Inventory Management

Business Process Recommendation

Procurement

LafargeHolcim

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FOREWORD

The LafargeHolcim Inventory Management Recommendations were designed to help planning, managing, and controlling inventories.

The systematic optimization of net working capital (NWC) is a focus of the LafargeHolcim Group. This document aims specifically at supporting the optimization of NWC through inventory management.

With the globalization of LafargeHolcim's businesses and the company's growing presence in new markets, working capital has become an important priority for top managers.

As the cement industry becomes increasingly globalized, LafargeHolcim – the world's largest cement, aggregates and ready-mix concrete producing companies, with operating companies on all continents – recognizes the need for standard inventory management criteria to facilitate more effective and efficient management of working capital.

In 2011, Procurement, in collaboration with Cement Industrial Performance (ex-CMS/Holcim) and with the support of Corporate Controlling, Sustainable Development, H&S, and legacy Holcim countries has established a program to optimize the sustainable management of net working capital at LafargeHolcim Countries with specific reference to inventory and strategic spares management as well as payables.

This program optimized business processes, practices, and transactions by focusing on suppliers and inventories.

In 2016, after the merger of the two legacy companies, Lafarge and Holcim, the Group established new targets for Strick Net Working Capital (SNWC) including functional targets for Procurement and Cement Industrial Performance (CIP).

Procurement decided to revise and update the "Inventory Management Recommendations" expecting that it supports LafargeHolcim to achieve its SNWC Target.

Working capital is not only a financial issue, but also an operational issue. It is about the way we conduct business processes and transactions involving inventories, suppliers, and customers.

It is the responsibility of every LafargeHolcim country to manage working capital well in order to free up funds that will allow the Group to keep growing.

We hope that you will find this document useful and we would like to express our sincere thanks for your support, collaboration, and cooperation in this important process.

INTRODUCTION

With this document we aim to provide inventory management staff at LafargeHolcim with a complete set of ideas and tools to optimize the strategic and operational activities related to the management of the procured inventory. Optimized inventory management will have a direct impact on net working capital (NWC).

Different types of inventories are managed in our industry:
- Finished and semi-finished products;
- Raw materials (extracted from quarries or procured through third-party suppliers);
- Fuels (procured through third party suppliers); and
- Parts and supplies (procured through third-party suppliers)

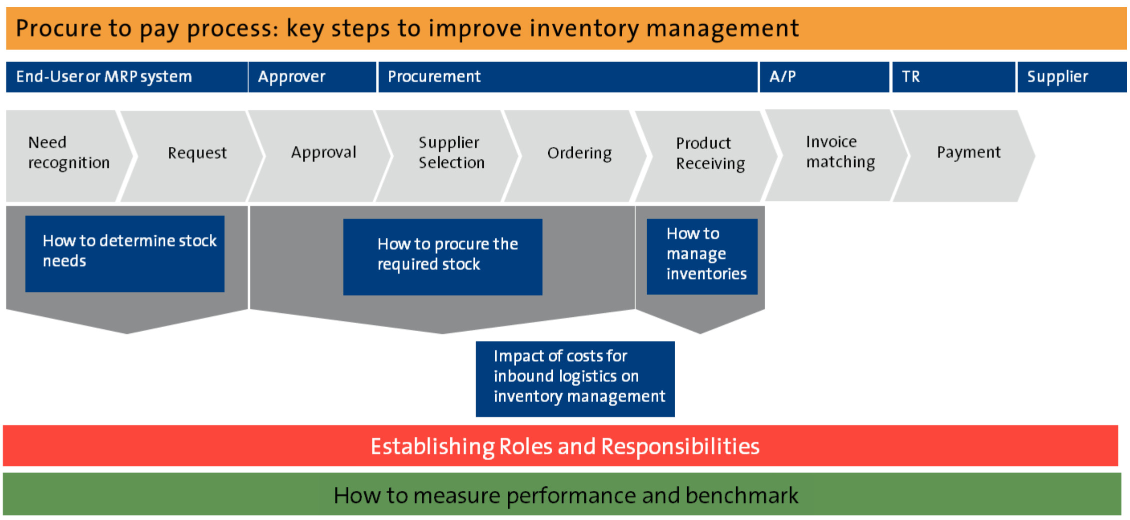
In addition to these inventories, LafargeHolcim warehouses also store critical spare parts, which can be capitalized in accordance with LHARP principle. They do not affect NWC.

In order to guarantee the necessary plant reliability, the availability of the required critical spare parts (assets and inventories defined by operations in a risk assessment and failure mode effect analysis) must be assured at all times.

This document focuses on "procured inventory", where procurement organizations and operations units within the Group can contribute to the optimization of net working capital while assuring plant reliability.

How to read this document?

The document is structured in line with the "Procure to Pay" process:
- At the end of each section, a "key" box summarizes the key message of that section.
- "Information boxes" indicate other sources of information related to the topic.



1 Contributing to LafargeHolcim results by managing inventories

Good inventory management aims to optimize a company's existing stocks by minimizing their volume and cost without endangering the company's ability to fulfill its commitments to customers. In order to reduce downtime, parts need to be available in the right quantity, in the right quality, in the right place and at the right time.

Optimal inventory management pursues the following objectives:
- To properly define the quantity of goods to order (lot size);
- To properly define the date for placing the order (reorder point);
- To properly define storage locations and conditions;
- To properly define the inventory levels needed;
- To properly define replenishment activities; and
- To properly control inventories.

Inventory management (IM) is not just a short-term operational function. It has strategic repercussions for a company because of its considerable impact on the level of net working capital as well as the reliability of operations.

Therefore the IM function has a double role:
- To manage a determined logistics system using optimal operational criteria; and
- To plan the logistics system as effectively as possible for the medium and long term.

One of the fastest ways to enhance shareholder value is to manage net working capital more effectively.

Net working capital is defined quite simply as current assets minus current liabilities. But it is influenced by all business processes and transactions involving customers, suppliers and inventories.
To better understand the impact of inventories on a company's net working capital (NWC), we need to analyze the NWC structure:

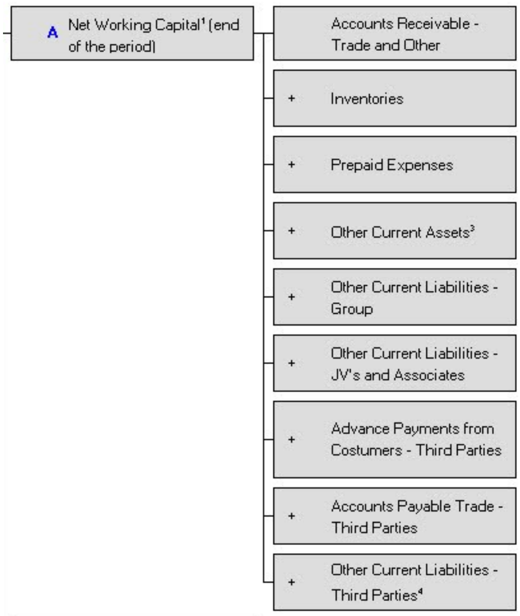
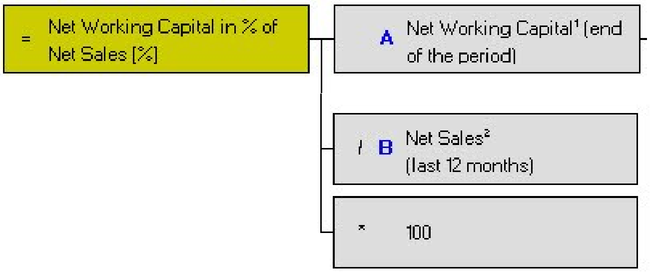


Figure 1.1: NWC structure (LHARP manual release 16.2)

$$\text{Net Working Capital in \% of Net Sales [\%]} = \frac{\text{Net Working Capital}}{\text{Net Sales (for previous 12 months)}} \times 100$$



[1]The Net Working Capital (NWC) represents the Net Working Capital at the end of the period.

[2]Net Sales has to represent the corresponding Net Sales for the last 12 month-period. For example the Net Sales to be used for the calculation of this indicator for June 2004 would be the Net Sales for the period from July 2003 to June 2004.

[3]Other Current Assets except the components of line 24: 'Income Tax Receivables/Prepayments' and 'Current Assets Held for Sales'. Please note, that the corresponding liabilities relating to the assets held for sales booked under 'Other Current Liabilities' must be also excluded not to distort the NWC indicator.

[4]Other Current Liabilities - Third Parties please note, that the corresponding liabilities relating to the assets held for sales must be also excluded so as not to distort the NWC indicator.

Figure 1.2: NWC calculation (LHARP manual release 16.2)

The inventory figure is calculated in absolute terms by normalizing each NWC element.
The composition of “inventories” is detailed in Figure 1.3.

It is also important to analyze the composition of the “inventories” figure as reported in the company balance sheet:

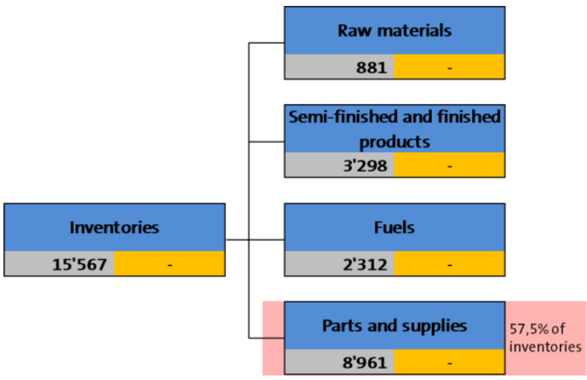


Figure 1.3: Sample inventories structure of a LafargeHolcim Country

Optimizing net working capital is an ongoing task at LafargeHolcim.
We have a major opportunity to contribute to LafargeHolcim’s NWC level by optimizing the way procured inventory is managed. This target can only be achieved through a coordinated interdisciplinary effort by Procurement, Finance and Operations to streamline integrate and synchronize supply chains and financial processes.

2 How to determine stock needs

The existence of stock is usually due to a difference in volume and terms between "goods reception flows" from a logistics chain and "goods issuing flows" generated by demand.

If we know with sufficient reliability what the "goods issuing flows" are, it is relatively simple to plan the "goods reception flows" so as to minimize inventory levels while taking into account technical and economic constraints.

Consequently, demand planning and forecasting are core aspects of inventory management.

A key driver in the optimization process is the availability of required items.

In order to optimize inventory levels, it is vital to have proper planning and scheduling. This ensures that the need for spare parts can be communicated at an early stage. It also facilitates a systematic approach to the detection of such needs that gives due consideration to the criticality of equipment and the associated risk of failure.

2.1 Risk Assessment & Failure Mode Effect Analysis

The systematic detection of spare parts needs can be divided into three major steps, as shown in figure 2.1:

1. Definition of plant-specific area risk matrixes
2. Development of Failure Mode Effect Analysis (FMEA) for the most critical equipment and
3. Definition of measures to reduce the probability or severity of an unforeseen incident

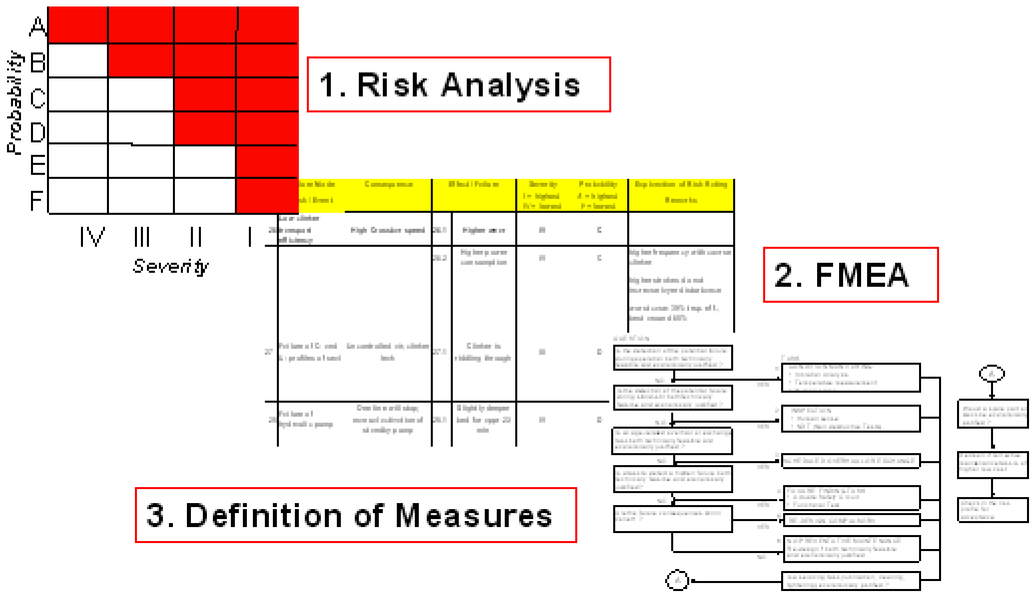


Figure 2.1: Process for systematic detection of spare parts needs

As shown above, the first step in the process of systematic detection is a risk analysis.
Risk can be defined as the probability of occurrence of an incident, multiplied by the severity of this specific incident:

$$\boxed{R = P * S}$$

Where: R: Risk
P: Probability
S: Severity

As it will be shown later this can be visualized in a so called "risk matrix", one of the axes representing the level of probability and the other the level of severity.
The probability factor can be expressed in terms of frequency, using probability indicators starting from "A" down to "F". A probability rating of "A" means that an unforeseen incident is likely to happen very frequently, thus “every three months”. The lowest probability is "F" (“once every 20 years”), which means that it is almost impossible that this incident will occur. The probability indicator can be adapted from case to case, but experience has shown that for the cement business the following classification is convenient:

A: Occurs every three months
B: Occurs once per six months
C: Occurs once per year
D: Occurs once per two to three years
E: Occurs once per five years
F: Occurs once per 20 years

The severity of an incident can be expressed in terms of production loss and excessive maintenance cost. A "catastrophic" incident has a severity rating of I, a "negligible" incident a rating of IV. For the severity in terms of production loss no standard setting can be applied, since this depends on the specific plant layout or even the area of the plant.

By monitoring the production loss, the customer point of view is being taken. It has to be determined for how long equipment can be shut down in a specific area before the customer has to be called to be informed that the product can no longer be delivered. This reserve time of course very much depends on the reserves in form of silos and bins that are to be found throughout the process. For instance, in the case of an equipment in the quarry, it might take up to two weeks or even more before the customer has to be called to be informed that no more product can be delivered. This is due to the fact that the quarry products are used and transformed in the production process, and therefore reserve is found throughout the process in pre-blinding beds, homogenization, clinker silos, and, ultimately cement silos. In another example, in the case of an equipment in the cement mill area, the reserve time that remains before our customers’ needs can no longer be satisfied is much smaller, since the only remaining equipment where product can be found is the cement silo. In an outsold market this can mean, that only a reserve of 12 hours or even less is held - taking an average value for the whole year.

That is why each time a major reserve in the process is found a new (separate) risk level has to be defined and therefore a cut has to be made.

The figure 2.2 shows a schematic example of a plant including the different area distributions.

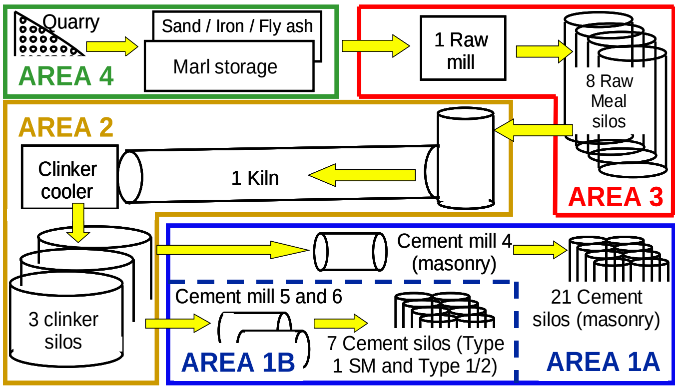


Figure 2.2: Schematic plant layout with area distribution for risk matrixes

The other parameter to be monitored on the severity axis is maintenance cost. The following standard procedure can be used to set the level of a “catastrophic” incident in a cement facility:

1. Take the upper specific maintenance cost guide value and multiply it by the cement capacity based on clinker production. This value represents the plant’s yearly maintenance budget.
2. Take 15% of the value calculated under point 1. This is the setting for a “catastrophic” incident: if more than 15% of the yearly maintenance budget is spent on one single unforeseen incident it is classed as “catastrophic”.
3. To determine the levels for the remaining severity classes from “II” to “IV” (negligible) the “catastrophic incident” value is divided into equal amounts down to zero.

As mentioned above, the “risk matrix” can be used to visualize the risk (figure 2.3).

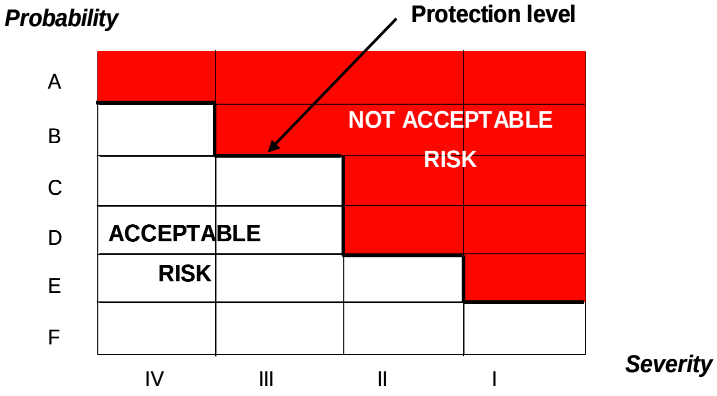


Figure 2.3: Risk matrix

The risk matrix as shown in figure 2.3 is built using the probability and the severity ratings as described above.

The line which separates the red from the white area is the “protection level”. The protection level has to be set by the plant manager, who balances the severity of an incident against the probability of its occurrence. The plant manager has to consider whether he is willing to accept an incident that occurs very frequently (probability “A”) but has a very low severity (severity rating “IV”). As shown in the example in figure 2.3 such an incident is unacceptable, so the field is red. Meanwhile, an incident that occurs less often (probability “B”) and that has a very low severity (severity rating “IV”) is acceptable, so the field is white. This means that the protection level is set between these two fields. Now the plant manager can switch over to the next column and apply the same approach until he reaches the column with a severity of “catastrophic”.

As shown in figure 2.4, four different areas can be distinguished in a risk matrix.

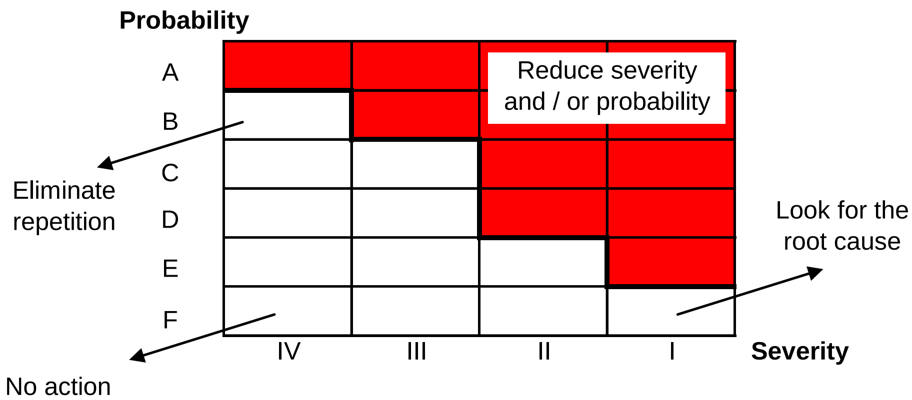


Figure 2.4: Different areas of a risk matrix

On the upper right area, the red area indicates an unacceptable level of risk. For this area actions must be defined to reduce the probability and / or the severity of an incident. The description of how this can be done will be given once the FMEA has been discussed.
In the field on the upper left side (field «B-IV»), we find incidents with a low severity but a high probability. For this type of incident, measures to reduce the probability need to be defined, because while the incidents may not be severe they still require attention and time.
In the field in the lower right corner of the matrix (field «F-I»), incidents are very improbable but if they do occur, the severity is high. For this type of incident, the root cause has to be detected.
In the remaining areas (white), no particular actions need to be considered. Figure 2.5 shows a sample risk matrix for the raw meal preparation area (Area 3 in figure 2.2).

Probability	A - Very high (once per 3 month)				
	B - Moderate (once per 6 months)				
	C - Occasional (once per 1 year)				
	D - Remote (once per 2 to 3 years)				
	E - Unlikely (once per 5 years)				
	F - Impossible (once per 20 yrs.)				
		IV : Negligible	III : Moderate	II : High	I : Catastrophic
		Severity			

Operation loss From [hours]:	0 - 4	4 - 12	12 - 48	over 48
Maintenance cost [kUSD]:	0 - 10	10 - 50	50 - 500	over 500

Figure 2.5: Example of a risk matrix for the raw meal preparation area as shown on the area distribution in figure 2.2

The plant-specific risk matrixes definition concludes the first step in the process of systematically detecting spare parts needs. It is very important to note that a risk matrix is not static. Changes in the market and in processes (e.g. the installation of a new raw mill with a higher capacity or the upgrading of a complete kiln line) can have a big influence on the plant-specific risk matrix. It is therefore recommended that matrixes are reviewed annually and adapted as necessary.

The second step to tackle is the "Failure Mode Effect Analysis" (FMEA). FMEA is a review technique, which was developed for the aerospace industry. It defines failure modes as well as actions to reduce the risk of failures.

The various failure modes are listed for specific equipment. Their position is recorded in the area risk matrix based on the probability of their occurrence and the severity of the incident.

Sub-Systems		Failure Modes		Cause	Effect	S	P	Assumptions / Explanations
					NO ACTIONS CONSIDERED			
Drive System	1	Motor failure	A	Bearing failure	Mill stopped for 72 hours	I	E	No spares kept on stock
			B	Winding failure	Mill stopped for 120 hours	I	E	No spares kept on stock
	2	Fluid coupling failure	A	Thermal plug failure due to ovlerlaod	Mill stopped for 7 days	I	B	No spares or similar plugs kept on stock
			B	Seals failure	Mill stopped for 7 days	I	E	No spares kept on stock
			C	Bearing failure	Mill stopped for 7 days	I	E	No spares kept on stock

Figure 2.6: Extract from an FMEA for a belt conveyor

The visualization of the different failure modes in the specific area risk matrix is shown in figure 2.7, where each number represents one failure mode in the FMEA of a belt conveyor. For the numbers located outside the protection level (i.e. in the red zone of the matrix), actions will have to be defined to reduce probability or severity so that they can be moved into the safe area of the matrix (white zone).

Probability					
	A - Very high (once per 3 month)				
	B - Moderate (once per 6 months)				2A
	C - Occasional (once per 1 year)				
	D - Remote (once per 2 to 3 years)				
	E - Unlikely (once per 5 years)				1A
	F - Impossible (once per 20 yrs.)				
		IV : Negligible	III : Moderate	II : High	I : Catastrophic
		Severity			

Operation loss From [hours]:	0 - 4	4 - 12	12 - 48	over 48
Maintenance cost [kUSD]:	0 - 10	10 - 50	50 - 500	over 500

Figure 2.7: Failure modes as defined in the FMEA and plotted in the risk matrix. Each number represents one specific failure mode as shown in Figure 2.6.

The development of the FMEAs is of utmost importance because it sets the focus on A-critical equipment (refer to the ABC criticality analysis as defined by the MAC/SAP standard). If A-critical equipment fails, this has an immediate impact on the main production process.

When developing FMEAs it is important that experienced people who have a deep knowledge and understanding of the plant and its equipment are involved in order to ensure that the process is rigorous.

The third and last step in the systematic detection of spare parts needs is the definition of the measures that will reduce the probability or severity of an unforeseen incident.

