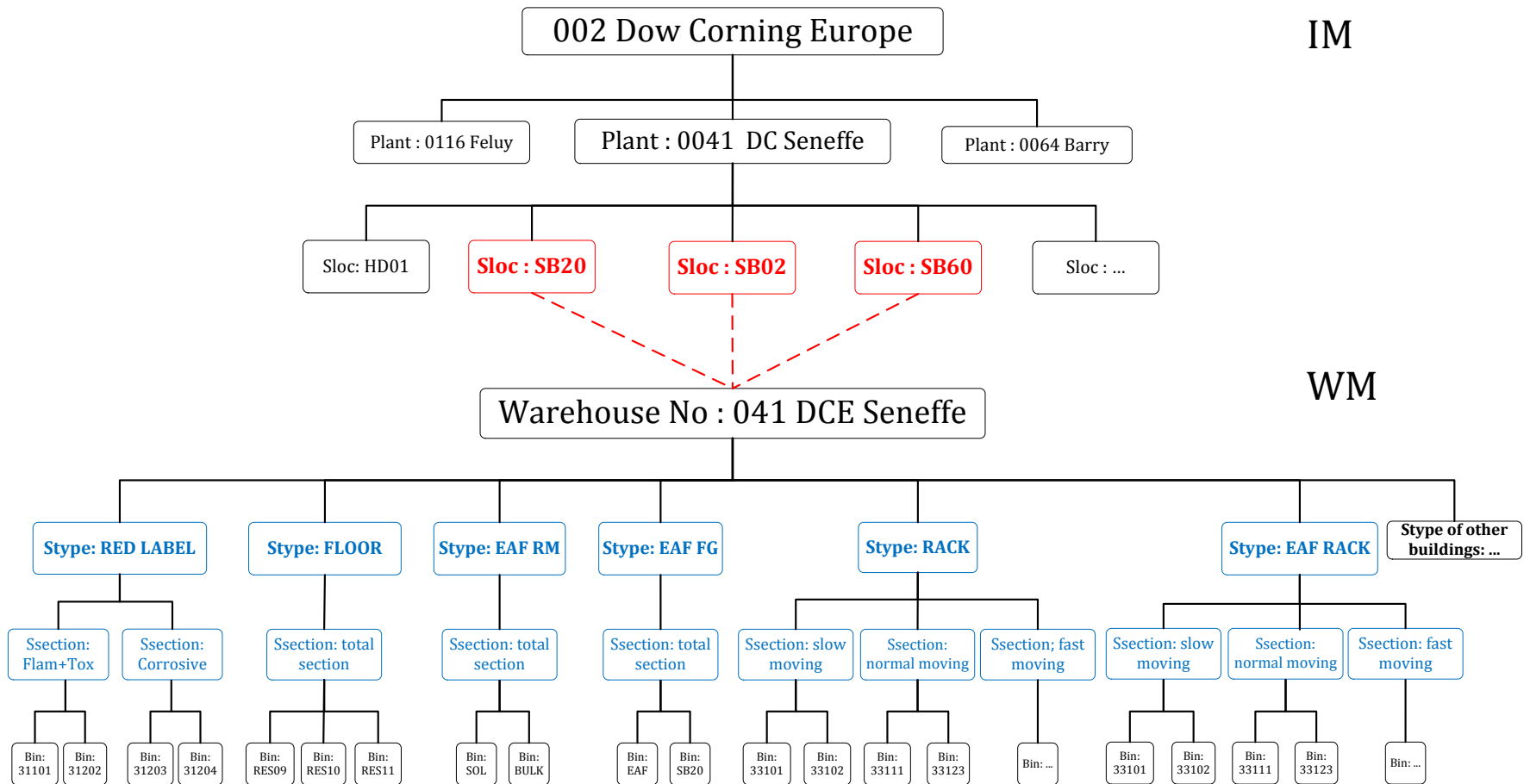


Figure 5.13 Organizational structure proposal

5.3 Final Organizational Structure Proposal and Discussion

This section will present the final results to expose the SAP architecture, as it should be set taking into account previous analysis. It gives an overview of the situation as it was analyzed in this thesis. To make things clearer, Figure 5.13 represents only the IM storage location and WM study framework: SB20 building. This means that only the new storage types of the SB20 are represented.