The measures to be taken can be categorized as follows:

1. Improvement of preventive maintenance, if technically and economically feasible through e.g. implementation of additional Preventive Maintenance Routines (PMRs) or adapting the frequency of already established PMRs;
2. Establishing a contingency plan, such as e.g. by making sure that the drawings of a specific shaft are available, so if necessary it can be produced in a nearby workshop; and
3. Holding a spare part. This does not mean that the spare part necessarily has to be kept on site. Maintenance with the very active support of procurement has to find an appropriate strategy.

As already mentioned, the numbers in the different fields of the above figure indicate a few examples of different failure modes that were considered in the FMEA of a belt conveyor. Every number is shown twice; once in white, which means that no action is being considered (initial risk according figure 2.7) and once in blue which reflects the case where an action is being considered.

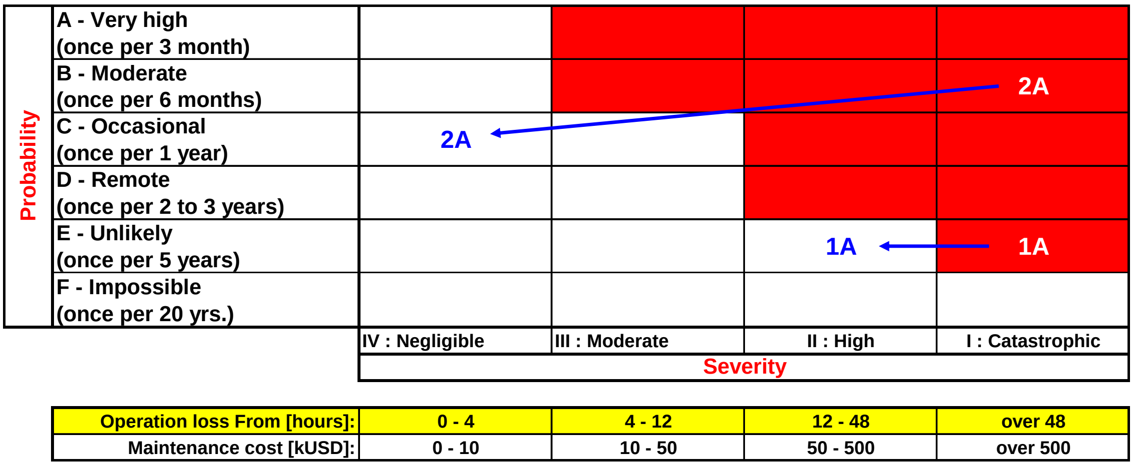


Figure 2.8: Impact of decision taken to reduce the severity of an incident. The blue numbers represent the failure modes after an action to reduce severity has been defined as shown in figure 2.6.

As shown in figure 2.8 in the case of “1A” a horizontal movement towards a lower severity rating has been reached. For this particular example of a bearing failure this can e.g. be reached through the implementation of a lubrication routine or vibration analysis. Especially the second measure can help in the early detection of a potential failure and so guarantee that spare parts are ordered on time.

For “2A” a horizontal as well as a vertical movement has been reached. Again, the horizontal movement will mainly be reached through measures such as improving maintenance routines, having a contingency plan or of course also holding a spare part (elimination of lead time to spare part). The vertical movement, thus the reduction of probability of occurrence of an unforeseen incident is very much related to assuring optimum working conditions. Proper installation of the parts and guaranteeing optimum working conditions are key elements in helping to reduce the probability of occurrence of a failure.

Besides the visualization as shown in figure 2.8 all measures have of course to be documented in subsequent columns of the FMEA template as shown in figure 2.6. This way the decision-making process is documented step by step.

It is of course also very important that all measures documented in the FMEA are put into practice, which in this example would mean that a new PMR would have to be implemented in SAP.

2.2 Maintenance Planning

The situation in many plants shows that maintenance is often blinded by short-term cost control measures instead of looking at long-term results. As a result of this, a reactive maintenance approach takes place, which increases cost and reduces equipment reliability.

It is therefore of utmost importance that the different tools and techniques that shall be applied in order to properly plan and schedule the work are clearly understood. This supports the move from a reactive towards a proactive maintenance approach.

This will not only help in increasing reliability, reducing costs and time-consuming reactive work, but is also an important step towards clearly defining the maintenance needs and optimizing resources (labor and material).

What is the difference between planning and scheduling? A lot of maintenance organizations believe it is the same. Other maintenance organizations know the difference, but in the end spend time on scheduling and very little on planning or vice versa.

Planning and Scheduling are not of the same maintenance activity or process. Planning defines the details of WHAT and HOW, while Scheduling defines the details of WHEN and WHO. In general, planning should always be done before scheduling.

However, both the planning and scheduling function are the center from which all maintenance activities are coordinated. Both represent the “work preparation” in maintenance and tackle the following aspect:

- Planning ➔ What is the work? How to do the work?
- Scheduling ➔ Who does the work? When to do the work?

Planning is mainly about identifying the problem and determining the proper solution, manpower, and other resources such as material, time, tools, equipment and technical data required for a safe, efficient and effective work execution.

Scheduling work is the process whereby the specific dates are finally defined and coordinated for the execution of (planned) work for the following week. Maintenance cannot move on from the reactive stage without firm control over the activities to be carried out. Therefore also poor management of backlog is a hurdle.

The planning and scheduling process is divided into three stages:

1. The Maintenance Master Schedule
2. The Weekly plan and
3. The Daily plan

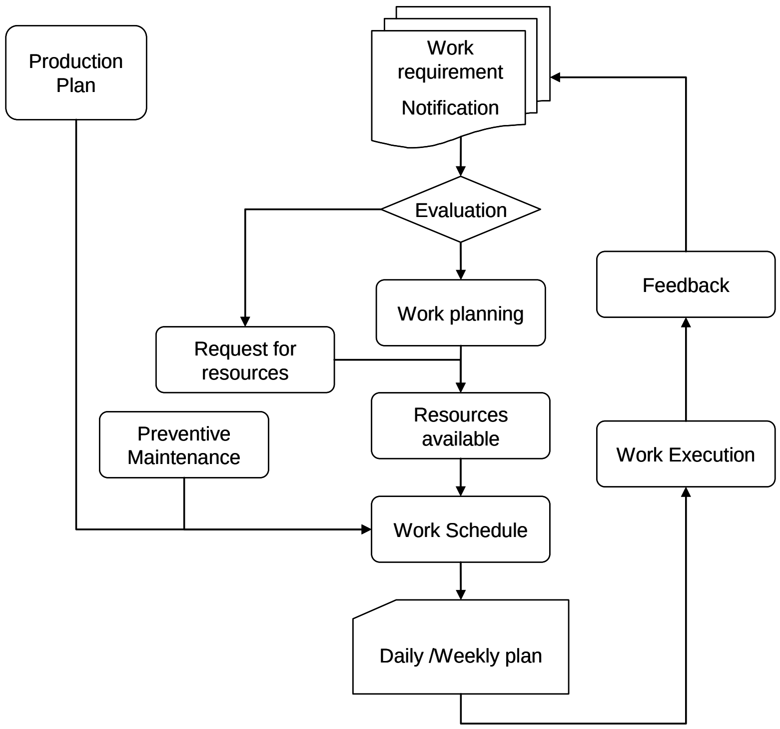


Figure 2.9 Planning and scheduling process

Maintenance management work cycle:

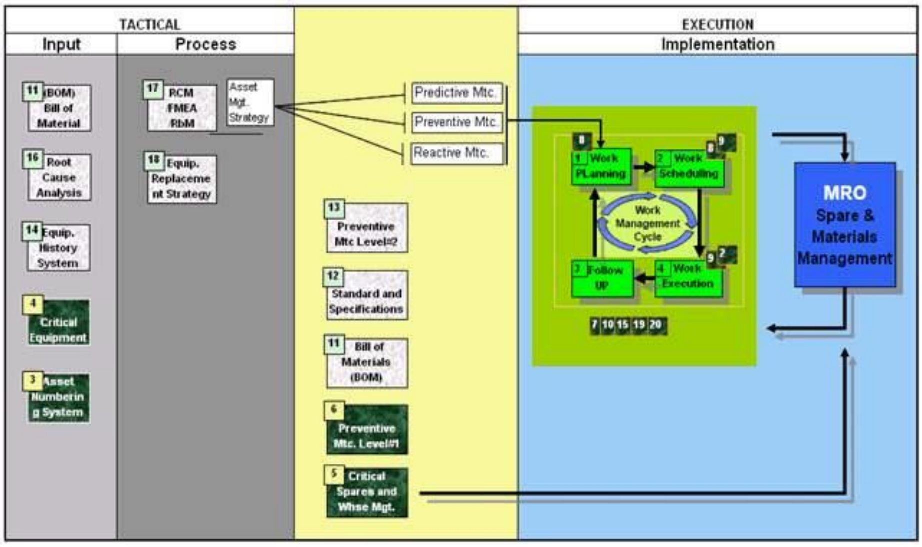


Figure 2.10 Maintenance management work cycle

2.2.1 Why the planning of maintenance activities has an influence on inventory management?

Maintenance tasks are only executed when a work order exists. A work order defines not only the work to be executed but also the required material. Every work order which needs spare and wear parts includes a basic start date. This start date triggers the purchasing request for the required material, which should arrive some days before the execution date. If all work is planned the inventory levels can be kept very low, as the parts used for planned work stay only for a few days in the warehouse. This means that the whole inventory of spare and wear parts exists almost only of critical spares.

2.3 Production Planning

Demand for raw materials can be planned using the Master Production Schedule (MPS), which is derived from the Sales Forecast.

At LafargeHolcim, demand for raw materials is generally planned 12 months in advance.

The production plan is reflected in the recipes for each type of product to be produced.

Recipes contain a bill of materials, including all materials needed to produce the final product. Production planning thus triggers the replenishment of raw materials within a certain period. A replenishment schedule can be created and communicated to the supplier based on existing contracts.

A 5-year plan is created in the form of a Plant Development Plan (PDP).

A Plant Master Plan translates business plan objectives into operational and organizational measures as well as CAPEX projects at plant level. To this end a Plant Master Plan covers all relevant aspects relating to materials and energy, production processes and plant organization. A Plant Master Plan includes an analysis of the prevailing situation regarding requirements, an identification of deficiencies, and an outline and evaluation of possible measures and means, resulting in actions and investment plans. Plant Master Plans cover a period of 5 years.

Proper short, medium and long-term planning and scheduling in combination with strong and solid preventive maintenance will not only help reduce the costs of spares and materials but will also help increase labor productivity and plant reliability.
Planning and scheduling are important steps in the effort to move from reactive maintenance to a proactive approach.
A complementary approach to determine which spares should be kept in stock is presented in *Chapter 4. How to manage inventories*.

3 How to Procure the required stock

3.1 Procurement Process for goods

The procurement process to be executed for goods depends on the Procurement Category. The operational procurement process for goods should be based on the usage of standard ERP (Enterprise Resource Planning) functions, in order to ensure process efficiency, contract compliance and internal controls:

- For recurrent purchases, ERP handled contracts should be in place and MRP (Material Requirement Planning) should be used to trigger stock replenishment; and
- For non-recurrent purchases, a bidding process should be followed.

The choice of the operational procurement process is based on the stock strategy matrix and the processes are described in the *LH Procurement Channels recommendation.*

For recurrent purchases, the ERP contracts and catalogs should reflect signed paper contracts negotiated by Category management teams.

3.2 Supplier Relationship Management (SRM)

The performance of the maintenance department depends to a large extent on the performance of the MRO (Maintenance, Repair and Operating) inventory suppliers and the quality of the material they supply.

It is poor practice to have multiple suppliers of a given spare part and keep extra inventory on hand just in case the suppliers fail to deliver.

The alternative to this costly “just in case” philosophy is to use the Pareto analysis (80/20 rule) to determine the top 10 suppliers of the vast majority of parts.

The idea is to build long-term partnerships with an optimal number of suppliers (as few as possible).

To do this, it is important to determine selection criteria to reduce the number of suppliers. The more obvious criteria are price, quality and service. However, other criteria related to order frequency and severity may also be considered:

- Compliance with OH&S, ISO 9000, ISO 14000;
- Delivery fulfillment: over/under-deliveries, lead time; and
- Quality of documentation provided: packing slip, invoice accuracy, technical documents.

The required information has to be gathered through a Supplier Qualification System and a Supplier Performance Evaluation System.

A good knowledge of the supplier base and the market allows us to define and implement supply strategies which, in combination with a close evaluation of supplier performance, helps us optimize inventory levels and ensure plant reliability.

4 How to manage inventories

4.1 Establishing Stock Strategies

The stock strategy must simplify work related to non-critical and low-cost items, and derive maximum benefits from high-value items. Close control is more important for fast moving items with a high unit value. Conversely, for slow moving or low unit value items, the cost of the stock control system may exceed the benefits to be gained, so simpler methods of control should be used instead.
Effective stocking strategies are based on the knowledge of the requirements and a proper analysis of current inventories. Inventory analysis serves to identify the items on which a business should focus its efforts (e.g. close control for high value items and simple control for low value items).

4.1.1 Inventory Analysis

The purpose of inventory analysis is to identify factors that have an impact on the process of establishing stock strategy. Two possible factors are the unit value of an item and its usage rate.

The Pareto principle is a baseline for ABC analysis and XYZ analysis and is widely used in logistics and procurement to optimize stocks of goods and to minimize the cost of keeping and replenishing stock.

ABC Analysis

The ABC analysis is a method of classifying items, events, or activities according to their relative importance. It is frequently used in inventory management to classify stock items into groups based on the total annual expenditure on, or total stockholding cost of, each item.

The classification into A, B, and C classes, their total value and quantity proportion can be illustrated in Figure 4.1.1:

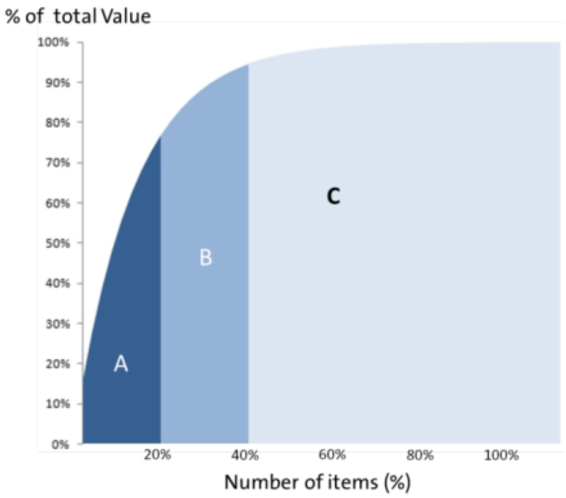


Figure 4.1.1: Example of an ABC Analysis graph

The precise shape of a Pareto curve will differ for any analysis but the broad shape remains similar – following ‘the 80/20 rule’.

The quantity proportion of materials in Class A is usually 20% and the total item number and represents approximately 80% of the total value, which means these materials are the most important ones and need precise attention in terms of accounting, forecasting and optimization. Organizations should concentrate more on the high value/critical items, and the ABC analysis is used to prioritize these items. For materials in class A, it is important to have accurate requirements defined, exact inventory management and control, and updated information about lead-times and market trends. A decision about safety stock for materials in Class A has a high impact on total inventory value.

The quantity proportion of materials in Class B usually accounts for 20% of total quantity and represents 15% of the total value. These medium-value materials must be further analyzed and each material (or group of materials) of Class B should have an optimized and individualized stocking strategy (see Figure 4.1.4 Stock Strategy Matrix).

The quantity proportion of materials in Class C usually accounts for 60% of total quantity and represents 5% of the total value. This class represents low value materials but the ordering process is usually time-consuming and requires high transactional volume. These materials are ideal candidates for automated and lean-procurement processes (e-sourcing, e-catalogues), single source or outsourced inventory management (Vendor Managed Inventory). Materials in Class C can be procured at a high frequency in fixed lot sizes. Please note that critical spares should not be classified in the Class C category.

XYZ Analysis

The second step in inventory analysis is the XYZ analysis. The XYZ analysis is also a method to classify items and can be used as a follow-up analysis to the ABC analysis. The XYZ analysis is used to analyze the quantity portion of an individual material according to its consumption pattern. The results of this analysis help:

- To identify items that can be planned well and have a high rate of consumption;
- To determine the level of safety stock; and
- To put the appropriate level of control in place.

The classification into X, Y, and Z classes, their levels of unpredictability and proportional quantities are illustrated in Figure 4.1.2:

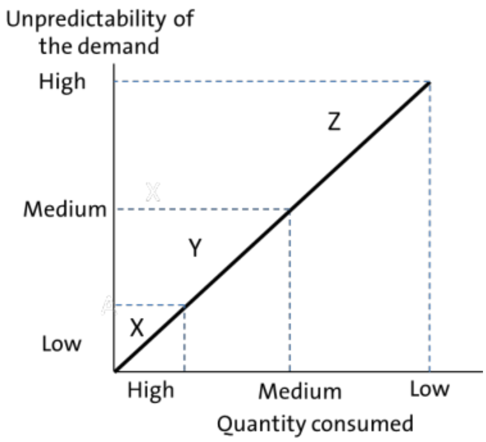


Figure 4.1.2: Example of an XYZ Analysis graph

The materials in class X are characterized by having the highest level of consumption, with a consumption pattern that is stable. Materials in Class X have a regular demand and high predictability; therefore the future demand can be accurately forecasted. They are ideal candidates for automated processes and usually have a high level of rotation.

The materials in class Y have a lower rotation and their consumption is difficult to predict due to fluctuating demand, often based on particular events happening in operations (e.g. maintenance work). It is more difficult to obtain good forecasting accuracy for these materials than for X materials.

The materials in class Z are not used regularly and the consumption is sporadic. The future consumption of materials in Class Z cannot be predicted based on previous consumption patterns. For these materials, the prediction of future consumption is done through a systematic approach, based on recommendations based on the risk analysis and the FMEA.

ABC-XYZ Matrix

The last step in inventory analysis is the ABC-XYZ matrix. The combined analyses of ABC and XYZ result in a matrix with nine different values. Determining the most appropriate inventory process for each value leads to substantial optimization potentials.
This process indeed helps identify materials with:

- high potential for rationalization, for which advance demand planning heavily involves Maintenance and Production; and
- high automation potential, for which lean-processes should be applied.

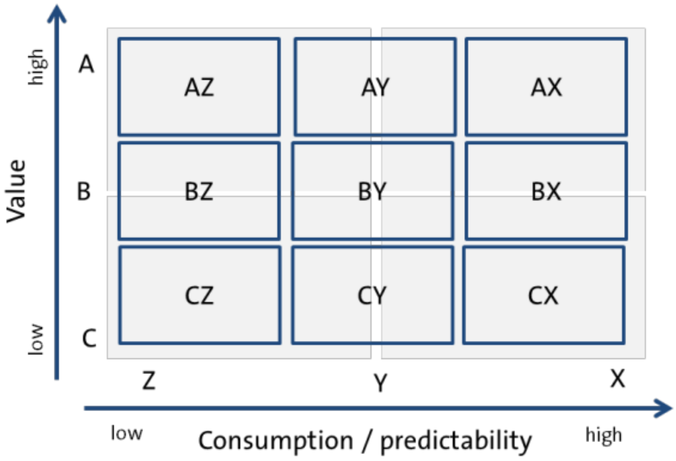


Figure 4.1.3: Example of an ABC-XYZ Matrix

Different material classifications can be assessed separately to reach a full scope analysis of all inventoried materials (including Spare Parts, Raw Materials, fuels, etc). For example:
Materials in the categories AX or BX have a high automation potential and optimal stock strategies can be monitored by the ERP.
Materials in the categories AZ or BZ should not be stocked, as they require a high level of planning and manual monitoring (reservation) is required.
Materials in the categories CZ or CY should not be stocked, unless critical.

Inventory analysis serves to identify the items on which a business should focus its efforts (e.g. close control for high-value items and simple control for low-value items).
ABC analysis determines the most popular lots, which require more precise accounting, forecasting and inventory.
XYZ analysis classifies inventory according to its nature, usage and precision of usage forecasts.
The process of combining the ABC and XYZ analyses in a matrix leads to substantial optimization levels.

4.1.2 Implementation of stock strategies

The “Stock Strategy Matrix” was developed in order to facilitate decision-making on the stock strategies to be implemented, and is based on the ABC-XYZ matrix.

The “Stock Strategy Matrix” is used to recommend stock strategies:

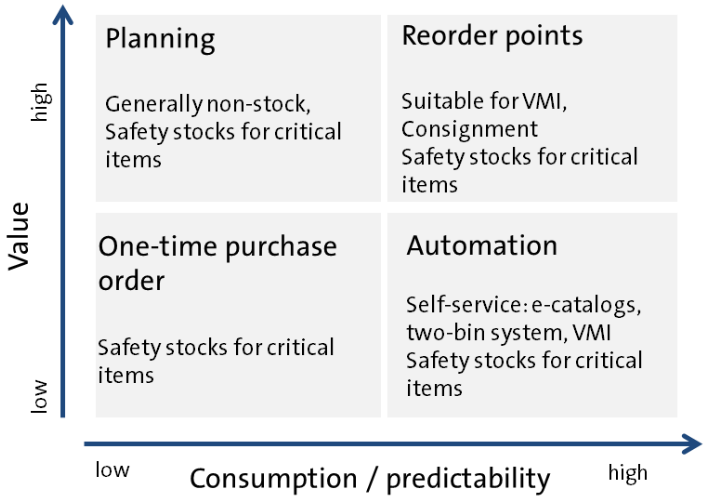


Figure 4.1.4: Stock strategy matrix

Important: Critical spare parts should have safety stocks established, regardless the quadrant.

Note that the optimal stock strategies cannot be implemented if the following elements are not in place:

- Demand needs are understood and planning processes are implemented:
  - Raw materials and fuels: identification of needs through production planning based on sales forecasts; and
  - Spare parts: identification of needs through a systematic approach:
    1. identification of areas of risk within the plant (Risk Assessment),
    2. identification of critical equipment and analysis of potential failures,
    3. definition of actions to minimize occurrence and severity, and maintenance planning programs.
- Reliable and consistent communication of needs that is:
  - from operations to the responsible inventory management personnel;
  - from the responsible inventory management personnel to the responsible procurement personnel; and
  - from the responsible procurement personnel to suppliers.
- Supplier and market are known;
- Strategic Sourcing options are implemented;
- Inventory composition is known (ABC & XYZ items identified); and
- Reorder methods are identified for each type of material (ABC & XYZ).

Stock strategies must simplify work related to non-critical and low-cost items and derive maximum benefits from high-value items.
“Planning of needs” and “negotiation with suppliers” are a vital part of maintaining optimal stock strategies.

4.2 Master data

Material Master Data is one of the foundations of effective procurement activity. It has a major impact on operational activities related to inventory management and consequently on net working capital.
Good quality stored data supports efficient supply activities in purchasing organizations and in operations.

Material Master in SAP

The material master database contains descriptions of the materials that a company procures, produces and stores. The material master record is an enterprise's central source of information on specific materials. The individual material master records contain data such as the order unit, responsible purchasing group, and over/under delivery tolerances.

Material data in SAP is organized according to the organizational level:

- SAP Client: this level contains data applicable to all individual group companies, all plants and all warehouses belonging to an enterprise;
- Plant: this level contains the data for each branch or plant location within a specific company. The data relevant to purchasing is stored at this level; and
- Storage location: this level contains data specific to a storage location. (e.g. stock levels).

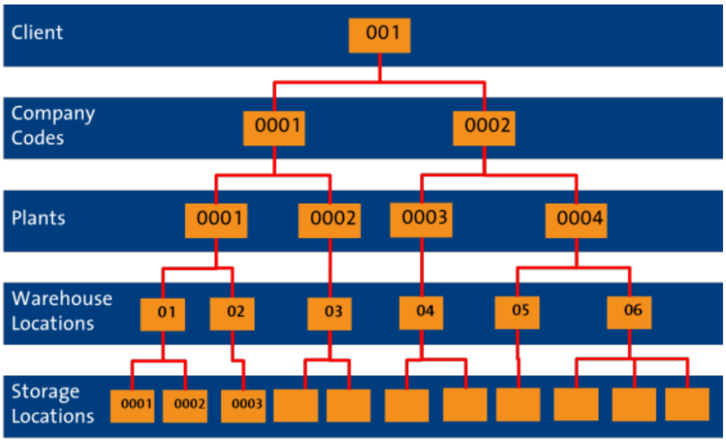


Figure 4.2.1: Organizational levels in SAP R/3

This data structure prevents redundant storage of material data when the same material is used in more than one plant or stored in more than one location.

Since different departments in a company work with the same material, but each department uses different information on the material, the data in a material master record is subdivided by user department. This is illustrated in the following diagram:

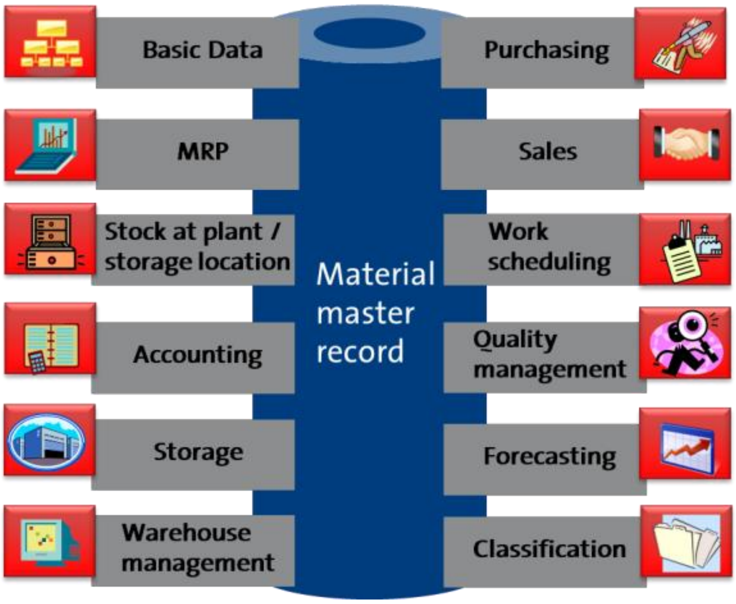


Figure 4.2.2: Material Master Structure in SAP R/3

Material Types

Materials with the same basic attributes are grouped together and assigned to a material type. The material type determines certain attributes and has important control functions that enable management of like materials in a uniform manner.
When creating a material master record, the material must be assigned to a material type.

Split Valuation

According to LHARP principles, a single material, valued at plant level, can have different prices associated with it depending on its condition, e.g. newly acquired part, refurbished part.
The Split Valuation functionality in SAP allows the same material ID to be valued at different prices. Instead of having a single valuation type, it has several.

The valuation category is defined in the master record of a material. It determines whether the material is subject to split valuation. The specified material type must also be maintained in the material master record.

This functionality enables the same material ID to be maintained in the same valuation centre (plant) with different prices instead of maintaining several material IDs for the same item.

The defined stock strategies and the negotiated conditions must be reflected in each material record by updating the parameters in the Material Master (e.g. reorder points, lead times). The data quality is assured by centralized master data management, which is supported by Master Data Policy and Procedures.

4.3 Inventory methods

4.3.1 Order replenishment methods

If we are to maintain an in-stock position of items wanted and dispose of unwanted items, we need to establish adequate controls over inventory on order and inventory in stock.

There are several proven methods for inventory control and replenishment. These are listed below, from simplest to most complex:
a) Visual review;
b) Two-bin system;
c) Reorder point; and
d) Kanban (Just in Time – JIT).

a) Visual review

Visual control is where the manager examines the inventory visually to determine if additional inventory is required.
- Reordering is based on actually looking at the inventory on hand;
- Min/max is a commonly used technique; and
- Color cards and “two-bin systems” help to facilitate visual control

b) Two-bin system

The two-bin system is a system that requires two storage containers. The containers each hold a predetermined quantity of the same material. The quantities may be the same or one may hold a larger quantity than the other.

The two-bin system works well for ordering anything from product inventory items that have a relatively stable usage to consumable supplies such as office products.

Quite simply, the two-bin system works as follows:
- The first bin is stacked on top of, or in front of, the second bin;
- a reorder card is placed on the bottom of each bin;
- material is drawn from the first (or most accessible) bin only;
- when the first bin is empty, it is exchanged with the second bin;
- the reorder card is used to replace items in the first bin;
- material is then drawn from the second bin while waiting for receipt of the material on order;
- when the new material arrives, it is placed in the empty bin, and the reorder card is returned to its proper place in the bin and
- the procedure is continued, with material being selected from one bin until it is depleted, then replenished through use of the reordering card

As long as the quantity of material in each bin is the same, you can continue to deplete one bin, place the order for the replenishment amount, and then deplete the second bin, and so on.

However, if the second bin has a smaller quantity of material than the first bin (which may be advantageous if the material is expensive and you do not want to have a high volume of material in stock when issuing a replacement order), then the quantity in the second bin (called the reorder point quantity) must be sufficient to cover the time required to receive the material (ordering lead time).

For example, if it takes 2 weeks to receive new material, then the second bin must contain at least a 2-week supply of that material. When the new material comes in, someone must withdraw a sufficient amount of material to replenish the reorder point quantity in the second bin, and then place the balance of the received material into the first bin. Users will then withdraw material from that bin.

The two-bin system is a simple procedure which does not rely on a computer-driven system but on a visual check. Training is necessary to ensure that warehouse personnel know how to reorder material when one bin is empty in order to avoid unanticipated stockouts.

The risk of stockouts can also be reduced through periodic audits of the items in the warehouse. Such audits can discover instances in which only one bin contains material, yet both reorder cards are visible. In such cases, action needs to be taken immediately to avoid a stockout.

The only analysis required in the two-bin system is the reorder point quantity to be placed in the second bin. Most companies are overly conservative with this quantity because they are fearful of running out of stock. As a result, they set this reorder point quantity too high, so material arrives before it is actually needed.

However, it is easy to periodically review the reorder point quantities and adjust when necessary. The easiest way to do this is to count the number of items remaining in the second bin when the new items arrive. If the remaining quantity exceeds a few days’ supply and vendor deliveries are relatively consistent, the reorder point quantity should be reduced by reducing the quantity of material in the second bin.

The two-bin system is easy to implement and maintain and is as effective as any complex computer driven system for reordering parts.

The two-bin system, in combination with a “self-service” area, is highly recommended for the management of “high rotation/low value” items. It is important to consider that end-users and key stakeholders involved are properly trained to secure maximum output of this method with proper controls.

c) Reorder point and safety stock

With this method, the replenishment is triggered when the sum of plant stock and receipts falls below the “reorder point”.

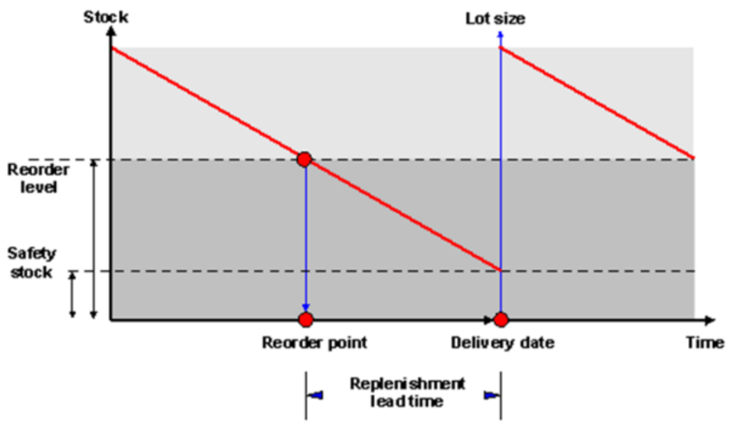


Figure 4.3.1: Reorder point graph

The “reorder point” calculation considers the average material requirements expected during the replenishment lead time, so that the sum of plant stock and receipts never falls below the safety stock level. The safety stock is additional inventory that is held as a safeguard against uncertainties in material planning.
The challenge with this method is to determine the sufficient amount of safety stock, or buffer stock, without stockpiling unnecessary quantities that might trigger higher inventory costs.

For detailed information about defining Reorder Point and Safety Stock, read *Chapter 4.5 Material Requirement Planning (MRP) Optimization.*

d) Kanban

Kanban is a Japanese term that means “signal” (Kanban stands for Kan = card, Ban = signal).
It is one of the primary tools of the JIT (just in time) system. It signals a cycle of replenishment for production and materials and maintains an orderly and efficient flow of materials throughout the entire manufacturing process. It is usually implemented via a printed card that contains specific information such as part name, description, quantity, etc.

The Japanese view Kanban as a simple parts-movement system that depends on cards and boxes/containers to take parts from one workstation to another on a production line.

The essence of the Kanban concept is that a supplier or the warehouse should only deliver components to the production line as and when they are needed, so that there is no storage in the production area.

Within this system, workstations located along production lines only produce/deliver desired components when they receive a card and an empty container, indicating that more parts are needed in production.

In the event of line interruptions, each workstation will only produce enough components to fill the container and then stop.

In addition, Kanban limits the amount of inventory in the process by acting as an authorization to produce more inventories.

Since Kanban is a chain process in which orders flow from one process to another, the production or delivery of components is pulled to the production line. This is in contrast to the traditional forecast oriented method where parts are pushed to the line.

Though “KANBAN” is an order review method developed for production lines, the “signal” concept can also be applied in LafargeHolcim Warehouses as a simple control method for high rotation / low value items (“self-service” areas)

4.3.2 Inventory methods

There are four inventory management methods that help optimize inventory levels and minimize the work required for replenishment activities:

a) Consignment stocks;
b) Vendor Managed Inventory;
c) Virtual warehouse; and
d) Central warehouse.

A principal goal for many of the methods mentioned above is to determine the minimum possible annual cost of ordering and stocking each item.

a) Consignment

Consignment inventory is inventory that is held at the customer's physical location, but is still legally owned by, and held at the risk of, the supplier.

In other words, the supplier places some of his inventory in the customer's warehouse and allows the customer to consume directly from his stock. The customer pays for the goods only when they are taken out of the warehouse.

The key benefit to the customer is that it does not have to tie up capital in inventory. This does not mean that there are no inventory carrying costs for the customer; it still incurs costs related to storing and managing the inventory.

The key benefit for the supplier is better customer control. By increasing the volume required from a smaller number of suppliers (pooling through supplier consolidation), the added costs can be better absorbed by the supplier.

However, consignment inventory will almost always add costs to the supply chain and should only be used when the benefits exceed these added costs.

Consignment inventory optimizes NWC levels by reducing inventory values. However, if the inventory reduction implies a deterioration in payment terms, then the NWC is not improved, there is simply a change in its structure.

When moving towards consignment, a complete TCO analysis should be performed that considers:
- Payment terms (cost of capital, e.g. interest rates and periods);
- Minimum consumption required by the supplier;
- Taxes;
- Start of warranties for stored items owned by the supplier (e.g. when delivering into the warehouse vs. when taking out); and
- Holding cost.

Motivation for supplier to move toward consignment:
- Better customer control, increased customer loyalty; and
- By increasing the volume required from a smaller number of suppliers (pooling through supplier consolidation), the added costs can be better-absorbed and turned into a win-win situation.

The key decision on consignment versus ownership comes down to the best cost of capital. A holistic view of all economic aspects is required.

b) Vendor Managed Inventory (VMI)

Vendor Managed Inventory is a means of optimizing supply chain performance in which the supplier is responsible for maintaining the customer's inventory levels. The supplier has access to the customer's inventory data and is responsible for generating purchase orders. Some facilities keep lower value with high rotation under VMI controls.
VMI does not change the “ownership” of inventory. It remains as it did prior to VMI.

The supplier receives electronic data on the customer's sales and stock levels. The supplier can view every item that the customer carries, as well as point of sale data. The supplier is responsible for creating and maintaining the inventory plan. Under VMI, the supplier generates the order, not the customer.

How does Vendor Managed Inventory work?
The customer sends a consumption plan and inventory data to the supplier on a prearranged schedule and the VMI system determines what should be ordered based on criteria established by the supplier and the customer. The supplier monitors the inventory status information to ensure that the customer always has the appropriate amount of stock on hand when needed. The customer can override the system when necessary if increased market demand is anticipated.

The benefits of VMI are numerous for both supplier and customer.

Dual benefits:
- Data entry errors are reduced thanks to computer-to-computer communication. Speed of processing is also improved; and
- A true partnership is formed between the supplier and the customer. They work more closely together and strengthen their ties.

Customer benefits:
- Stockouts and inventory levels will decrease;
- Planning and ordering costs will decrease because responsibility is shifted to the supplier;
- The overall service level is improved by having the right product at the right time;
- The supplier is more focused on providing good service.

Supplier benefits:
- Access to the customer's planning data makes forecasting easier;
- Reduction in customer ordering errors (which in the past would probably have led to returns);
- Access to stock levels helps identify priorities (replenishing for stock or for a stockout). Before VMI, a supplier does not know the quantity and the products that are ordered from stock. With VMI, the supplier can see the potential need for an item before the item is ordered.

Through vendor managed inventory methods, a true partnership can be created between the supplier and the customer.

A combination of consignment and VMI methods can also be used to manage inventory:

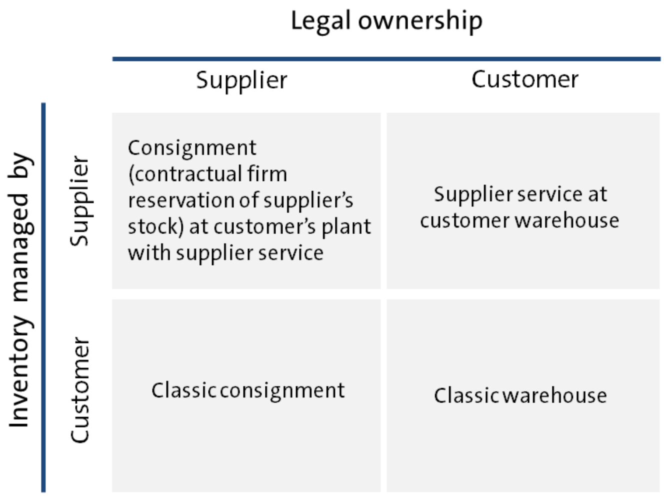


Figure 4.8: Combination of Consignment & VMI

Two major control values are used:
- the economic order quantity (EOQ), which determines the optimum size and frequency of orders; and
- the reorder point, which is the minimum stock level at which additional quantities are ordered.

c) Virtual warehouse

The virtual warehouse is a concept which makes it possible to share spare and wear parts between plants. In the SAP system all parts are stored together with the information about its physical location. With the new concept the location of the parts in the system is not the physical storage location but the virtual warehouse. This warehouse is common for all plants. When the end-user needs a spare part and this is not available in the local plant he looks into the virtual warehouse if a replacement is available. If the economic benefit is given, the item is transported from one plant to the other. The economic benefit is calculated considering transportation cost and the standstill time caused by the lead time when the item is ordered on the local market.
Not all items are held in the virtual warehouse, ideally items with high value and low turnover which are common to different plants are kept under this concept.

d) Central warehouse

For materials that are common among several plants (ideally within short distance between them) an external storage location can be used. This is a central warehouse. The location is chosen mainly on logistics and cost considerations where materials flow costs can be rationalized in terms of lead time to spare, transportation costs, storage costs and service response. The central warehouse can be managed by Country personnel or a service provider. Administrator is responsible for the correct storage and the delivery to the plants whenever a part is required. Availability and potential items that can be kept in a central warehouse is nevertheless limited due to standardization of items across plants where a feasibility study can represent storage opportunities across plants (i.e. grinding media, filter bags, refractory).

4.3.3 Inventory replenishment system

Material Requirement Planning (MRP) is a system that comprises all the necessary activities to monitor stocks and automatically create proposals for purchasing and production (planned orders, purchase requisitions or delivery schedules).

MRP is a dependent demand system which calculates materials requirements to satisfy known and forecast demand.

The core goals of the MRP system are as follows:
- To optimize the inventory service level;
- To optimize the availability of materials;
- To minimize the warehouse stock levels (when excess is detected); and
- To optimize the logistics costs.

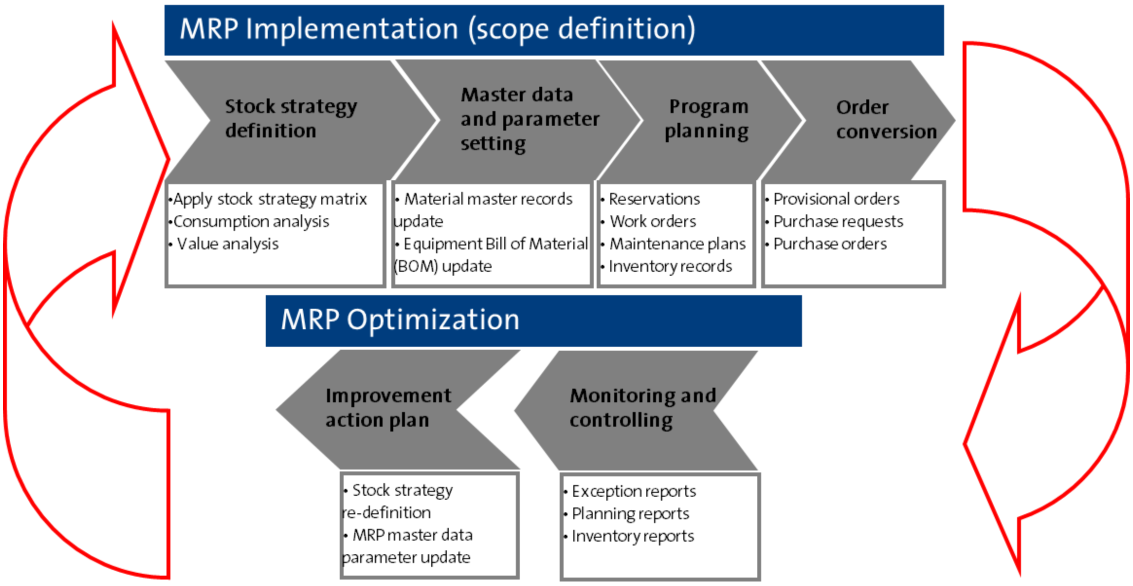


Figure 4.9: MRP Process

For details on how to implement/optimize the MRP strategy, read *Chapter 5 Material Requirement Planning (MRP) Optimization.*

4.4 Goods movements

Goods movements are transactions that result in a change in stock.

Material is procured from external or internal sources on the basis of the requirements determined by Material Requirements Planning. The delivery is entered as a goods receipt. The material is stored and managed until it is delivered to the customer (Sales & Distribution) or used for internal purposes (for example, for maintenance or production).

For all transactions, if they are supported in an ERP, the inventory management module accesses both master data (such as material master data) and transaction data (such as purchasing documents) shared by all logistics modules.

4.4.1 Goods receipt

A GR is a goods movement which records the receipt of goods from a vendor or from production. A goods receipt leads to an increase in warehouse stock.

4.4.2 Goods issue

A GI is a goods movement which records the withdrawal, issue, consumption or shipment of a material to a customer. A goods issue leads to a reduction in warehouse stock.

4.4.3 Goods return

Any good issued that is not used by the Maintenance department nor consumed must be returned to the warehouse stock. This is important to allow the item to be shown as available in the inventory, ensure proper storage of the good in the warehouse, and avoid the risk of the good being reordered to meet the needed inventory level.

4.4.4 Stock transfer

A stock transfer is the removal of material from one storage location to another Storage Location. Stock transfers can occur either within the same plant or between different plants.

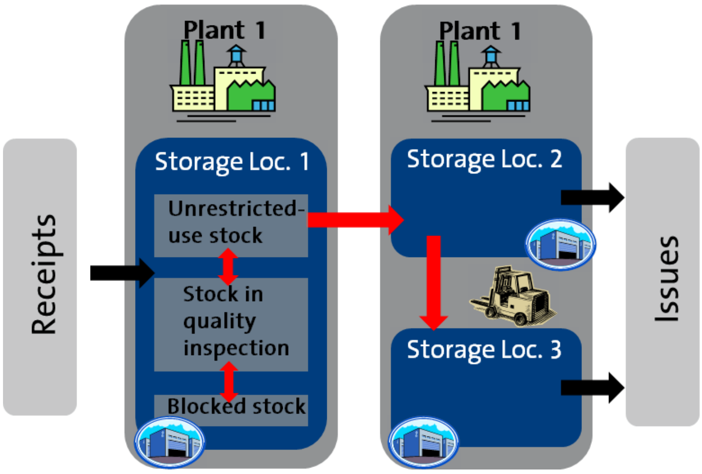


Figure 4.10: Different types of stock transfer in SAP R/3

4.4.5 Stock Types

In SAP, stock movements are also related to material movements between different stock types:

4.4.6 Transfer posting

A transfer posting is a general term for a stock transfer or changes in stock type or stock category of a material. It is irrelevant whether the posting occurs in conjunction with a physical movement or not.

Examples of transfer postings are:
- Transfer posting from material to material;
- Release from quality inspection stock; or
- Transfer of consignment material into company's own stock.

4.4.7 Material Documents

When posting a goods movement in the SAP System, the following documents are created:
- Material document; and
- Accounting document.

Material document

A material document is generated as proof of the movement and as a source of information for any application that follows.

Accounting document

If the movement is relevant to financial accounting (that is, if it leads to an update of the G/L accounts), an accounting document is created in parallel to the material document. The G/L accounts involved in a goods movement are updated through an automatic account assignment.

4.4.8 Physical inventory count

For balance sheet operational planning accuracy, a physical count of the inventory in the company's warehouse stocks needs to be made periodically. Various procedures can be implemented for this.

The SAP R/3 System supports the following physical inventory procedures:
- Periodic inventory;
- Continuous inventory; and
- Inventory sampling.

Periodic inventory

All of the company's stocks are physically counted on the balance sheet date. All material must be counted. During counting, the entire warehouse must be blocked for material movements.

Continuous inventory

Stocks are counted continuously during the entire physical year. In this case, it is important to ensure that all materials are physically counted at least once during the year.

Inventory sampling

Randomly selected stocks are counted on the balance sheet date. If the variances between the result of the count and the book inventory balance are small, it is assumed that the book inventory balance for the other stocks is correct.

Regardless of the physical inventory method, in SAP the physical inventory process can be divided into three phases:
1. Physical inventory preparation:
   - Create a physical inventory document,
   - Block for material posting,
   - Print and distribute the physical inventory document,
   - Perform physical inventory count (count stocks), and
   - Enter the results of the count on the physical inventory document printout.
2. Physical inventory analysis:
   - Enter the result of the count into the system, and
   - Initiate a recount (if necessary).
3. Post inventory differences.

4.4.9 Cycle counting

Cycle counting is a method of physical inventory where stocks are counted at regular intervals within a fiscal year. These intervals (or cycles) depend on the cycle counting indicator set for the materials. This method allows fast-moving items to be counted more frequently than slow-moving items. The system allows for classification of items so they can be counted with a higher frequency throughout the year whenever highlighted as critical or more relevant for the operation.

Cycle Counting Indicator

A system generated, user-verified key to the frequency of count for a material. This indicator is critical in allowing the system to assign materials to physical inventory documents within the annual cycle counting plan.

Dependencies

Prior to the initiation of a cycle counting program, cycle counting indicators must be established. In order to execute a cycle counting program properly, indicators must be established, based on frequency of issue and cost. The ERP system will generate suggested indicators based on these factors for a designated timeframe, which the user may accept or modify.

Service Level

The use of a structured cycle counting program is critical to inventory accuracy, which is central to the proper execution and use of material requirements planning. Our predictive/preventative maintenance program relies on materials being available when needed and as planned.

Timeliness

Cycle counting indicators should be set no more than once a year. Cycle counts should be accomplished in a systematic way during the year based on the system-proposed count frequency.