The aim of this section is to provide well-organized summary in order to group together all findings of my analysis. Here are several points to be noticed:

- IM module remains the same except for the storage locations.
- The S-loc SENF is deleted.
- The three new storage locations are in red (SB20, SB02, SB60) and are warehouse managed (dotted red lines).
- WM module remains the same except for S-type and S-section.
- Former SB20 S-types are removed and replaced by the six new S-types: floor, rack, EAF rack, raw material, finished good and red label depicted in Figure 5.13.
- Each storage type is divided into several storage sections except for floor storages.

We have presented our recommendations to then logistic team and supervisors. They were very interested in learning more about this subject to improve their processes. However each change in the organizational structure of SAP is an important project. It implies a lot of time for data management¹⁷ team that have to modify each parameter involved in the project. Such a project requires new procedures and thus, trainings and well organized teams.

Concerning the putaway strategy, the creation of the new S-types and S-section is not a tricky task in itself but the assignment of S-type and S-section indicators for each material is. Once all indicators have been configured, we have to analyze each material to assign the best indicator. It implies to load two new fields for each item (4,601 in Seneffe) and for each new item. Moreover, as we have seen in section 5.1.1.3, storage unit type and storage bin type parameters must be maintained up-to-date to ensure physical compatibility between the bin and the pallet. Dow

¹⁷ Data management team takes care of data as a valuable resource [Wikipedia]. It creates new items, update parameters, etc.

Corning currently maintain SUT on 3116 items (only 67% of the data), it implies to complete this field for the other 1,485 items which represents a quite heavy task.

The current capacity utilization of the warehouse (see Appendix 16 for detailed figures per storage type) allows managing storage assignment as it is now. Moreover, the problems faced by SB20 logistic team are not important enough to justify such investment of time and resources. This is why our improvement should be considered in the long term.

In conclusion, there is a great need for improvement of the storage locations layout, not only for the purpose of the putaway strategy but also for the global visibility of the buildings. The impacts of this project are extremely positive for picking process and delivery creations.

5.4 Wider Application

One of the objectives of my thesis is to generalize DC case and see what we can learn from this analysis. In this regard, this section points out the most important arguments discovered about the putaway and picking strategy in order to summarize advices about the approach to adopt in this kind of study.

The design of IM and WM organizational structure implies a perfect understanding of the company, its processes, its products etc. Since it implies large quantity of information, it is appropriate to analyze warehousing notion according to the proposition of Rouwenhorst et al. (1999): resources, processes and organization. The implementation of a putaway and picking requires a complete evaluation of the business to take each element into account. We have to adopt a critical look at the current effectiveness of the process.

This thesis could have included a review of the physical arrangement of warehouse SB20. Indeed, complete review of the stock placement and stock removal processes may incorporate an assessment of the physical disposition of a warehouse: zones, racks, aisle, bin size, bar codes position etc. However, the more the project is an in-depth review, the more the outcomes are difficult to evaluate. It is important to set limits and define right from the beginning the scope of the study in order to keep the primary objective of the project in mind.

Our methodology used to implement the putaway strategy is interesting for other cases. From a general point of view, companies should ensure that terminal guns are suitable to scan each bar code inside the warehouse.

Regarding the putaway strategy, the most important points to keep in mind for others case study are the following:

- Analyze the warehouse layout: racks, bins, storage rules, etc.
- Divide the warehouse into storage types according to physical and organizational features. It is not recommended to create too much storage type that could leads to a dedicated storage policy and a reduction in performance.
- Divide the storage type into storage sections. They are very useful to divide the areas into fast, normal and slow moving. It is important to conduct a study to discover which zone is faster than another one. Sometimes, field research changes the basic idea about the accessibility of a storage location. As we have proposed in this thesis, storage sections may be used for various reasons. It is a good idea to define storage section in function of the

Picking activity at DC Seneffe is quite specific since batch determination takes place at IM level. However, we can learn some lesson from this case:

- Though previous version of SAP did not allow to manage several storage locations with one warehouse number, SAP clients should keep in mind that the solution to several problems may be to create several links between storage locations and warehouse number (see Figure 3.1).
- Primary objective of the storage locations is not to physically define areas inside a site. However, storage location must divide the type of stock. This distinction may be useful for operations which do not imply WM: it is the case for picking at DC Seneffe.
- Storage locations are involved in many activities of the business processes. It is essential to evaluate the impact on other departments.