5 Material Requirement Planning (MRP) Optimization.

Materials requirement planning **optimization** is a continuous process that is used to keep materials management up to date and enhance the usage of the MRP system.

Due to the numerous MRP parameters and interactions, it is not easy for the MRP controller, without support from other stakeholders, to define the correct settings. Cross-functional decision making helps to select the right MRP configuration for each material.

Structured analysis and assessment are required to identify and select suitable MRP parameters, allowing Countries to establish optimized inventory levels.

When choosing the stock strategy and MRP parameters, the following influencing factors are to be considered:

- Prioritize and define the scope in order to start with a well-defined and limited amount of materials in order to gain confidence on usage.
- Once confidence on usage is gained, increasing the number of materials covered by MRP by selected waves, according to area needs.
- The period of time considered for the analysis and the frequency of doing this will determine the sustainability of the MRP parameter setting review.

Through proper material planning and by defining a stock strategy and accurate MRP parameters for each material, a significant contribution can be made toward:

- Improving the Net Working Capital position through sustainable inventory stock level optimization.
- Optimizing inventory service levels, thereby increasing internal stakeholders' confidence in inventory service levels.
- Reducing stock-out risks while optimizing inventory carrying costs

5.1 Materials requirement planning (MRP) process

The MRP process has a direct impact on procurement activities (see figure below), as the execution of MRP triggers the purchasing process. The main MRP process steps are:

- MRP scoping and definition;
- Stock strategy definition;
- Material MRP master data and parameter setting;
- Program planning;
- Order conversion (MRP execution);
- Monitoring and controlling; and
- Improvement action plan.

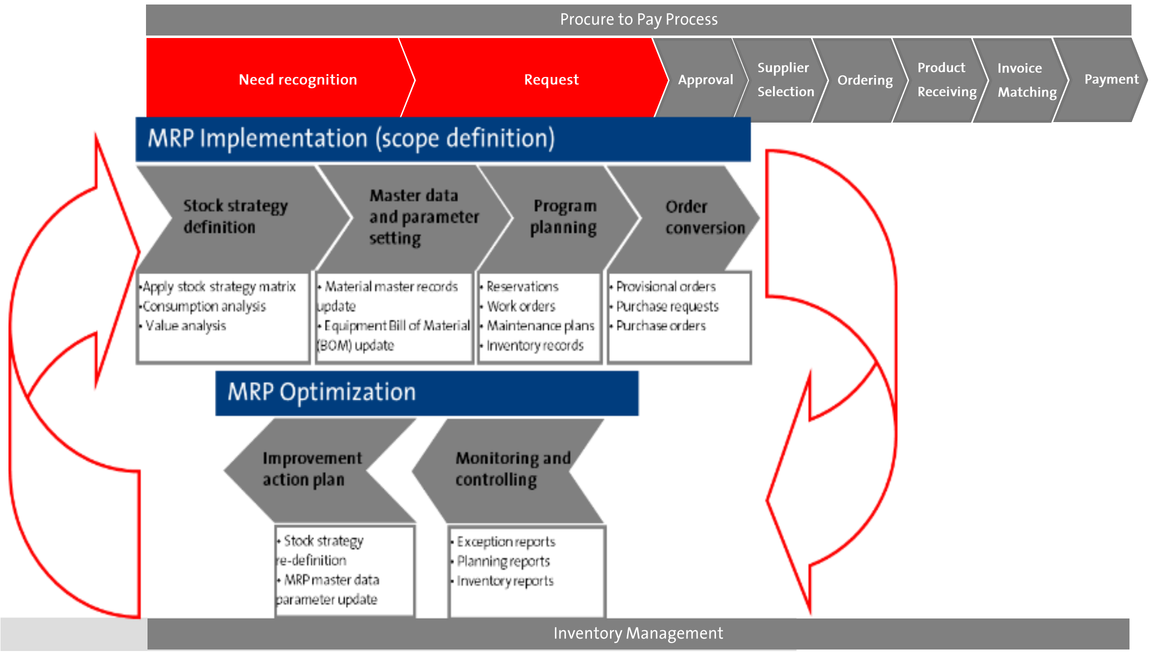


Figure 5.1: MRP Process and Procurement activities

MRP processes involve the review and analysis of system-generated proposals for the replenishment of inventoried materials and the initiation of the subsequent procurement process. This includes the maintenance of material master data parameters that control replenishment determination.

It should be considered that MRP works best when:

- Documents related to materials (e.g. work orders, purchase requisitions, purchase orders) are processed in a timely manner and **duly closed.**
- Material records use a standard master data structure (e.g. naming convention);
- A proper bill of materials (BOM) is in place for equipment;
- There is a relatively good certainty of the production/maintenance planning horizon;
- Maintenance planning is accurate;
- Material descriptions are compiled properly and are complete; and
- Lead times for materials are accurately calculated and have low variance.

5.1.1 MRP and inventory management optimization

The core goal of a materials requirement planning (MRP) system is to balance the following objectives:

- To optimize the inventory service level;
- To optimize the availability of materials;
- To minimize the warehouse stock levels (when excess is detected); and
- To optimize the logistics costs (reduce replenishment times).

In order to facilitate the achievement of these objectives, it is essential that materials requirement planning is done in cross-functional collaboration (e.g. Procurement, Warehouse, Operations), as all these roles provide relevant information for proper setup of the system.

5.1.2 MRP scoping and definition

MRP is a system that comprises all the activities necessary to provide the optimal required amounts and types of materials at the right time.

An analytical process is needed during implementation of the MRP system because there may be lack of historical data, insufficient knowledge or, simply, limited resources and time. Also, often a systematic decision-making process (like the one described in Chapter 2), supports the implementation of MRP. The nature of the demand (independent or dependent) plays an important role in determining the requirement for materials; hence materials planning must be flexible so that it can be adjusted to meet the needs of different materials with different types of demand.

The first step of any MRP implementation or optimization process it is to identify the type of demand for each material or group of materials. For this purpose, the various types of demand are defined as follows:

- **Independent demand:** Independent demand is demand that is not linked to or caused by the demand for another material. This demand normally is erratic and follows consumption patterns that are not predictable or that are difficult to predict.

  At LafargeHolcim, materials such as personnel protective equipment (PPE) are materials with independent demand.

- **Dependent demand:** Dependent demand is linked to or caused by the demand for another material. Materials with dependent demand are required as dictated by other materials planning activities, such as those of maintenance or production.

  At LafargeHolcim, limestone, fly ash, and some solid fuels such as coal and petcoke are examples of materials with dependent demand. Certain spare parts that are part of an equipment bill of material (BOM) can also be considered materials with dependent demand since they depend on planned maintenance activities.

5.1.3 MRP procedures

MRP procedures depend on the nature of the demand, which will affect the reorder method to be used by MRP. The chart below summarizes these procedures and the different reorder methods that can be used. Definitions were explained in *Chapter 4.3.1 Order replenishment methods.*

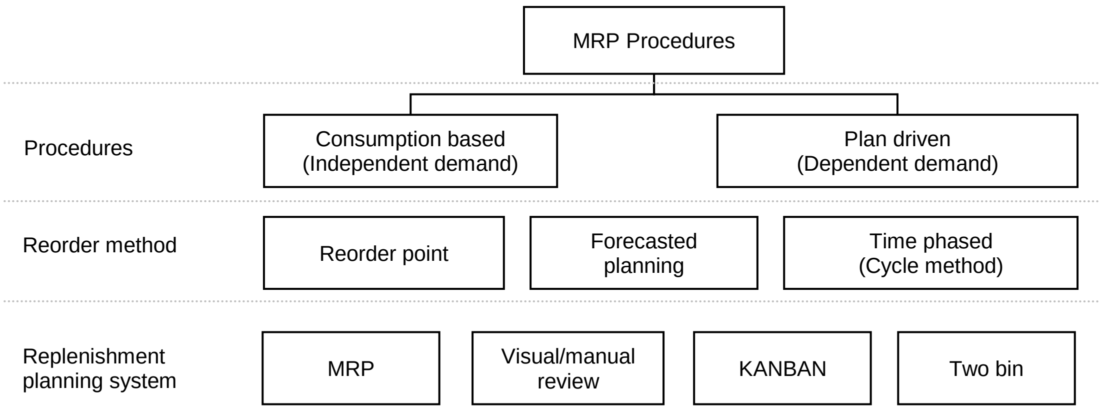


Figure 5.2: MRP Procedures

Consumption based:
The MRP procedure for independent-demand materials is based on material consumption patterns. For consumption-based materials it is necessary to regulate both when the material requirement is to be channeled through a purchase order (PO) (order date) and the quantity of material to be ordered (PO quantity or lot size). The combination of a fixed or variable PO quantity and fixed or variable PO period determines the right requirement. This concept is generally known as the “reorder policy.” Definitions and examples of the reorder policy can be found in *Chapter 5.4.4 Reorder Policies*

Plan driven:
The MRP procedure for dependent-demand materials is based on planning activities based on the bill of materials (BOM) explosion for production materials or for maintenance activities that generate planning-related interdependencies (e.g. work orders, material reservations, purchasing orders).

There are three different reorder methods that can be used with any of the two MRP procedures described above:

Reorder point (ROP): the system verifies whether the stock available is below the ROP determined for the material. If the stock falls below the established ROP, a replenishment process is triggered.

Forecast planning: a forecast based on historic consumption values is used to estimate future requirements and trigger a replenishment process according to the forecast.

Time-phased planning: this system is used for materials with defined demand periods within a certain time horizon. This method is also called “cycle method.” The replenishment process is triggered in synchronization with defined periods.

The outcome of this first step is the understanding of different demand types, enabling the establishment of the proper MRP process and reorder methods. This will facilitates the selection of the optimum MRP parameters in later stages.

5.2 Stock strategy definition

It is essential that the correct MRP parameters are set for each material in order to obtain optimum results from the implementation and execution of MRP.

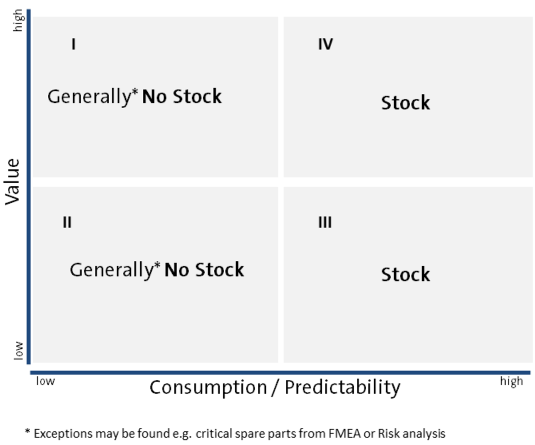


Figure 5.3: Stock Strategy matrix

As defined in *Chapter 4.1 Establishing Stock Strategies*, the Stock Strategy Matrix (SSM) can be used to select the proper stock strategy for each material or group of materials.

According to the definition of the SSM, once materials are mapped into the matrix, the quadrants help to determine whether a material should be kept in stock.
The Pareto principle combined with ABC and XYZ analyses is highly recommended in order to properly apply the Stock Strategy Matrix.

5.2.1 Applying the Stock Strategy Matrix

This section describes the key process steps to be followed in order to establish a proper MRP system based on the SSM.

It is recommended that the application of the Stock Strategy Matrix be prepared by a cross-functional task force comprising Operations, Warehouse and Procurement staff, as all of these functions provide relevant decision-making information.

5.2.2 Defining priorities

In order to assess and optimize MRP parameters, materials should be grouped (listed) for prioritization and further analysis.

The following decision tree is recommended for defining the priority and sequence of materials or groups of materials to be analyzed and for setting their MRP parameters.

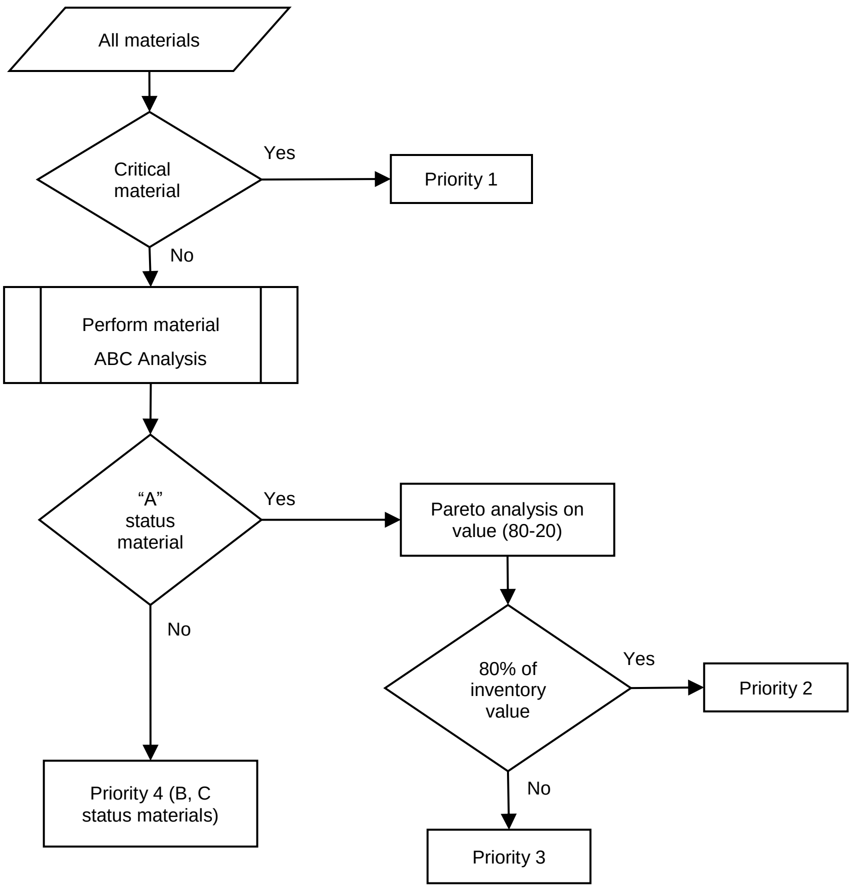


Figure 5.4 : Decision tree for defining priorities on setting the MRP

In addition to the decision tree, it is recommended by MAC SAP to implement and use the Inventory Management Cockpit Report in SAP. The MAC SAP documentation can be found following the link:
https://sites.google.com/a/holcim.com/cp-htec-cm-mac-sap-enhancement/mac-sap-configuration/4-specific-mac-sap-process/4-4-inventory-management-cockpit

Recommended actions by priority

- Priority 1

1. Select those materials already identified as critical materials;
2. Include them in Quadrant I of the SSM (or in Quadrant IV if high consumption is detected), regardless of the limits defined;
3. It is recommended that the stock strategy for these materials be defined by a risk analysis assessment and/or the failure mode effect analysis (FMEA); and
4. Define and select MRP parameter combinations as required. Chapter 3 includes a description of the main MRP parameters to be considered and defined by the cross-functional team.

- Priority 2

1. For non-critical materials, perform an ABC analysis and select those materials defined as type A;
2. It is recommended that type "A" materials be split into a second group based on the Pareto principle, whereby further analysis is focused on the materials that represent 80% of the total inventory value under analysis.
3. In coordination with Operations and Procurement staff, plot each material in the SSM;
4. Define and select the MRP parameters in cross-functional collaboration*. Chapter 5.3 MRP parameter settings*, includes a description of the main MRP parameters to be considered.

- Priority 3

Once Priority 2 materials have been mapped and the parameters selected, proceed with the materials defined as Priority 3 (the remaining 20%) by following Steps 3 and 4 as described under Priority 2.

- Priority 4

Once the parameters and settings for the materials allocated to the previous priorities have been discussed and established, the actions and steps defined for Priorities 2 and 3 should be applied to Priority 4 materials (B & C materials).

Defining boundaries

The next step is to map each material or group of materials correctly onto the SSM. For this task a material list, ordered by priority, needs to be prepared and the boundaries (limits) established for each quadrant of the SSM. Following are recommendations for defining the boundaries:

Download material lists

For each of the defined priorities, a list of materials must be downloaded from the ERP system (e.g. SAP) and organized in a file containing the following information for each material:

a. Material ID code;
b. Material description;
c. Material group (PCS) description;

d. Total stock amount;
e. Unit of measure;
f. Unit value;
g. Total inventory value;
h. Criticality of material; and
i. ABC analysis status.

Here is a sample list extracted in the proposed manner:

Material ID code	Material Description	Material Group (PCS) description	Stock Amount	Unit of measure	Unit Value	Total Inventory Value	ABC Status	Critical
408000003123	REF;BRICK;ANKRAL Z1;VDZ;B322	040106 Magnesia Bricks	12,640.00	EA	669.05	8,456,845.50	A	
408000003124	REF;BRICK;ANKRAL Z1;VDZ;B622	040106 Magnesia Bricks	6,300.00	EA	615.22	3,875,855.20	B	
408000000517	REF;BRICK;MAGNESIA MA-SPINAL;VDZ;B318	040106 Magnesia Bricks	4,354.00	EA	571.75	2,489,416.08	C	
408000004205	REF;BRICK;MGOS;VDZ;B-618 ANKRAL-R1	040106 Magnesia Bricks	5,832.00	EA	348.19	2,030,672.33	A	X
408000000116	REF;BRICK;ANKRLZ1;425;250X198X103/91.50M	040106 Magnesia Bricks	2,000.00	EA	996.20	1,992,397.99	A	
308000091440	BALL;DW:LP/CO-M/2005/03	040404 Wear part for Mill	10.00	EA	184576.55	1,845,765.45	A	
408000003571	GRINDING MEDIA;90MM; HI CROME;SPHERICAL	040203 Grind Ball Stel Cast	222.00	QNT	8209.33	1,822,471.26	A	X
408000007751	IMP;REF;ANKRAL ZC-CB B322;MAKE:RHI	040106 Magnesia Bricks	4,480.00	EA	387.65	1,736,690.88	B	
408000002917	REF;BRICK;ALMAG 85;B-322	040106 Magnesia Bricks	2,350.00	EA	715.68	1,681,840.00	B	
408000004206	REF;BRICK;MGOH;VDZ;B-322I ANKRAL-ZE	040106 Magnesia Bricks	2,600.00	EA	615.56	1,600,457.36	B	X
408000000065	REF;LCC;HYDR;ACCMON-CAR	040109 Castables	30,000.00	KG	41.93	1,258,007.68	C	
458000016305	BAG;D/C;150X4267MM;CO POLYMER ACRYLIC	040701 Filter Bags	1,000.00	EA	1154.96	1,154,962.38	C	
408000004095	GRINDING MEDIA;25;HI CR;SPHERICAL	040203 Grind Ball Stel Cast	160.00	QNT	7157.88	1,145,260.14		
408000002916	REF;BRICK;ALMAG 85;B-622	040106 Magnesia Bricks	1,600.00	EA	702.96	1,124,735.54		
408000000115	REF;ANKRLZ1;825;250X198X103/91.50MM	040106 Magnesia Bricks	1,100.00	EA	996.20	1,095,824.43		
408000007752	IMP;REF;ANKRAL ZC-CB B622;MAKE:RHI	040106 Magnesia Bricks	2,720.00	EA	387.33	1,053,527.85		
458000014115	TYRE;OFF ROAD;29.5IN.WIDTH;25IN RIM DIA	041101 Tire-Off-RoadMo.Eqpt	3.00	EA	335245.67	1,005,737.01		
308000182698	GRATE PLATE;DW:LP/GC/2005/29;IS:4522 GR9	030526 Plates	180.00	EA	5508.00	991,440.00		
408000003283	REF;BRICK;MGOH;VDZ;B-622I ANKRAL-ZE	040106 Magnesia Bricks	1,460.00	EA	615.79	899,049.01		
408000000356	REF;BRICK;ANKRLZE;425;250X198X103/91.5	040106 Magnesia Bricks	1,200.00	EA	721.00	865,197.75		

Figure 5.5: Example of an extraction of a list of material

Since boundaries may vary for each material or group of materials, it is recommended to segment (split) the priority lists for each material group (PCS) and define the different boundaries for each material group.

Value threshold

The vertical axis of the SSM is the material unit “$ value” that indicates the level above or below which a material should be considered “low value” or "high value". This value can be defined as the simple average of the unit values under consideration, selecting this value as the limit.

Consumption thresholds

The horizontal axis of the SSM is the consumption rate for each material, calculated for a fixed period of time (e.g. yearly). High or low consumption limits are to be defined using the material master historical consumption rates within the same time frame. The threshold setting can be made using either of the following options:

- The cross-functional team selects a representative value for **all the materials or groups of materials** as the threshold between high and low consumption; or

- The cross-functional team assesses **each material** and establishes the consumption rate as either “high" or "low” based on historical data.

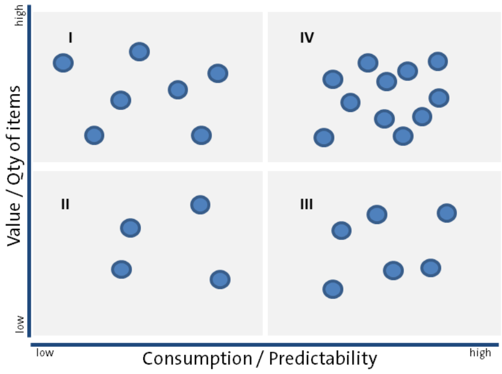


Figure 5.6: SSM with mapping of materials

Once the limits have been selected, each material or group of materials will need to be assessed and mapped onto the SSM according to the scope and limits defined. The map for each group assessed will appear as in figure 5.6.

5.3 MRP parameter setting

Once the materials have been plotted on the SSM, the selection and setting of MRP parameters should be completed and added to the material master record.

Data integrity (completeness of data) is required for the MRP system to yield good results. Any inaccuracy in the inventory master data or bill of materials (BOM) data will most likely result in incorrect output data.

Parameters that need to be maintained or updated during an MRP optimization process are described below.

It is recommended that all parameters be kept as material-specific as possible. This can be achieved once the materials have been mapped onto the SSM following the steps given in the previous section.

5.3.1 Specific MRP parameters (SAP definitions)

These are the main parameters that impact the results of the MRP execution. The following parameter descriptions and definitions are based on the most common and mandatory SAP parameters to be maintained by the data administrator. The source of these definitions is the standard SAP R/3 system.

MRP type

This parameter determines whether and how the material is planned. This parameter must be maintained for all materials that have been selected for planning with MRP. There are several standard SAP MRP types to be selected. Those that are most likely to be used by LafargeHolcim are described:

PD	Materials with slow rotation and high value (upper left quadrant of the SSM) for which Maintenance normally has sufficient time to plan consumption of the components within work orders. This type will trigger replenishment activities based on reservations generated from work orders.
VB	Materials with regular consumption (same quantity periodically) and mid-to-high value (upper right quadrant of the SSM). These materials normally have sufficient consumption history, so the reorder point (ROP) can be determined and set manually based on this history. This type will trigger replenishment activities based on ROP levels set manually in the material master.
VM	This is a variant of VB type of MRP; it differs only in that the ROP is calculated automatically by the system and is not set manually by the user.
V1	Materials with regular consumption with some moderate deviation (i.e. quantity increased due to plant shutdown) and high value, (upper right quadrant of the SSM). This type will trigger replenishment activities based on ROP levels set manually in the material master and also take into account all the reservations generated from work orders.
V2	This is a variant of the V1 type of MRP; it differs only in that the ROP is calculated automatically by the system and is not set manually by the user.
ND	For those materials for which there is no stock strategy defined due to non-criticality, very low value, low rotation and a self-service storage area where replenishment is triggered by manual methods such as the two-bin system. This setting ignores all the other MRP parameters in SAP. Purchasing activities are triggered via manual requisitions posted in SAP.

The main MRP types can be **generally mapped** as follows:

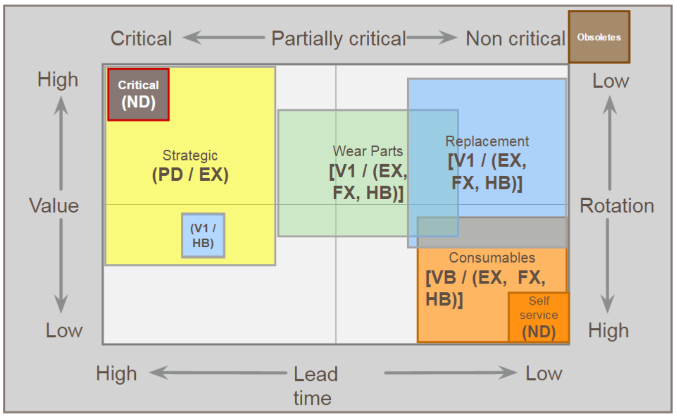


Figure 5.7: MRP material distribution

Reorder point (ROP)

This parameter will trigger the corresponding replenishment (provisional order, purchasing request or purchasing order) when the stock level of the material falls below this quantity. This level provides the optimum level of inventory to meet anticipated demand during the time it takes to receive a new order.

A simple method of calculating the reorder level involves the calculation of usage rate per day, lead time and the safety stock. This can be expressed by the following formula:

Reorder point = (Average usage per day x *Lead time (in days)) + Safety stock*

In the SAP parameterization process the ROP value must include the safety stock as shown above.

MRP controller

This parameter specifies the code assigned to the MRP controller responsible for materials planning.

Lot size

This parameter reflects the quantity of material to be purchased when a requirement is triggered. In the SAP system, this parameter should be maintained as this determines which lot sizing procedure the system uses to calculate the quantity to be procured. In SAP different lot size procedures are available; they are described as follows:

Lot Size HB: used when replenishment to the maximum stock level is required;
Lot size FX: used when a fixed standard quantity will be ordered in the event of a shortage;
Lot size EX: used when a lot-for-lot order quantity will be ordered.

Along with the lot size type parameter, the SAP system requires the minimum value for the purchasing lot. When a minimum lot size is required, the value to be set should reflect the minimum procurement quantity that is to be purchased when a purchasing order is released.

When selecting the minimum or maximum lot size, it is recommended that the lot size be calculated using the Economic Order Quantity (EOQ) model.

In order to optimize overall costs (purchasing costs, warehousing costs), two aspects should be considered. The first is to combine several requirements in one lot that covers several periods of consumption in order to reduce ordering costs (purchase order and logistic costs). The second aspect to consider is that higher storage costs may be incurred if lots are combined into one lot size, since quantities procured earlier than actually required have to be stored.

- Economic order quantity (EOQ)

The economic order quantity is the quantity to order that balances the costs associated with holding stocks against the costs associated with placing an order.

The main stockholding costs are usually related to working capital, whereas the main order costs are usually associated with the transactions necessary to generate the information to place an order

The "Wilson model" proposes the following formula to calculate EOQ in an environment of discrete and dependent demand of items.

$$EOQ = \sqrt{\frac{2A \times S}{C \times i}}$$

A = Annual Usage S = Cost per Order

C = Cost of Item i = Annual Cost to Carry

EOQ is used as the basis for defining lot size.

- Maximum stock level

This parameter is used to set the maximum desired level of stock for a material. In SAP systems it is mandatory only when the HB lot size parameter has been selected. For the other lot size options, it is not mandatory but it is highly recommended that this field be maintained as it could have an impact on the inventory level held by the company.

Lead time

The total replenishment lead time is measured from the time the requirement is triggered to the time the material is received and ready for use. For MRP, lead time is one of the most sensitive parameters, as its proper selection or calculation affects the overall planning schedule in the system. Generally, lead time is measured from the time the requirement is triggered to the time the material is received and ready for use. Lead times may change according to seasons or holidays or overall demand for the product.

It is recommended that the lead time calculation be included in the different components shown and described in figure 5.8.

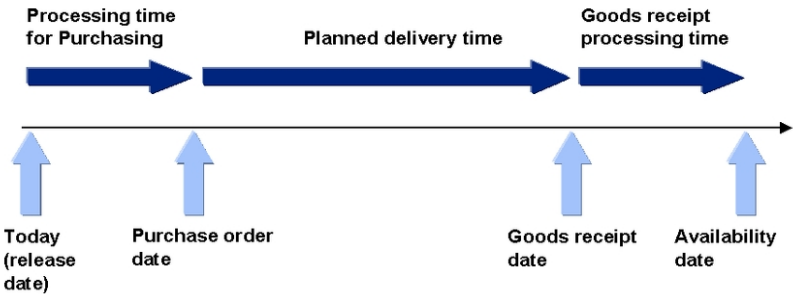


Figure 5.8 Lead time calculation

- Processing time for purchasing: This is the time required to convert a purchase requisition into a purchase order (including all internal approvals) and issue it to the supplier. The time required is measured in working days according to the Country calendar.
- Planned delivery time: This parameter is the time that it takes for a material to be received by the purchasing organization from the day of the purchase order. Enter the number of days it normally takes to get delivery of the material in this parameter. This time plus the processing time plus the goods receipt processing time equals the overall lead time.
- Goods receipt processing time: This parameter is the time that it takes for a warehouse or purchasing organization to process the receipt of materials in the system in order for them to be shown as part of the inventory or the material to be shown as ready for issuing to the plant. This parameter usually is set as 1 day. In most of the systems, goods receipts should be processed within 24 hours from the reception date.

Safety stock

Specifies the quantity required to accommodate demand variability in the period.

The purpose of safety stock is to make up for uncertainties in material planning that would otherwise result in excess consumption during the replenishment lead time. Its role is, therefore, to prevent the occurrence of shortfalls in quantities.

The higher the safety stock level, the higher the inventory cost incurred. However, stock-out costs fall as safety stock rises. Ultimately, the goal is to ensure that the safety stock is at a level that minimizes both the inventory costs and stock-out costs.

Figure 5.9: Safety stock calculation graph

The size of the safety stock depends on the type of inventory policy being used for the material.

A commonly used approach calculates safety stock based on the following factors:

- Demand rate (DR): the average amount of materials consumed per unit of time;
- Lead time (Lt);
- Z factor (see table below) related to the Service level: Naturally, when the desired service level is increased, the required safety stock will increase as well; and
- Forecast error (Fe): an estimate of how far actual demand may be from forecast demand, expressed as the standard deviation σ of demand.

The formula to calculate safety stock based on the factors above is as follows:

$$\boxed{SS = Z * \sqrt{((Lt * Fe^2) + (DR^2 * \sigma Lt))}}$$

Service Level	Z Values
50%	0
75%	0.675
80%	0.85
85%	1.05
90%	1.3
95%	1.6
97%	1.9
98%	2
100%	4

Service level

Service level is an expression of the ability of a process to deliver satisfactory results, expressed as a percentage value.

For inventory management, in the case of unexpected demand-related variation, this parameter specifies the desired probability that a chosen level of safety stock will prevent a stock outage.

For example, when reliable suppliers are available for a specific material, safety stocks can be kept low. When selecting the service level it is important to be aware that the higher the service level selected, the higher the cost of safety stocks.

Ultimately, the goal is to ensure that the service level is set at the point where the safety stock costs (carrying costs) equal the stock-out costs, so that the overall cost is minimized. See figure 5.10.

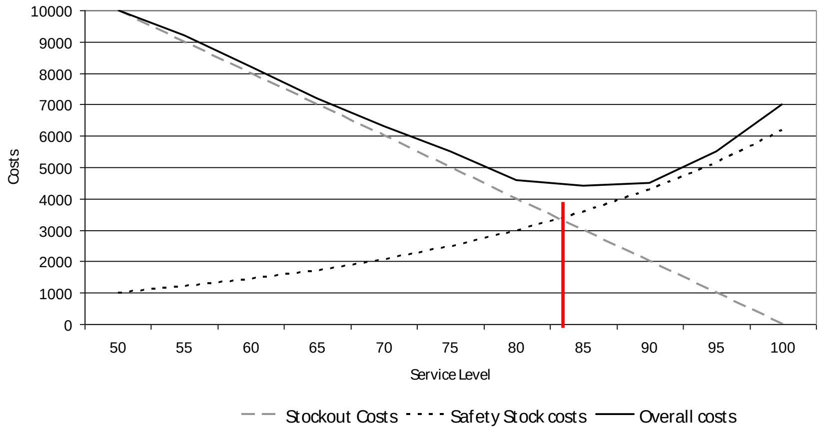


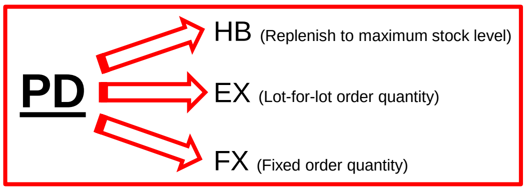
Figure 5.10: Service level calculation graph

A 100% service level cannot be achieved; furthermore, setting this as a target may lead to disproportionately high stocks, hence high carrying costs. Therefore, it is recommended not to set the service level at 100%, as this may oppose an optimization opportunity.

5.3.2 Recommended parameter settings for different scenarios

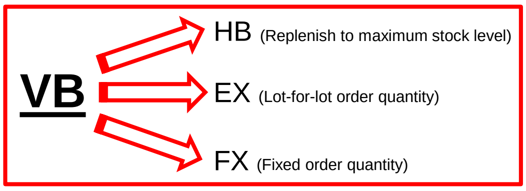
MRP parameters can be combined to establish the behavior and material variance in inventory management. These tables are based on the SAP system using as a comparison basis the MRP type combined with the lot size parameter and the parameters required to be set by the system according to the **combination.**

Details on combination of parameters with MRP type:



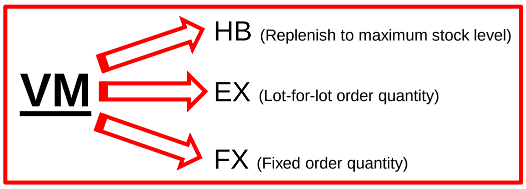
Lot Size	Description	Other Parameters
HB Replenish to Maximum Stock Level	• MRP considers current stock, safety stock, outstanding purchase orders, firm planned orders, reservations and the timing of planned items. • The net requirements calculation is carried out each time there has been a change in the available stock. • The resulting planned order will be sufficient to cover all known requirements, including safety stock, up to the maximum stock level. • The order is triggered when the available quantity is negative, meaning the requirement quantities are greater than expected receipts and stock quantity.	Maximum Stock Level is required by the system as mandatory Safety stock greater than zero is desired
EX Lot-for-Lot Order Quantity	• MRP considers current stock, safety stock, outstanding purchase orders, firm planned orders, reservations and the timing of planned items. • The net requirements calculation is carried out each time there has been a change in the available stock level, which considers safety stock. • The resulting planned order will be sufficient to cover all known requirements, including safety stock. The resulting uncommitted stock will equal the safety stock level. • The order is triggered when the available quantity is negative, meaning the requirement quantities are greater than expected receipts and stock quantity.	Safety stock is desired
FX Fixed Order Quantity	• MRP considers current stock, safety stock, outstanding purchase orders, firm planned orders, reservations and the timing of planned items. • The net requirements calculation is carried out every time there has been a change in the available stock. The resulting planned order will be sufficient to cover all known requirements, including safety stock. The system will propose orders in multiples of the fixed lot size. • The order is triggered when the available quantity is negative, meaning the requirement quantities are greater than expected receipts and stock quantity.	Fixed lot size is required Safety stock greater than zero desired

Details on combination of parameters with MRP type:



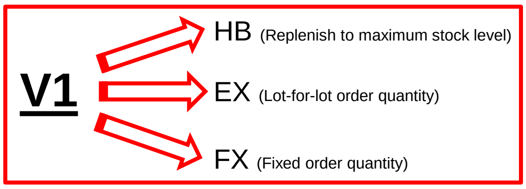
Lot Size	Description	Other Parameters
HB Replenish to Maximum Stock Level	• MRP considers current stock, safety stock, outstanding purchase orders and firm planned orders. • Reservations from plant maintenance and the timing of planned items are NOT considered. • The net requirements calculation is only carried out once the available stock level has fallen below the ROP. In this case, available stock does not consider safety stock. • The resulting planned order will be sufficient to cover the shortage to the maximum stock level.	Reorder point required Maximum stock level required Safety stock is required
EX Lot-for-Lot Order Quantity	• MRP considers current stock, outstanding purchase orders and firm planned orders. • Reservations from plant maintenance and the timing of planned items are NOT considered. • The net requirements calculation is only carried out once the available stock level has fallen below the ROP. In this case, available stock does not consider safety stock. • The resulting planned order will be sufficient to cover the shortage from the reorder point.	Reorder point required Safety stock greater than zero desired
FX Fixed Order Quantity	• MRP considers current stock, outstanding purchase orders and firm planned orders. • Reservations from plant maintenance and the timing of planned items are NOT considered. • The net requirements calculation is only carried out once the available stock level has fallen below the ROP. In this case, available stock does not consider safety stock. • The resulting planned order will be sufficient to cover the shortage from the reorder point. In this case, the system will propose orders in multiples of the fixed lot size.	Fixed lot size is required Reorder point required Safety stock greater than zero desired

Details on combination of parameters with MRP type:



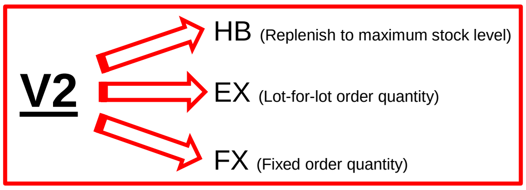
Lot Size	Description	Other Parameters
HB Replenish to Maximum Stock Level	• MRP considers current stock, safety stock, outstanding purchase orders and firm planned orders. • Reservations from plant maintenance and the timing of planned items are NOT considered. • The net requirements calculation is only carried out once the available stock level has fallen below the ROP. In this case, available stock does not consider safety stock. • The resulting planned order will be sufficient to cover the shortage to the maximum stock level.	Reorder point automatically calculated by the system Maximum stock level required Safety stock greater than zero desired
EX Lot-for-Lot Order Quantity	• MRP considers current stock, outstanding purchase orders and firm planned orders. • Reservations from plant maintenance and the timing of planned items are NOT considered. • The net requirements calculation is only carried out once the available stock level has fallen below the ROP. In this case, available stock does not consider safety stock. • The resulting planned order will be sufficient to cover the shortage from the reorder point.	Reorder point automatically calculated by the system Safety stock greater than zero desired
FX Fixed Order Quantity	• MRP considers current stock, outstanding purchase orders and firmed planned orders. • Reservations from plant maintenance and the timing of planned items are NOT considered. • The net requirements calculation is only carried out once the available stock level has fallen below the ROP. In this case, available stock does not consider safety stock. • The resulting planned order will be sufficient to cover the shortage from the reorder point. In this case, the system will propose orders in multiples of the fixed lot size.	Fixed lot size is required Reorder point automatically calculated by the system Safety stock greater than zero desired

Details on combination of parameters with MRP type**:**



Lot Size	Description	Other Parameters
HB Replenish to Maximum Stock Level	• MRP order proposal considers current stock, safety stock, outstanding purchase orders, firm planned orders, and reservations providing that configurations of this MRP type are set to consider maintenance planning. • The timing of the planned items is not considered. • The planned order will be sufficient to cover the shortage to the maximum stock level. • The net requirements calculation is only carried out once the available stock level has fallen below the reorder point. In this case, available stock does not consider safety stock.	Reorder point required Maximum stock level required Safety stock greater than zero desired
EX Lot-for-Lot Order Quantity	• MRP order proposal considers current stock, outstanding purchase orders, firm planned orders, and reservations providing that configurations of this MRP type are set to consider maintenance planning. • The timing of the planned items is not considered. • The planned order will be sufficient to cover the shortage from the reorder point. • The net requirements calculation is only carried out once the available stock level has fallen below the reorder point. In this case, available stock does not consider safety stock.	Reorder point required Safety stock greater than zero desired
FX Fixed Order Quantity	• MRP order proposal considers current stock, outstanding purchase orders, firm planned orders, and reservations providing that configurations of this MRP type are set to consider maintenance planning. • The timing of the planned items is not considered. • The planned order will be sufficient to cover the shortage from the reorder point. In this case, the system will propose orders in multiples of the fixed lot size. • The net requirements calculation is only carried out once the available stock level has fallen below the reorder point. In this case, available stock does not consider safety stock.	Fixed lot size is required Reorder point required Safety stock greater than zero desired

Details on combination of parameters with MRP type:



Lot Size	Description	Other Parameters
HB Replenish to Maximum Stock Level	• MRP order proposal considers current stock, safety stock, outstanding purchase orders, firm planned orders, and reservations providing that configurations of this MRP type are set to consider maintenance planning. • The timing of the planned items is not considered. • The planned order will be sufficient to cover the shortage to the maximum stock level. • The net requirements calculation is only carried out once the available stock level has fallen below the reorder point. In this case, available stock does not consider safety stock.	Reorder point automatically calculated by the system Maximum stock level required Safety stock greater than zero desired
EX Lot-for-Lot Order Quantity	• MRP order proposal considers current stock, outstanding purchase orders, firm planned orders and reservations providing that configurations of this MRP type are set to consider maintenance planning. • The timing of the planned items is not considered. • The planned order will be sufficient to cover the shortage from the reorder point. • The net requirements calculation is only carried out once the available stock level has fallen below the reorder point. In this case, available stock does not consider safety stock.	Reorder point automatically calculated by the system Safety stock greater than zero desired
FX Fixed Order Quantity	• MRP order proposal considers current stock, outstanding purchase orders, firm planned orders and reservations providing that configurations of this MRP type are set to consider maintenance planning. • The timing of the planned items is not considered. • The planned order will be sufficient to cover the shortage from the reorder point. In this case, the system will propose orders in multiples of the fixed lot size. • The net requirements calculation is only carried out once the available stock level has fallen below the reorder point. In this case, available stock does not consider safety stock.	Fixed lot Size is required Reorder point automatically calculated by the system Safety stock greater than zero desired

Details on combination of parameters with MRP type **"ND":**

Lot Size	Description	Other Parameters
HB Replenish to Maximum Stock Level	MRP has no impact. Manual requisition must be created.	Any entry in the other fields is ignored
EX Lot-for-Lot Order Quantity	MRP has no impact. Manual requisition must be created.	Any entry in the other fields is ignored
FX Fixed Order Quantity	MRP has no impact. Manual requisition must be created.	Any entry in the other fields is ignored

5.4 MRP planning and order conversion

This section introduces the main tasks of the MRP controller/planner and provides some recommendations on how to set up the MRP planning and order conversion processes.

5.4.1 MRP controller

In order to coordinate and monitor the materials flow more effectively, it is recommended that an MRP controller be established. An existing function in the organization could be nominated as MRP controller. This role is responsible for executing the MRP, responding to requirements by building up stocks of materials or directly initiating their procurement. This position is responsible for ensuring a high level of availability with a low level of tied-up capital (inventory).

The main tasks to be performed by the MRP controller are as follows:

- Serving as a link between functions (e.g. Purchasing, Operations);
- Maintaining MRP material master data;
- Monitoring materials planning;
- Executing materials planning;
- Analyzing materials planning on a qualitative and quantitative basis; and
- Ensuring the closing of outstanding open objects (e.g. purchase orders, reservations, and work orders).

It is recommended that MRP controllers be responsible and accountable for the planning of a limited amount of materials. Responsibilities can be divided up either by priority or by material group. For instance, the warehouse or inventory manager could be assigned an MRP controller code, and all common, high-rotation, low-value materials could be set with this code. These materials would then be planned centrally for the whole plant. Specific and equipment-related materials (e.g. high value, low or high consumption) would be assigned to another MRP controller.

5.4.2 MRP execution formats

MRP can be executed in either a centralized or a decentralized form. The following chart summarizes and compares the advantages and disadvantages of the two different scenarios.

The recommended scenario will depend on the evaluation of the specific local situation and the availability of resources at Country level.

Criteria	MRP planning fully centralized, Plant level	MRP planning decentralized, Department level
Flexibility	Low	High
Speed of changes	Low	High
Coordination efforts	High	Low

Materials' planning is generally carried out at plant level, taking all available stock in the plant into account during planning. However, stocks from individual storage locations can be excluded from requirements planning or they can be planned independently.

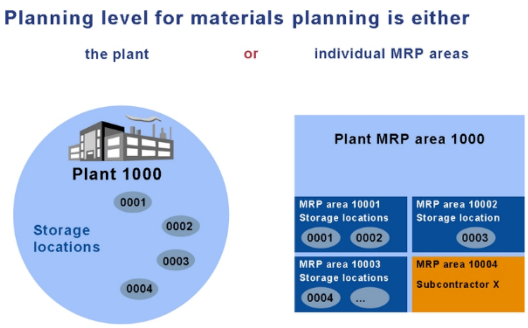


Figure 5.11: Planning levels

In addition to these execution formats, is recommended to consider the concept of the **virtual warehouse**, which is an inventory management concept that can be used when demand and inventories from two or more sites can be consolidated. Geographical conditions and common systems (e.g. common SAP) allow such consolidation.

In this case, the MRP parameters for materials shared or consolidated by several plants should be predetermined jointly by all targeted Countries/plants that will be supplied by the virtual warehouse.

The predetermined parameters are then set in the system but only for the Country/plant that will stock those shared/consolidated materials.

Based on identified good practices, the main steps of the process for managing MRP in a virtual warehouse are the following:

1. Define materials (item by item) to be virtually consolidated.
2. Define a geographical place/site (Country/plant) where each selected material will be stored.
3. Set the MRP parameter only in the system of the selected Country/plant where the materials will be stored (see Step 2). The selection of the MRP parameters for the material to be set in the system has to take into consideration the demand patterns of all participating Countries/plants.

4. The system must enable the requirement planning and stock selection (e.g. place reservations) at all the geographical places/sites (Countries/plants). This can be done by providing access to and visibility of the shared and common stocks of the selected materials at each location.
5. Execute MRP only at the Country/plant where the materials are kept in stock and the MRP setting has been defined. The system will consider all the planned reservations by all other plants and the replenishment will be triggered according to all these requirements.

5.4.3 MRP execution frequency

MRP can be executed at a frequency that fits the planning needs and depends mainly on variables such as:

- Resources available; and
- Amount of materials to be planned.

The main frequencies available to be considered are
- Daily (d);
- Weekly (w);
- Monthly (m); or
- Flexible periods (f)

In order to establish the best MRP execution strategy, it is recommended to perform an analysis combining the execution format/frequency and the reorder policy.

The **weekly** format is highly recommended; experience shows that it provides a manageable time frame for analysis even when high amount of materials are to be planned through MRP.

5.4.4 Reorder policies

The reorder policies are defined by the combination of the following characteristics:

1. Purchase order quantity (**q**);
2. Purchase order period (**t**);
3. Purchase order limit or reorder points (**s**);
4. Target stock (**S**); and
5. Service level.

Reorder policies depend on the reorder methods selected and are used for inventory control and for the definition of the replenishment type.

Reorder point

This procedure is used for determining the order date and purchase order quantity. The reorder point depends on typical consumption and on the safety stock. Ideally, the ordered materials arrive when the safety stock level has been reached.

a) **s,q Policy:** for this policy, the PO quantity (q) is fixed, and the PO period (t) is variable. See Figure 5.12.

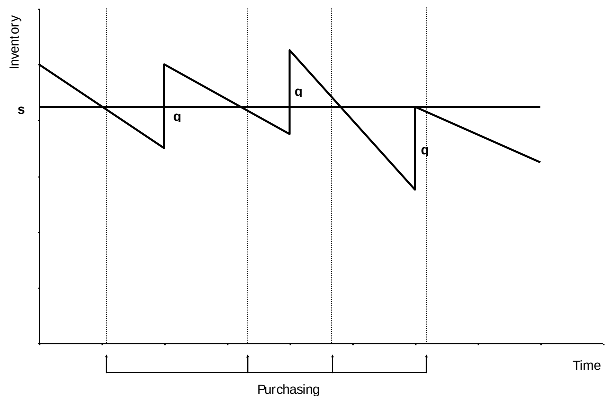


Figure 5.12: s,q Policy

This policy takes requirement fluctuations into account; hence, stock-outs normally do not occur whereas inventory carrying costs remain low. However, the materials planning effort associated with this policy is usually high, requiring continual stock checks among other tasks.