Before deciding to implement automatic putaway and picking, a company should carefully assess the trade-off between time saved and additional time in maintaining data. As stated above, both improvements imply to maintain and change a large amount of data. Furthermore, the more the strategy is exhaustive, the more data management has to maintain parameters. Even if managers would like to automate process, the big question is: “Is it worth it?”.

6. Conclusion

This thesis investigates the stock placement and stock removal activities in a company supported by SAP system. The aim is to analyze a real case study in order to propose improvements for Dow Corning Seneffe as well as general advices applicable in other cases. The work is divided into four main parts. The first stage is to present useful concepts and the theory about picking and putaway strategy. Afterwards the organizational structure of SAP and the parameters are explained in order to provide a clear understanding of the standard proposition. The third part gives required explanations about the current situation of the real case study, Dow Corning Seneffe. This part already offers a critical analysis by showing the main disadvantages of the current system. Finally, the last section is the real added-value of the project and the enforcement of the three previous parts. It provides consistent and clear recommendations.

The purpose of my thesis is to address the specific problem of stock placement and removal strategy using the ERP SAP. The putaway and picking activities are supposed to be correlated due to similar settings. However, Dow Corning Seneffe has not been applied the picking strategy on the WM level: it only maintains it on the IM module. Therefore the picking strategy considers the storage locations but not the WM structure. This work results in two distinct studies that are summarized hereafter.

Concerning putaway (stock placement policy), changes are quite important knowing that actual situation is fully manual. The recommendations discuss the “redesign” of the WM module (except for bins that are physically defined) to address a brand new automatic strategy. The first thing to do is the design of new S-type on basis of physical and organizational criteria. Afterwards storage section is defined depending of the time required to access the bin of the rack. Finally, a storage type search and storage section search are provided for each classes of material. The automatic putaway strategy will surely provide a decrease in error and improve space utilization, which result in a reduction of the overall warehouse movements. However, as exposed in Appendix 16, only 26% of the total capacity is used. This small utilization rate can justify a manual putaway on basis of the operator’s experience. This project must therefore be viewed over the long-term.

The picking strategy analysis has really provided positive results. The introduction of three storage locations per building improves the batch search strategy. Moreover, the IPPO Feluy-

Seneffe will also benefit from this change. This project has direct and clear benefits on the business. Dow Corning Seneffe will probably deploy it within the next months, which demonstrates company's interest in this work.

It may be helpful to take a step back to find the improvements and additional benefits the ERP system was supposed to provide, but that have not been observed to date. An external review of the system will allow critical analysis on the whole consistency of the system. The case of Dow Corning has revealed a recurring pattern in big companies. Indeed, during new information system implementation, many companies do not have the required experience to set the system optimally. Therefore, they tend to make incremental changes to the settings to resolve various problems, at the expense of the overall consistency. When the new SAP version has allowed several S-loc managed with WMS, they should have scrapped SENF and created the three storage location per building. It is the same problem for the S-types.

It is sometimes difficult to make decisions to improve processes since each enhancement involves changes and a lot of persons may fight against them. In particular, storage location changes will impact a lot of departments. Planners will have to work with these new storage locations, without reaping any benefit. However, a manager has to think about the global advantages and take the best decisions for the overall business.

The number of papers dealing with the storage assignment project policy is quite large. Many of them however are focusing on fictive cases without taking into account the possible integration of an ERP. This creates a gap between theory and practice. In this context, the present thesis may bring in a new perspective, which leaves room for future researches by incorporating ERP systems into basic researches.

Finally, it is important to ask if the automation of the stock placement and removal does make sense. In the actual evolution of processes, managers want to minimize manual activities and give all the responsibilities to the IT system. They rationally want processes to be automatic in order to reduce error rates and non-value-added activities, but where does the human stand in this vision? The trade-off of more people time versus computer-time is still going on.

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