Inventory carrying costs includes warehousing costs such as rent, utilities and salaries, financial costs such as inventory opportunity cost, and inventory costs related to perishability, shrinkage and insurance.

This policy applies normally for maintenance, repair and operations (MRO) materials with independent demand patterns. As described in Chapter 5.1.3, this policy will be applied mostly to materials with high consumption rate and high value.

b) **s,S Policy:** in this variant, the PO quantity and the PO period are variable. The maximum stock level is, however fixed as it defines the reorder point. See Figure 5.13.

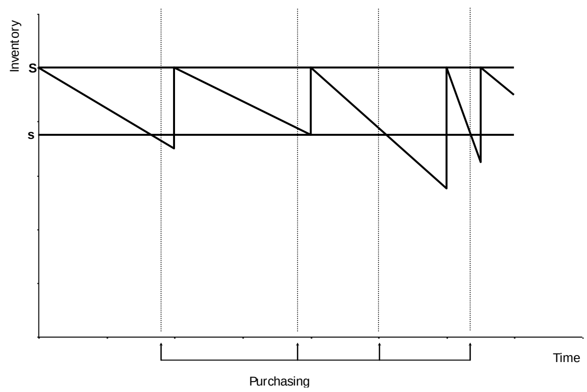


Figure 5.13: s,S Policy

This policy requires continual stock checks; however, the carrying costs are controlled as maximum stock levels are defined.

This policy also applies for maintenance, repair and operations (MRO) materials, where a maximum stock level can be set and afforded.

Time phased

This is a consumption-oriented reordering procedure. A date prompts the system to trigger the creation of a purchase order within a constant time interval (i.e. cyclical) in which the PO quantity is either fixed or variable.

The following are two common alternative policies to be selected with this reorder method:

c) **t,q Policy**: the replenishment order is created within a fixed period (t0) and for a fixed quantity (q0). See Figure 5.14.

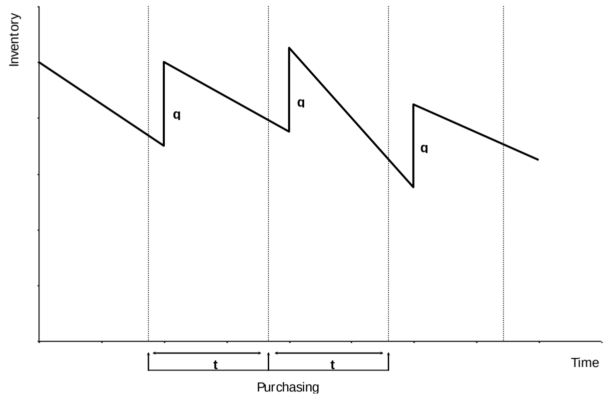


Figure 5.14: t,q Policy

The material planning effort associated with the t,q policy is generally low. Beyond normal inventory levels the warehouse stock levels do not need to be checked continuously. However, if demand fluctuates (e.g. high material demand due to production peaks) this may result in stock-out situations or high storage costs (overstock). These situations can be minimized by setting reasonable service level and lead time parameters.

This t,q policy is generally recommended for raw materials and semi-finished products for which the requirements remain constant over a long period of time.

This policy has the following disadvantages:

- Stock shortfalls that can arise if demand exceeds normal levels, thus causing higher stock-out costs; and
- Risk of overstock due to fixed replenishment quantities.

d) **t,S Policy**: for this policy the replenishment order is created within fixed time cycles (t0) but with variable quantities (qi). As a prerequisite, maximum stock levels should be defined. After t0 time units, replenishment of materials occurs to fill the maximum target stock (S) level. See figure 5.15.

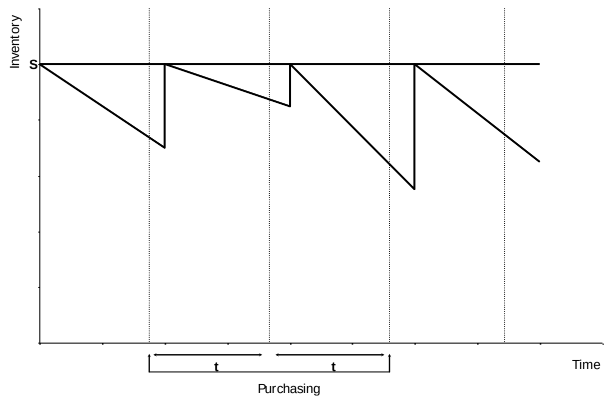


Figure 5.15: t,S Policy

This policy counteracts the risk of overstocks; however, because there is no reorder point to trigger the replenishment, stock-outs may occur.

This policy is recommended for categories for which several low-value materials are procured (like some allocated in PCS Segments 03 and 04) or for which inventories are controlled by the suppliers (vendor managed inventory) and those materials are part of a self-service area.

Some of the advantages of this policy are:

- Controlled carrying costs due to stock level settings; and
- Collective replenishment can be triggered for similar materials.

Some specific disadvantages for this policy are:

- Risk of stock-outs when demand exceeds expected level.

Summary of reorder policies

For high-value, low-consumption and critical materials, correct replenishment planning should be executed through the utilization of BOMs and maintenance planning (see Chapter 2).

For materials with high value and high rotation, the proper usage of an MRP in combination with the reorder policies described below is preferred.

		Replenish quantity (q)	Replenish period (t)	Replenish limit/reorder point (s)	Maximum stock (S)
Reorder Point Method	s,q policy	Variable	Fixed	Fixed	Variable
	s,S policy	Variable	Variable	Fixed	Fixed

The reorder cycle method, in which order quantities and lead times are easier to calculate and set, is more suitable for materials for which demand or consumption is stable (e.g. raw materials, fuels) or for low-value materials with low consumption. See *Chapter 4.1.2: Implementation of Stock strategies.*

		Replenish quantity (q)	Replenish period (t)	Replenish limit/reorder point (s)	Maximum stock (S)
Reorder Cycle Method	t,q policy	Fixed	Fixed	None	None
	t,S policy	Fixed	Variable	None	Fixed

For all the mentioned reorder policies it is recommended that the service level parameter is maintained in order to define the correct safety stock required.

The reorder policies can be added to the chart described in Chapter 5.3 of this document.

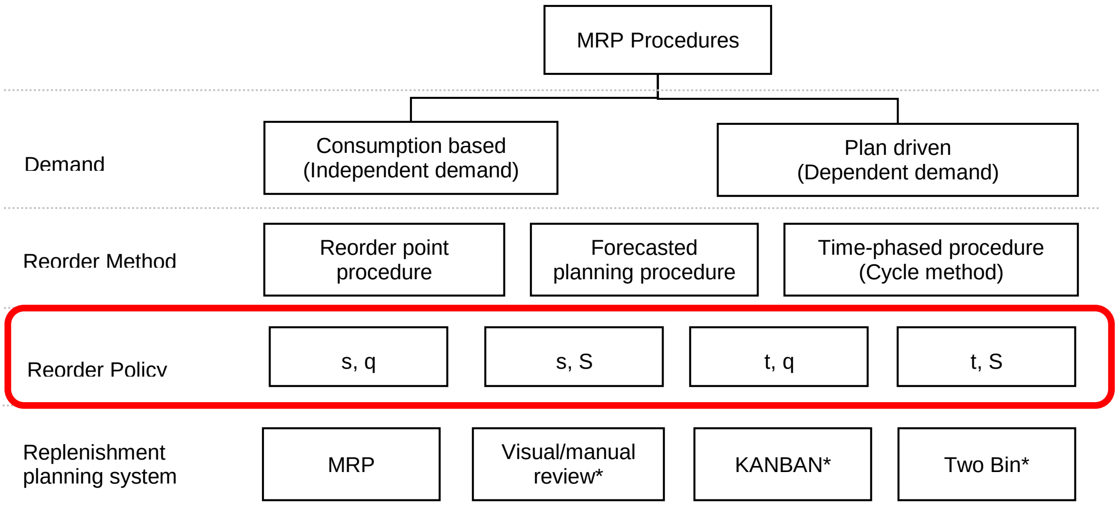


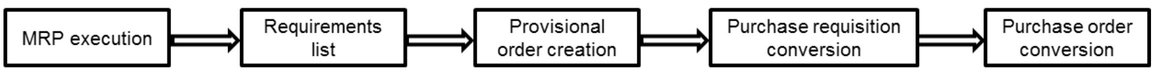
Figure 5.16 MRP Procedures

5.4.5 MRP order conversion

In the SAP system, MRP can be configured/customized to have different outputs when executed, such as:

- Provisional orders: These are merely system-generated estimates of material needs based on current MRP parameter settings and current stocks. Once the amount is validated, these provisional orders can be converted into purchase requisitions or purchase orders; otherwise they can be ignored and not processed.

  This configuration is recommended when MRP is implemented for the first time, when material requirements must be monitored closely, or when there is uncertainty about current MRP settings. This configuration tightens the control level and avoids unnecessary purchase requisitions or overstocks.



- Purchase requisitions (PR): With this configuration, the system creates purchase requisitions once MRP runs. It can also be customized to allow the modification of final amounts if MRP is run manually.

  This configuration is recommended when MRP is run manually, not automatically, since additional work (e.g. converting provisional orders into PRs) can be avoided by modifying the requested amounts prior to the release of the PR.

- Purchase orders: This configuration will create a purchase order directly once the MRP is run. This reduces the workload since no interim steps or validation processes are required for the material requests.

This configuration is recommended when materials run through MRP have been properly assessed and the parameter selections are accurate. These materials must have a contract in place where the source of supply (supplier) is available with pre-agreed terms and conditions.

5.5 MRP monitoring and controlling

This section introduces various analysis reports recommended for controlling materials planning. These reports can help to monitor and control the impact of MRP on materials planning.

It is fundamental that these reports be generated and analyzed with a certain frequency (e.g. monthly) in order to ensure a **sustainable MRP optimization process.**

5.5.1 MRP list and stock/requirements list

In MRP execution, this is the first report used to analyze the current stock/requirements; this report allows the MRP controller to assess the current planning situation or the result of an MRP execution. The system gathers the various types of materials planning information from the following sources:

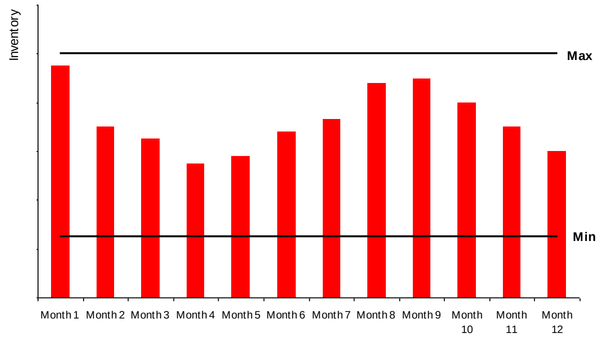
- Planned orders;
- Purchase requisitions;
- Purchase orders;
- Schedule agreements
- Stock reservations; and
- Stock levels.

5.5.2 Maximum-Minimum stock value analysis

This analysis is intended for monitoring and tracking the stock value trend of materials ordered using MRP.

The steps involved in this analysis are as follows:

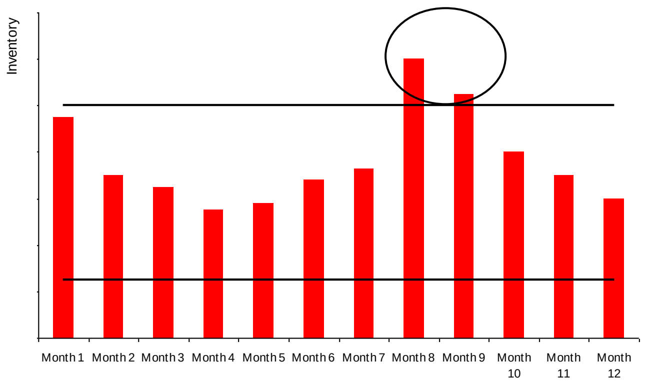
1. Select an analysis period (last 12 rolling months is recommended).
2. List all materials, or groups of selected materials, planned through MRP along with the following information:
   - Actual material stock value
   - Actual maximum stock value (upper limit) set in the system
   - Actual minimum or safety stock value (lower limit) set in the system
3. Total each of the above values.
4. Create a graph that shows the monthly trend of these values as follows:



Different scenarios can be found through this analysis:

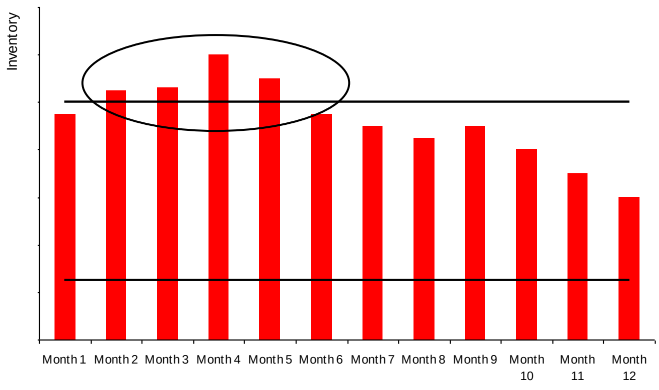
a. Stable between limits (see previous graph): The conclusion may be that the inventory value and MRP settings (max. and min.) have been correctly established. A trend line or series of inventory values that remains between the upper and lower limits indicates that the material MRP parameters are most probably correct and that further improvements can be made by analyzing the maximum levels and adjusting them to match the maximum consumption/demand recorded in the period.

b. Special and justified cases where limits (max. or min.) are reached or in some cases exceeded (e.g. annual plant shutdown period when material stocks may rise above the maximum limit).



This case may be considered normal and no alarm should be triggered with regard to modification or optimization of the MRP parameters. This scenario may reflect the seasonality of the planned materials. The same period should be analyzed periodically to confirm the seasonality of the materials.

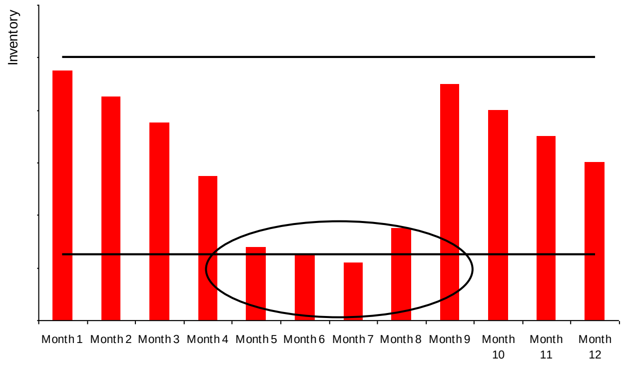
c. Special cases in which the maximum limits have periodically been reached (overstock) without any specific reason (e.g. no planned plant shutdowns in the affected period).



This case should be further analyzed. The possible drivers for the overstocks shown in this case are:

- ✓ Manual modification of order quantity setting (above the maximum); or
- ✓ Purchase requests done manually and not through MRP.

d. Special cases in which the minimum limits have been occasionally reached (stock-out risk).



This case should be further analyzed. The possible factors that can influence stocks to fall below the minimum are:

- ✓ Unexpected demand (e.g. equipment breakdown);
- ✓ Irregular MRP execution; or
- ✓ Unreliable lead time setting.

5.5.3 Dead stock analysis

Dead stock analysis relates to that part of the warehouse stock that has not moved for a certain period of time and is above the safety stock limit and below the actual consumption rate or demand. See figure 5.17.

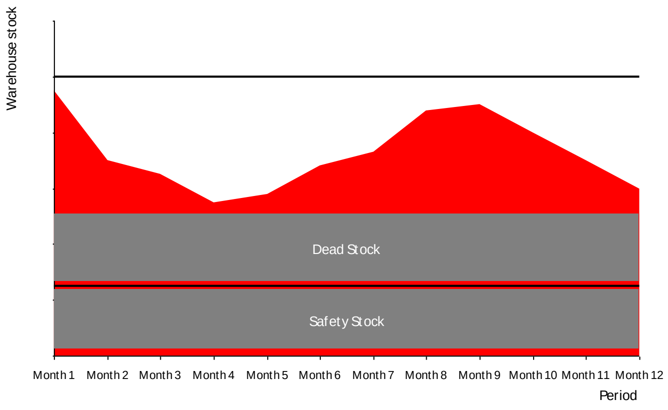


Figure 5.17: Dead stock

Analysis of the dead stock helps to identify excessively high stock levels and allows important control parameters, such as safety stock, to be recalculated.

The difference (delta) between dead stock and safety stock can be regarded as a potential target for inventory optimization.

Dead stock generally occurs when slow-moving items are continually replenished even when they are not needed.

5.5.4 Range of coverage analysis

The range of coverage of a material provides information about the level of warehouse stock in relation to the demand. It indicates how long the warehouse stock will last, based on the average daily requirement. The graph below shows the change in warehouse stock levels over time. The future requirement is subtracted from the current warehouse stock to give the number of days of stock supply.

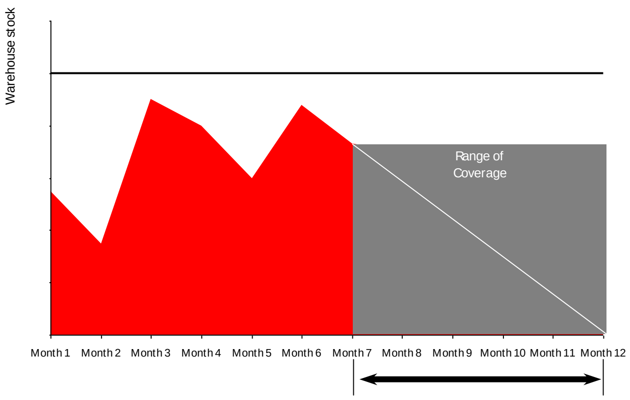


Figure 5.18: Evolution of warehouse stock

Analysis based on a range of coverage criteria allows materials with an excessively large range of coverage to be identified. These materials can then be adapted to the consumption rate.

The following formulas can be used to analyze the range of coverage for consumption requirements.

Consumption range of coverage = current stock level/average daily consumption

Stock days' supply = current stock level/average daily requirements.

5.5.5 Inventory turnover analysis

Inventory turnover indicates how often an average inventory is turned around within a defined period (see figure below).

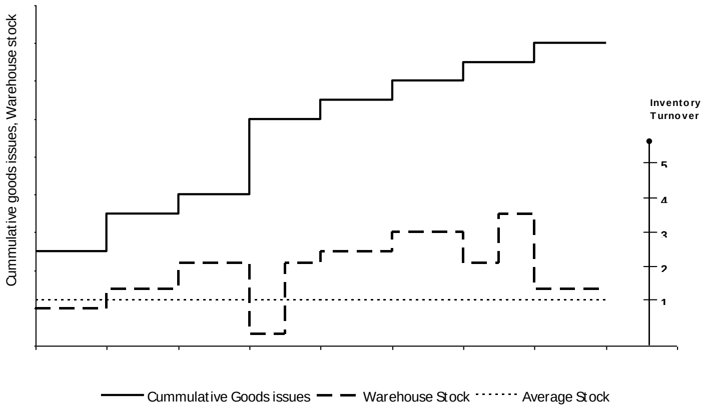


Figure 5.19: Inventory turnover

Inventory turnover is calculated by:

Inventory turnover = stock consumption during the period/average stock in the same period

5.6 Example on how to implement MRP in SAP

Document explaining step by step the implementation of MRP within EBM (Europe Business Model) can be found following the link:

https://docs.google.com/document/d/1dOnlOMRISbnST7DuWzuoxvpGnZawg9hh_6mmwwaftOg/edit

6 Establishing Roles & Responsibilities

Good management of inventories requires an interdisciplinary approach, combining different kinds of expertise but focusing on a common objective. Clear roles and responsibilities need to be established between operations (maintenance and production), inventory officers and procurement, at the different stages of the Procure-to-Pay process.

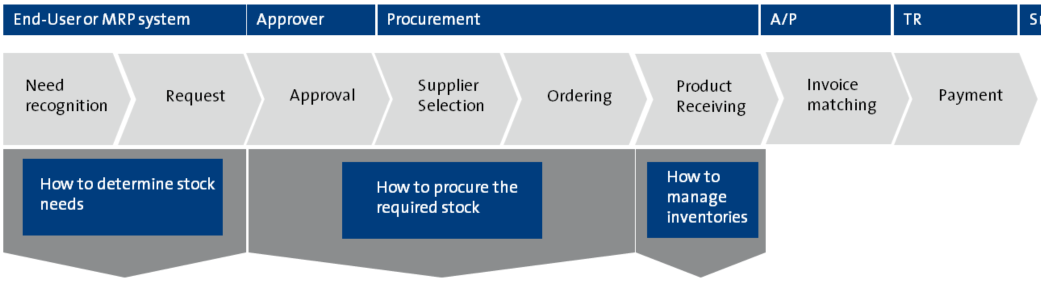


Figure 6.1: “Procure-to-Pay process”

6.1 Stock needs definition

The stock needs definition process primary requires operations’ involvement in demand planning, and is supported by the inventory officers and procurement.

In particular, the key interdisciplinary activities when establishing stock strategies are related to:
- Defining lead times;
- Defining safety stocks;
- Defining lot size; and
- Defining reorder point levels.

Each of the above activities was described in detail in Chapter 4.6 MRP Optimization. Each function plays a role in these above activities.

Maintenance responsibilities:

- Establish and maintain a bill of materials (BOM);
- Use a systematic approach to defining spare parts needs;
- Communicate material consumption planning requirements in advance (13 weeks) to inventory officers and procurement;
- Communicate major shutdown planning to inventory officers and procurement;
- Manage reservations and order requirements;
- Communicate clear technical specifications for required materials; and
- Provide safety stocks requirements.

Production responsibilities:

- Communicate annual requirements formally in advance (1 year +) to inventory officers and procurement: the needs are based on production forecasting (fuel consumption, raw materials, etc.);
- Adjustment of production plan monthly/weekly; and
- Provide safety stocks requirements.

Inventory manager responsibilities:

- Participate in demand planning / scheduling meetings of Operations (eg: participation in plant shutdown planning meeting);
- Check accuracy of system data versus physical stock;
- Administer and control inventory requirements and reservations; and
- Coordinate information flows with Operations and Procurement about lead-times and costs: in particular, provide information about historical consumption, ABC, XYZ analyses.

Procurement responsibilities:

- Participate in demand planning / scheduling meetings of Operations (eg: participation in plant shutdown planning meeting); and
- Analyze suppliers'/market's ability to cover the need for strategic and critical parts and provide delivery time information to Operations during planning.

6.2 Procure the required stock

The purchasing process primary requires procurement involvement and is supported by the inventory officers and operations:

Procurement responsibilities:

- Lead negotiations with vendors, and involve Operations and Inventory Manager as needed;
- Implement contracts to ensure the availability of the consumption plan and to optimize replenishment activities for recurrent purchases;
- Implement lead times and delivery terms aligned to "field" expectations;
- Implement and monitor a periodic supplier performance evaluation system; and
- Determine and validate lead times to spare.

Operations responsibilities:

- Participate in the negotiations with vendors, when required by Procurement: in particular, participate in technical evaluations of vendor's proposals;
- Determine criticality of parts; and
- Identify and establish links to bill of materials with optimal MRP settings for planned (PD) items.

Inventory manager responsibilities:

- Participate in the negotiations with vendors, when required by Procurement

6.3 Manage the inventories

The inventory management activities primary requires inventory officers' involvement and is supported by operations and procurement:

Inventory manager responsibilities:

- Perform housekeeping in warehouse;
- Guarantee optimal storage conditions;
- Check accuracy of system data versus physical stock;
- Carry out reservations and preparation;
- Administer and control inventory obsolescence and ageing;
- Maintain security for all stored materials and parts in a clean and orderly manner;
- Coordinate information flows with the plant and Procurement;
- Maintain defined stocking strategies;
- Ensure delivered goods are posted in SAP (discipline);
- Support Material Master cleaning activities;
- Ensure there is a quality inspection in the goods reception process;
- Conduct quality inspection of standard materials; and
- Support the process for identifying obsolete items.

Maintenance responsibilities:

- Conduct quality inspections in the goods reception process for specific parts where technical knowledge is required;
- Support Material Master cleaning activities;
- Support the process for identifying obsolete items; and
- Ensure maintenance of Spare parts and tools.

Procurement responsibilities:

- Support Material Master cleaning activities; and
- Support the process for identifying obsolete items.

7 Management of Obsolete items

Having clear procedures, roles & responsibilities in relation to the management of obsolete items contributes directly to the quality and level of inventories held by LafargeHolcim countries.
This has a direct impact on:

- Net working capital levels: by contributing to define and maintain optimal inventory levels
- Plant reliability: by having the right parts, in the right conditions, and at the right time to ensure the reliable operation of plant machinery and equipment
- Financial Statements: by contributing to the reliable reporting of inventory balance and clear and proper segregation of duties

7.1 LHARP definitions (LHARP manual release 16.2)

A part is consider obsolete when:

- The related equipment is permanently out of use
- There is no related equipment
- The spare part is damaged

Those parts have to be 100% provided for and then written off upon physical removal from inventory.

The spare part inventories have an allowance for obsolescence (also known as slow moving provision) raised globally by applying the following rule:

- 30% after 1 year without usage
- 50% after 2 years without usage
- 80% after 3 years without usage

The calculation of the allowances is based on original costs (straight-line basis) and must be applied against all inventories recorded in 'Parts and Supplies'.

Usage is defined as being used within the production process. If only one unit of an inventory item is used, then this entire inventory item is not subject to the allowance for obsolescence, even if a large amount of the item is on stock.

Note that where parts and supplies are used after having raised an allowance for obsolescence, they have to be charged to the receiving cost center at the original cost and not at the reduced value. The allowance is released when appropriate to type of cost 'Other Provisions and Write-Offs'.

The obsolescence is charged to production cost:

- In the case of clinker and cement and aggregates to 'Plant Management' auxiliary cost center
- In the case of ready-mix concrete and asphalt to the main production cost center using the type of cost 'Other Provisions and Write-Offs'.

Note that critical and rotating spare parts that do not meet the capitalization threshold defined for property, plant and equipment (PPE) are no longer considered critical and rotating spares.

They are therefore included in inventory category 'Parts and Supplies' and are subject to the calculation of allowance for obsolescence of spare parts.

Costs (including allowance for obsolescence) of spare parts inventories are normally linked to the cost center where they are most likely to be used. Where the spare part is thereafter used in a different plant the inventory has to be transferred at cost. The plant that was carrying the related obsolescence allowance will reverse the allowance using the type of cost 'Other Provisions and Write-Offs'.

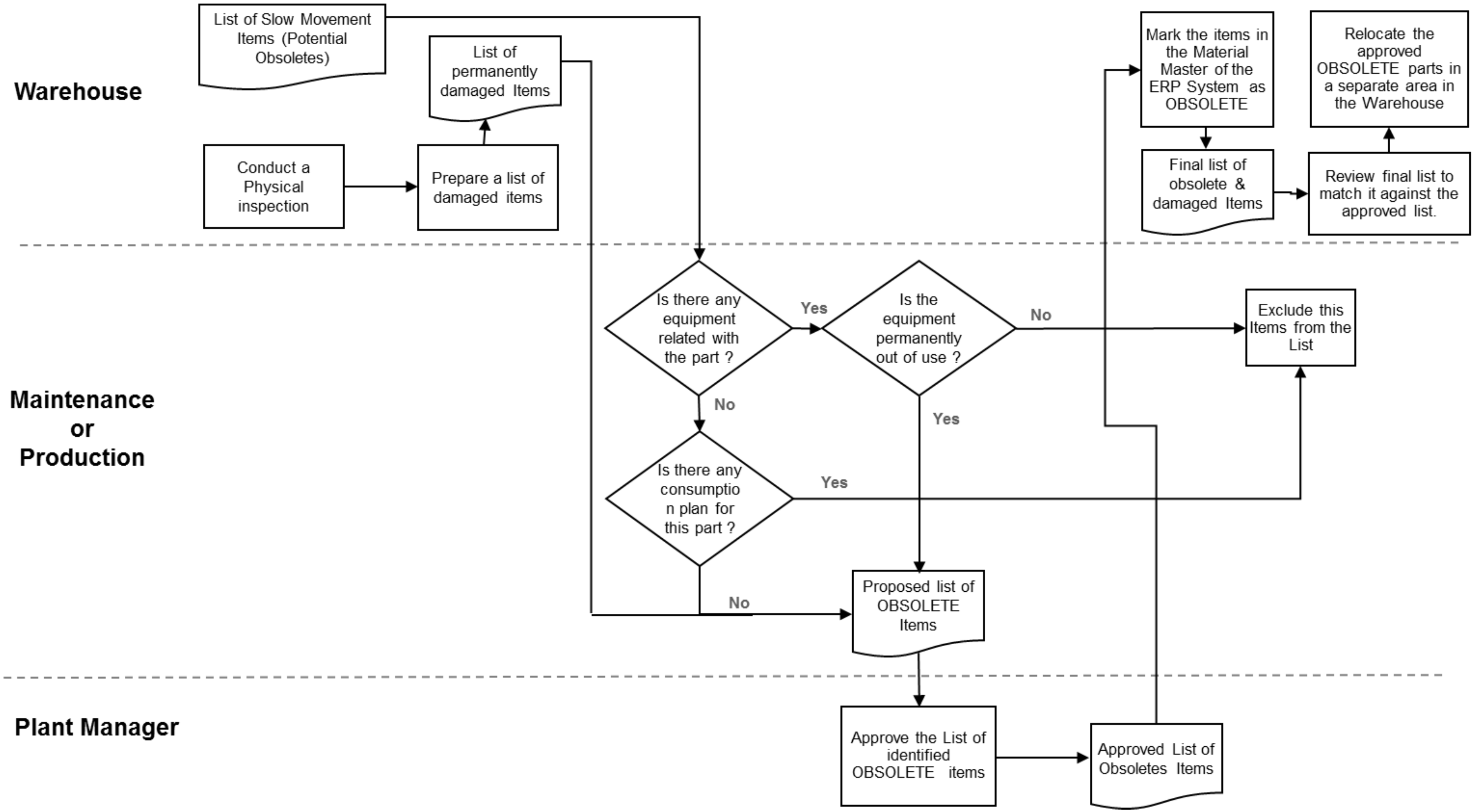
7.2 Identification of obsolete items

7.2.1 Key steps to follow in order to identify obsolete items

1. Obtain a “Slow movement” report that lists all the parts sorted by last consumption date.
2. Conduct a physical inspection on the more expensive parts that have not been used for long time in order to verify their condition.
3. Link the parts to equipment to verify whether it is a part of an obsolete or critical equipment and every time a decision is made to discontinue the utilization of an equipment, all the related and specific spare parts should be considered for obsolescence analysis.
4. Identify if there is a consumption plan for the parts not damaged and not linked to a critical equipment
5. Prepare a list of potential obsolete items to be submitted for approval in order to be declared as obsolete parts.
6. Warehouse / Material Master responsible should update in SAP the status of the approved list of obsolete items identifying them as “obsolete“
7. Warehouse relocate the approved obsolete items in a specific area within the premises

E.g.: ultrasonic test to identify physical condition of an expensive slow movement part

7.2.2 Flowchart with process to identify obsolete items

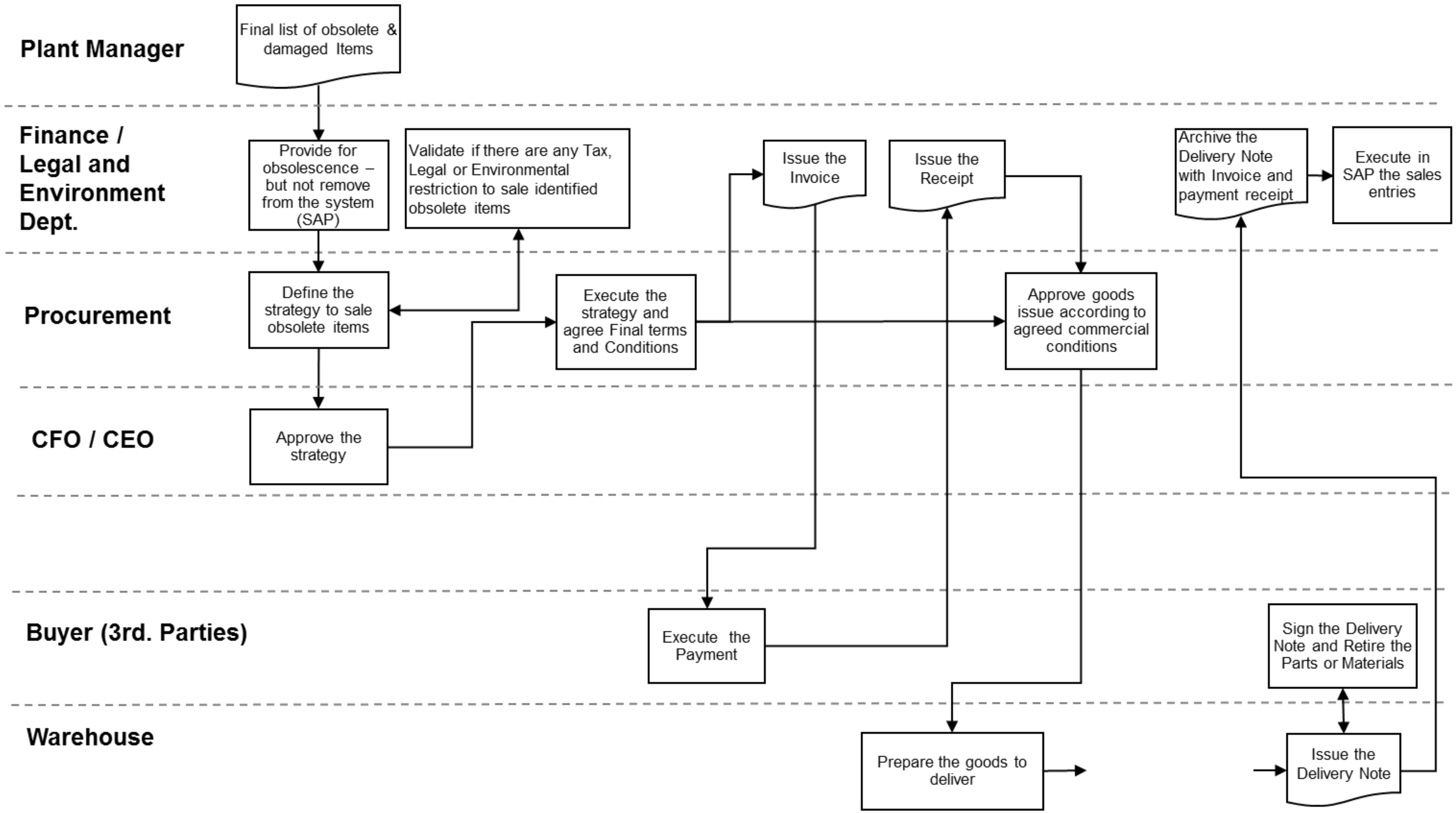


7.3 Disposal and sale

7.3.1 Key steps to follow in order to proceed with the write-off and sale of obsolete items

1. Once the List of identified obsolete items are approved by Management, the relevant area (e.g. Warehouse) in coordination with Finance can write off the obsolete items 100%. However, in order not to lose control of the inventory quantities, it is recommended that the obsolete items are not immediately consumed in the ERP system, but initially their value to be adjusted or written down to $1 (for instance) or to a value close to zero, and then when sold or disposed of, the quantities should be removed from the ERP system.
2. Procurement and Warehouse receive from the Plant Manager the approved list of obsolete items to proceed with their disposal or sale and select the ones suitable for sale based on market knowledge.
3. Procurement checks with Legal, Tax and Environment Department if there are restrictions or specific requirements to sell the identified obsolete items.
4. Procurement defines the sale strategy by applying different methodologies:
    a. Advertise in newspapers, internet, etc.
    b. Ask for quotations to selected candidates (e.g.: current suppliers)
    c. Public or private auction.
    d. Communicate to other LafargeHolcim Countries/Plants in the same region.
5. CFO/ CEO approves the sale strategy.
6. Procurement execute the strategy.
7. Procurement informs finance and legal departments the final terms and conditions agreed.
8. The relevant department (e.g. Finance, Invoicing, Marketing and Sales) issues the Invoice according to legal conditions.
9. The relevant department (e.g. Finance, Invoicing, Marketing and Sales) collects the payment from the buyer of the goods, and issues a receipt. Finance archives a copy of the receipt attached to the invoice. Note that if the sale is on credit terms finance should approve first the term of payment after assessing the financial conditions of the buyer.
10. Warehouse packs the obsolete items and delivers them according to agreed commercial conditions. Warehouse issues a delivery note to be signed as received by the buyer of the goods, and remove quantities off the system.
11. Warehouse send the delivery note (signed by the buyer/receiver) to the accounting department.
12. Accounting department proceed to archive the delivery note attached to the invoice.
13. Finance conducts the corresponding sales entries in SAP and ensures all required transactions are processed through to physical verification.
14. If the obsoletes cannot be sold, they would be disposed of and procurement department shall provide the justification for disposal.

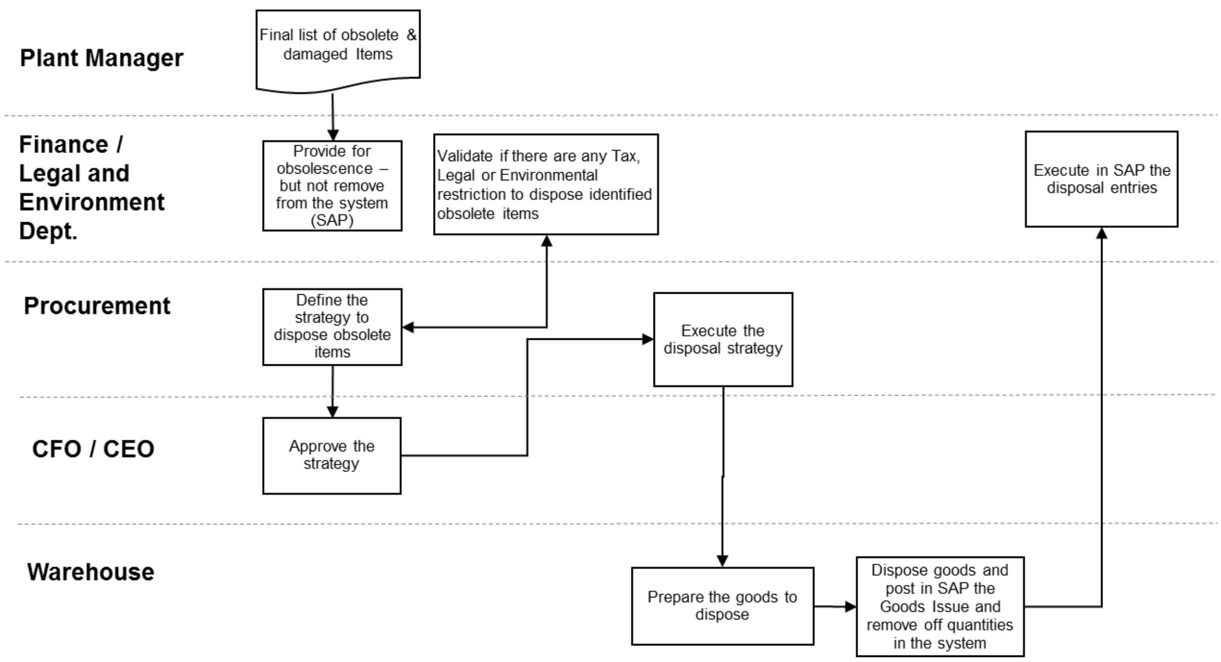
7.3.2 Flowchart with process to to proceed with the write-off and sale of obsolete items



7.3.2 Key steps to follow in order to proceed with the disposal of obsolete items

1. Once the list of identified obsolete items is approved by management, the relevant area (e.g. Warehouse) in coordination with finance can write off the obsolete items 100%. However, in order to not lose control of the inventory quantities, it is recommended that the obsolete items are not immediately consumed in the ERP system but initially their value to be adjusted or written down to $1 (for instance) or to a value close to zero, and then when sold or disposed of, the quantities to be removed off the ERP system.
2. Procurement analyze the list of approved obsolete items and identify those that are not suitable for sale, based on market knowledge.
3. Procurement check with Legal, Tax and Environment Department if there are restrictions or specific requirements to dispose of the identified obsolete items.
4. Procurement define the disposal strategy.
5. CFO / CEO approves the disposal strategy.
6. Procurement, with collaboration of the warehouse staff, execute the strategy and remove the quantities from inventory.
7. Procurement informs the Environment Department at the conclusion of the disposal process.
8. Finance conduct, in SAP, the respective disposal entries and ensures validity of such transaction through physical verification.

7.3.3 Flowchart to proceed with the disposal of obsolete items



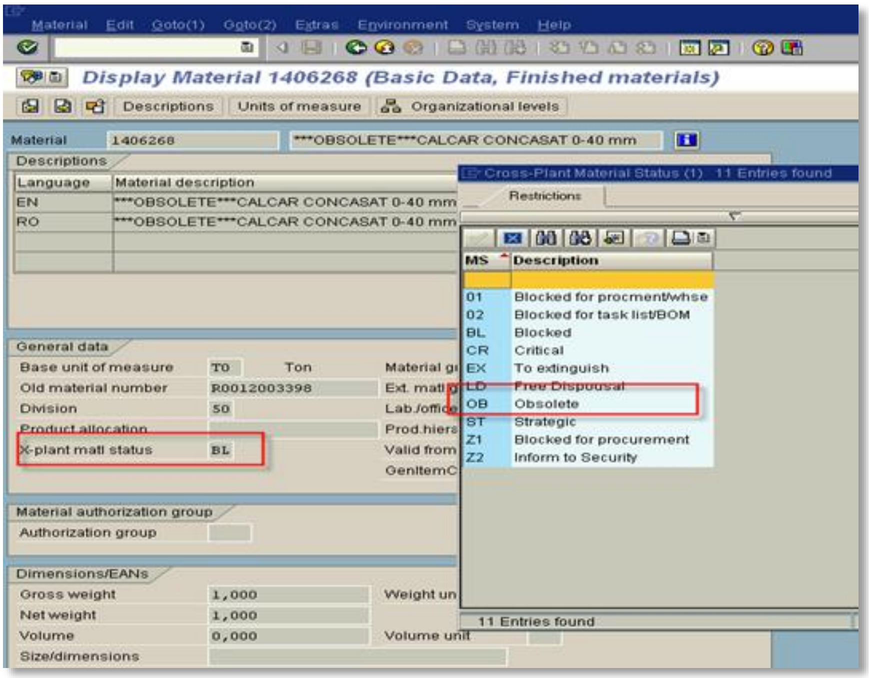
7.4 SAP Master Data Administration

After identifying obsolete items, their status has to be immediately updated in the ERP System.

The “obsolete” status related to each material ID has to be reflected in the Material Master in order to facilitate any further actions to be taken in relation to those items and to ensure consistent reporting.

SAP offers several options to do this, nevertheless, it is recommended to use the standard field “Plant material status” within the “General data”.

In order to do this, it is necessary to customize a special status “Obsolete” and to assign this value to each material ID that fulfils this condition.



7.5 Main Roles and Responsibilities

- Warehouse:
  - Provide the list of slow movement items to operation to start the obsolete identification process
  - Identify damaged items stored in the warehouse
  - Relocate identified obsolete items to a special storage area with in the warehouse
  - Mark the materials identified as obsolete in the SAP Master Data
  - Deliver to third parties the obsolete items sold issuing the delivery note and removing them off the System.

- Maintenance / Production:
  - Identify obsolete items
  - Analyze, define and implement alternatives of usage for the slow movement items
  - Submit final list of obsolete items for approval by Plant Management

- Plant Manager:
  - Authorize list of items to be classified as obsolete

- Procurement
  - Analyze, propose and implement selling and disposal strategies considering legal, taxes and environmental restrictions
  - Communicate to finance and to the warehouse the commercial terms agreed with third parties

- Finance:
  - Provide the warehouse staff with the list of slow movement items
  - Issue the invoice related to the sale of the obsolete items (or Sales & Mkt Dept.), according to commercial terms informed by Procurement
  - Collect the funds received from the third parties related to sale of obsolete items (or Sales & Mkt Dept.)
  - Archive and be sure to have the invoices, funds receipts and delivery notes related to each selling transaction
  - Conduct the inventory adjustments and coordinate the write off process in SAP

- Legal / Tax / Environment Departments:
  - Inform regulations and constraints to be taken into consideration during the process for disposal and sales of obsolete items.

- CFO / CEO:
  - Authorize the strategy for sale and dispose obsolete items.

7.6 Actions to consider in order to avoid obsolescence

- Increase accuracy during the consumption planning process specially by:
  - Defining the right quantity needed
  - Defining an accurate deadline for the need
  - Specifying clearly the technical conditions of the parts to be purchased
  - Taking into consideration short, medium and long term planning of maintenance activities that will need the parts. E.g.: consider the equipment replacement strategies (Plant Development Plan – PDP, Mid Term Planing – MTP).
- Implement a systematic methodology to define safety stock needs, based on Risk Assessment and a Failure Mode Effect Analysis (FMEA).
- Increase the usage of the Bill of Materials (BOM) in order to link the spare parts to the equipment and to facilitate maintenance activities.
- Incorporate elements that contribute to the stock strategy during the negotiation process:
  - Analyzing consignment stocks implementation (considering TCO)
  - When negotiating an equipment replacement, analyze the alternatives to get rid of the spare parts of the old equipment (e.g.: given the parts as a part of payment of the new equipment).
  - Ensuring a correct and safety packaging and handling
  - Ensuring a proper supplier selection that can fulfil reliable lead-times and goods quality
- Have the appropriate storage conditions for the materials stored at the Warehouse.

8 How to Measure Cost and Benchmark

In the previous sections of this document, we have learnt how to define optimal inventory levels through a systematic approach:
- Needs detection;
- Market knowledge and strategic sourcing;
- Replenishment strategy; and
- Proper layout and operational processes.

Once optimal levels are established, they have to be sustained, and the way to track sustainability is by measuring and benchmarking.
Before we can understand what and how to measure, it is important to clarify some concepts related to inventories, such as “LHARP definitions to be applied to critical parts”, and “cost of carrying stocks”.

8.1 Capitalization criteria and LHARP principles

Once “critical parts” are identified, as a result of risk assessment (refer to *Chapter 2. How to determine stock needs*), we must analyze whether these parts have to be capitalized according to LHARP definitions. Capitalization thresholds are defined in Chapter 3.1.2.4 of the LHARP Manual release 16.2. Expenditure below these thresholds will be expensed in the income statement, while expenditure over these thresholds will qualify for recognition as an asset.

Based on this principle we can answer the question “What is a capitalized part as defined by LHARP?” as follows:

Critical Parts Not to be capitalized as PPE (*)	Critical Parts to be capitalized (PPE)
Part to be used within next 12 months Value < USD 20’000	Part not used within the next 12 months Value USD >20’000
Handled in SAP-MM	Managed in SAP-Asset Management
These parts are part of the plant inventory “Parts and Supplies” and have an impact on NWC	These parts are not considered as part of the plant inventory value and are to be capitalized.

(*) PPE= Property, Plant and Equipment

Figure 6.1: Capitalization criteria

8.2 Cost of carrying stock

The only good reason for carrying inventory beyond current needs is if it costs less to carry it than not to have it.
When optimizing inventory levels and consequently net working capital, the cost of carrying stock should be considered in the analysis.
The following points must be considered when calculating the cost of carrying inventories:
- Storage facility costs;
- Counting, transporting and handling;
- Risk of obsolescence;
- Insurance and taxes;
- Risk of loss;
- Opportunity costs (a company cost of capital, representing the rate of return the company could earn from investments opportunities); and
- Shelf life.

There are several methods of calculating the cost of carrying stocks based on the above elements. The most common one, due to its ease of use, is the “annual rate ad-valorem” method.

Annual rate “Ad-Valorem”

This is a method that facilitates the economic analysis of the cost of carrying stock (or holding cost). It assumes that the holding cost can be estimated by applying an annual rate (defined percentage) to the inventory value. The logic of the method lies in establishing a proportional link between the cost of the stored items (“ad-valorem”) and the cost of holding them in stock (the higher the value of the items stored, the higher the holding cost).

The annual rate “ad-valorem” can vary between 15% and 40%. A typical breakdown of this rate might be:

Finance cost of stocks:	8% to 20%;
Storage cost:	5% to 15%; and
Loss/obsolescence cost:	2% to 15%.

Based on the current rates offered by financial markets, a recommended annual rate “ad-valorem” to be used is 20% to 25%.

The formula to be applied for the calculation of the holding cost is the following:

Holding Cost = Annual Rate “Add-Valorem” x [Avrg. Stock x Unit Price] x [Days inventory/365]

E.g. Holding cost = 0.25 x [50 units x 10 USD] x [45 days inventory/365 days]
Holding cost = 15.41 USD (annual rate ad-valorem = 25%)

Inventory definitions and valuations, as well as obsolescence adjustment rules, are specified in Chapter 3.1.1.6 of the LHARP Manual release 16.2.

8.3 Cost Impact of Inbound Logistics on Inventory Management

The value of an inventory is not only defined by the amount paid for the goods, but also by the additional cost of acquiring the goods. Analysis has shown that, depending on the product, these costs can add as much as 25% of the original product price. This applies especially to products produced in one geographical region but used in another.

According to LHARP, all additional costs incurred in the purchase must be added to the value of the item itself. Therefore these additional costs have an impact on:

- Valuation and depreciation of capitalized equipment; and
- Total landed cost of goods including stock keeping.

Analysis has also shown that freight costs account for a significant portion of these additional costs.

Freight costs can be split into mode of transportation (truck, vessel, rail, plane, etc.) or type of packaging (bulk, containerized). Due to the macroeconomic environment, freight rates are volatile.

Any improvement in inventory management should consider these cost elements and calculate the various options. There might be potential to lower the average inventory by increasing the number of shipments (frequency) if the freight cost allows this. Supplier management is crucial to aligning production lot sizes with transportation capacity, availability and storage capacity. The Wilson Model can be used to calculate the impact of higher or lower freight costs on the total landed cost.

Framework agreements with defined freight forwarders can increase service levels at optimized cost.

Key points:
- Rolling forecasting is crucial;
- Freight costs play a role in defining the optimal balance between production lot size and delivery lot size;
- Freight markets are volatile: any strategy should consider spot-market procurement versus long-term agreements with appropriate freight forwarders; and
- Partnering can increase service levels.

8.4 Examples of Inventory Management scorecards

The purpose of worldwide reporting and controlling of inventory activities is to provide transparent facts and figures on the comparable performance of Countries and of the entire LafargeHolcim Group. This is done by:
- Drawing a clear picture of inventory management performance; and
- Building a knowledge base for benchmarking in order to leverage best practices and capitalize on learning.

The below examples of inventory management scorecards could be used as a reporting tool for presenting the results of a Country’s inventory management.

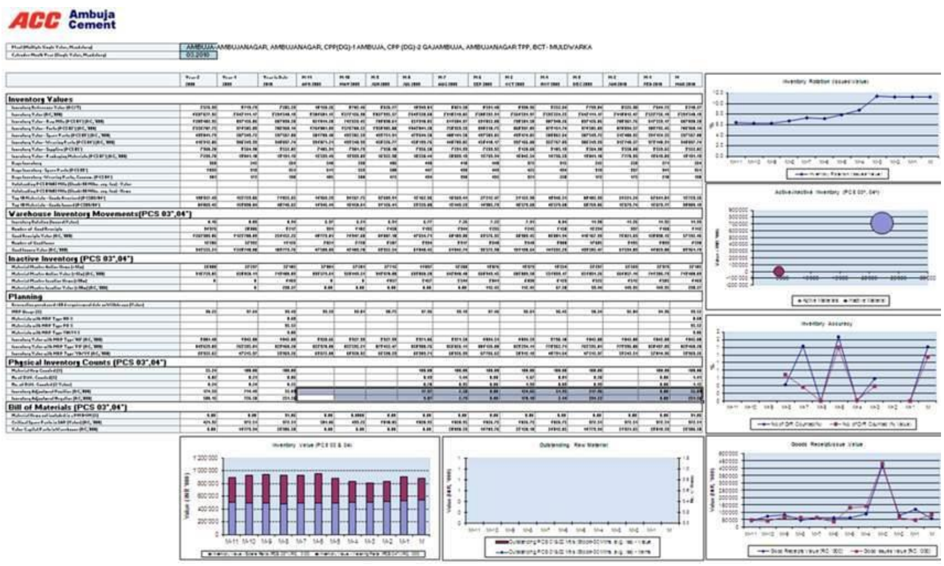


Figure 8.1 Example of an Inventory Management Dashboard in India

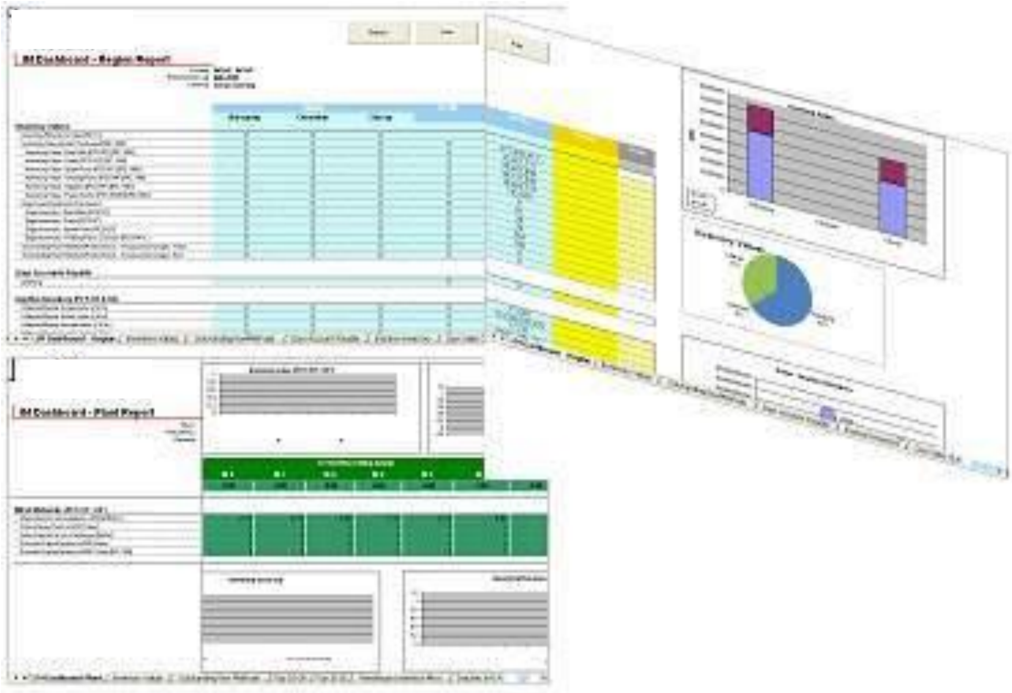


Figure 8.2 Example of an Inventory Management Dashboard in APAC

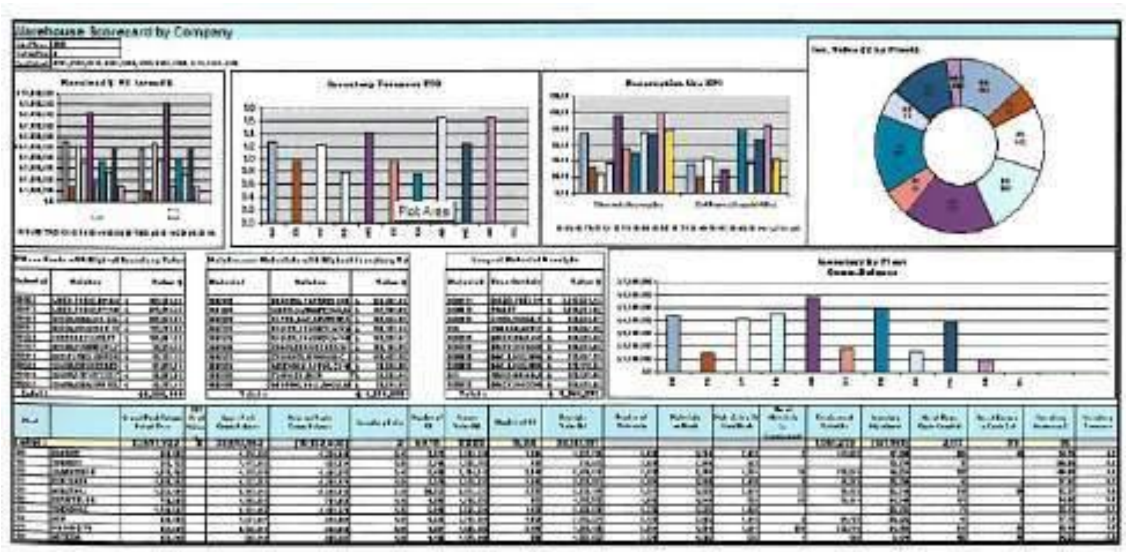
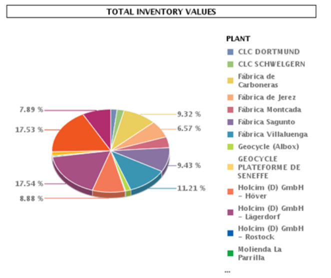


Figure 8.3 Example of a monthly report in US, run at plant level and country regional level

	[Units]	GEOCYCLE PLATEFORME DE SENEFFE	Holcim (D) GmbH – Höver	Holcim (D) GmbH – Lägerdorf	Holcim (D) GmbH – Rostock	Molienda La Parrilla	Molienda Tarragona	Usine d'Obourg	WERK KOLLENBACH
INVENTORY VALUE									
Inventory Value ['000]	[RC]	62.89394	2637.6416	5208.3003	11.89563	131.78952	451.89198	5205.903	2344.12144
Inventory Value – Spare Parts (PCS 03*) ['000]	[RC]	48.01865	1502.46094	3798.01953	11.66258	93.56818	253.95037	3544.94926	1047.64869
Inventory Value – Consumible (PCS 03*) ['000]	[RC]	2.37168	15.0527	141.22582	0.10277	2.45059	13.90069	150.14493	44.25533
Inventory Value – Wearing Parts (PCS 04*) ['000]	[RC]		788.57605	712.56101		0.84622	42.43058	1153.53082	958.20658
Inventory Value – Consumables. (PCS 04*) ['000]	[RC]	12.50361	331.55191	556.49394	0.13028	34.92453	141.61034	357.27799	294.01084
Inventory Value – Virtual Warehouse ['000]	[RC]		545.77709	151.37748				344.00412	335.327
Inventory Value – Consignment Stock ['000]	[RC]								
Inventory Value – Capitalized Spare Parts ['000]	[RC]								
WAREHOUSE INVENTORY MOVMENTS									
Number of Good Receipts	[#]	3	248	320				257	135
Number of Good Receipts by Bar Coding	[#]								
Number of Good Receipts by virtual Warehouse	[#]		33	2				9	14
Good Receipts Value ['000]	[RC]	8.29018	237.00699	320.99285				575.10468	416.48821
Number of Good Issues	[#]	4	415	1441		7		377	225
Number of Goods Issues by Bar Coding	[#]		370	1329					2
Number of Goods Issues by virtual Warehouse	[#]		3	4				3	
Good Issues Value ['000]	[RC]	5.39744	88.3859	204.06328		0.20107		168.57328	59.33878
INACTIVE INVENTORY									
Inactive Parts Inventory Ratio	[%]	89.53	55.76	68.74	98.00	83.57	97.81	57.60	41.05
Inactive Parts Inventory Value ['000]	[RC]	56.31006	1271.15218	3549.27875	11.65744	110.14241	442.00653	3089.10713	962.34605
Parts Inventory Value ['000]	[RC]	62.89394	2279.71179	5163.51836	11.89563	131.78952	451.89198	5362.96698	2344.12144
Material Master Inactive Items (12 m)	[#]	212	1602	5049	52	388	833	3892	2593
Mat. Master Inactive Items – with Stock (12 m)	[#]	212	1595	5049	52	388	833	3892	2592
Strategical	[#]		39					76	
Mat. Master Inactive Items – without Stock (12 m)	[#]		7						1
PLANNING PROCESS									
MRP Usage	[%]	100.00	62.24	93.06				60.27	58.21
PR Created using MRP	[#]	4	178	322				132	78
Total PR Created	[#]	4	286	346		2		219	134
Planning Accuracy	[%]		1.00	0.99		1.00		0.99	1.00
Materials with MRP Type 'ND'	[%]	21.13	41.08	56.85		99.83	21.67	11.58	48.95
Materials with MRP Type 'PD'	[%]	2.38	18.89	16.24	97.83			2.47	50.33
Materials with MRP Type 'V1'	[%]		23.98	13.15				53.74	0.67
Materials with MRP Type 'VB'	[%]	74.10714286	16.02019738	13.7244984	2.173913043	0.165016502	78.33418498	31.80929463	0.051378661
Inventory value with MRP Type 'ND'	[%]	1.40	36.54	46.63		100.94	16.82	11.48	21.30
Inventory value with MRP Type 'PD'	[%]	0.31	38.41	31.22	97.46			8.97	79.50
Inventory value with MRP Type 'V1'	[%]		19.83	19.95				70.05	1.06
Inventory value with MRP Type 'VB'	[%]	102.0291377	5.796060145	4.980708316	3.408842299	0.957113222	86.35060985	12.46809403	0.050025086
PHYSICAL INVENTORY COUNT									
Material items counted	[%]			100.00					100.00
Number of differences counted	[%]			100.00					
Inventory Adjustements ['000]	[RC]			1.9035					
BILL OF MATERIALS									
Material items included in a PM BOM [%]	[%]		69.07	79.45				74.00	5.44



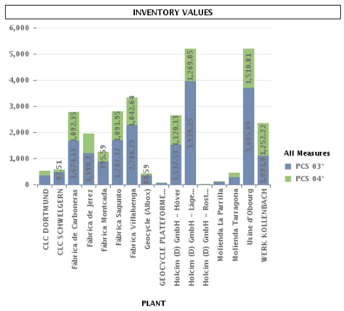


Figure 8.4 Example of an Inventory Management Dashboard in EMEA

9 Warehouse

9.1 Warehouse layout

The main objectives of a storage system are:
- To ensure adequate physical conditions for stored items;
- To minimize issue time;
- To increase reliability: data consistency (system vs. actual stocks);
- To minimize storage costs;
- To optimize space; and
- To optimize goods handling (goods flow minimum time and maximum safety conditions).

The following systems have to be considered when designing the Warehouse Layout:
- ISO 9000 (Quality System);
- ISO 14000 (Environmental System); and
- HSMS (LH Health and Safety Management System).

The storage location has to be clean and free of dust and other contaminants. The floor has to be clean. Equipment must be stored in a dry location. Extreme heat or cold has to be avoided. Storage temperatures must range between 10°C and 38°C.

If equipment is stored in shipping containers, “moisture absorbent” material should be placed in the container prior to storage. For warehouse storage the part has to be covered and well ventilated.

The part has to be stored out of direct sunlight.

In order to move and load the part safely, overhead cranes or portable cranes of adequate capacity must be available.

Shelves have to be easily accessible from platforms. Aisles must be clearly marked and free of obstacles.

Refurbished and critical parts have to be marked with a tag so they are clearly distinguishable from new ones.

Scrap must be kept in a separate area. This area is only for temporary storage and scrap material has to be removed on a regular basis. Hazardous goods (e.g. batteries or solvents) must be kept in a special area which is emptied on a regular base.

Access to the warehouse must be properly restricted to defined responsible people. Key business partners/users must be provided with a security and access control system (e.g. swipe card system or magnetic remote control) that monitors access outside regular working hours. Entry points which are used as emergency exits as well as the emergency pathways should be free of all obstacles at all times.

The areas to be considered in a warehouse layout are shown in the diagram below:

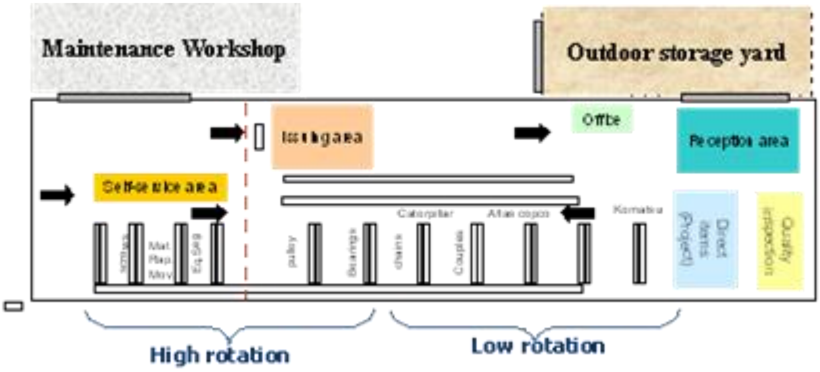


Figure 9.1: Warehouse layout – areas to be considered

Figure 9.2: Warehouse layout can be placed at the main entrance

9.1.1 Reception area

The reception area should have easy access for unloading goods from trucks. The area can be organized by weekdays to allow quick visual control of the goods received each day. A simple and efficient system can be used to minimize storage time. Items placed on the floor or the shelves are waiting to be stored in their proper storage locations.
The floor is used for medium-sized items and the shelves are used for small items. Floor and shelves are divided into the reception days.

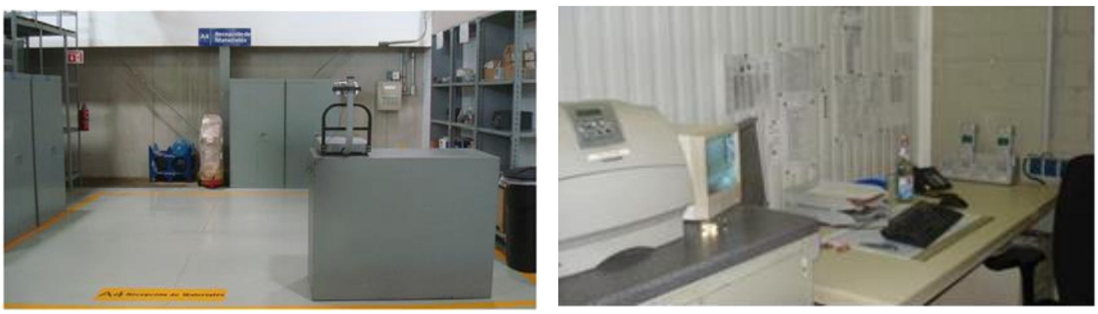


Figure 9.3: Examples of a reception area

At the reception area, a quality inspection counter has to be available for holding goods pending quality control by technical personnel. Inspection tools have to be available in this area.
Another special area required in the reception area is one for non-stock items that have been received at the warehouse premises (e.g. project items, direct purchases) and are waiting for collection by the responsible personnel.

Storage area

General ways of optimizing the lay-out of the storage area and, therefore, the operation of the warehouse:

- Parts with high rotation should be kept next to the issuing counter

Figure 9.4: Issuing counter

- Heavy parts should be stored close to the ground

Figure 9.5: Ground storage

- The warehouse should be kept clean at all times in order to guarantee optimal storage conditions.

Figure 9.6 Examples of warehouse perfectly clean

- An identification system to easily locate the stored goods should be implemented and updated in the system (SAP). A labeling system differentiating critical items, dangerous items and refurbished items should be implemented and updated in the system (SAP)

Figure 9.6 Example of an identification system

- Security, control and monitoring equipment should be installed in the "self-service" areas

Figure 9.7 Surveillance in the warehouse

- Special building arrangements to guarantee the good condition of the stored items should be installed (e.g. heating systems for electrodes in humid countries; air conditioners for electronic components, anti-humidity equipment, active ventilation for flammable solvents, etc).

Figure 9.8 Special are in the warehouse

9.1.2 Issuing area

The issuing area must have easy access from the maintenance workshop.

- It must allow visual control from the clerk’s desk;
- A clear issuing procedure must be implemented and communicated;
- During working time, goods must be issued by the warehouse staff and posted in the system;
- During the night or weekend, goods are issued by selected responsible personnel and registered in a special book to allow control and entry into the system on the next working day;
- An access policy has to be implemented using controls defined by local internal auditors;
- Clerk’s desk must have a computer for storage location searches in order to accelerate the issuing process;
- Requester must bring the required information in order to process the goods issue (work order number, reservation number, cost center number, project number;
- A warehouse layout plan has to be posted in order to facilitate efficient location of goods (especially in “self-service” areas); and
- Goods related to direct purchases (charged to work orders/projects) have to be stored in a separate area, under warehouse custody, so they can be easily picked up by the owners.

Figure 9.9: Example of an issuing area

9.1.3 Outdoor Storage Yard

The outdoor storage yard should be as small as possible but as big as necessary. Since the material which is kept there is exposed to the weather, only heavy-duty material should be stored there.

Although material is kept outside, it is still necessary to ensure that it can be easily located. Material should never be placed directly on the ground but on supports such as pallets to allow water to drain away.

- It should allow the circulation and operation of forklifts;
- It should allow the circulation of supplier trucks for deliveries;
- It should separate vehicle from pedestrian traffic;
- It should have a concrete floor and a metal roof over specific areas;
- Access should be restricted by a fence; and
- Order and cleanliness should be observed at all times.

Figure 9.10: Examples of outdoor storage yards

9.1.4 Self Service Area

A self service area, combined with a simple replenishment method (e.g. two-bin system), serves to distribute high-rotation, low-cost items, thus simplifying the workload and allowing resources to be redirected to control and maintenance of more expensive parts.

The replenishment method has to be supported by contracts with a minimal number of suppliers to cover the range of items stored in this area. In this way, it is possible to implement “Vendor Managed Inventory” (periodic visits to review inventory levels and to replenish to established maximum levels).

A contract that simplifies the administrative workload and ensures the minimum controls should be posted in SAP (e.g. contract by material group with a limited value based on budget).

The shelves have to be labeled to indicate minimum and maximum levels required for each item (based on consumption analysis).

The area must allow free and easy access from the maintenance workshop, with controls such as:

- Visual control from the issuing counter;
- Doorbell;
- Access via electronic cards; or
- Video security system.

Figure 9.11: Example of self-service area

Figure 9.12: Self-service area with access controlled via electronic system

Figure 9.13: Self-service area with replenishment system using issuing counter

Figure 9.14: Self-service area with visual control using “cards”

Figure 9.15: Self-service area with vending machine.

9.1.5 Systematic layout planning

A systematic layout planning (SLP) can be implemented. This approach considers a Pareto approach to prioritize items and develop an activity relationship chart to determine optimal storage locations.

9.2 Stock management best practice: barcode and radio frequency

Barcodes are a fast, easy, and accurate data entry method.

They are used to automate the operational workload in the warehouse, particularly for goods issuing and inventory counting.

Barcodes typically contain only ID data, which is used by a computer system to identify all pertinent data associated with the material.

A barcode is a series of varying width vertical lines (called bars) and spaces. Bars and spaces together are named “elements”. Different combinations of bars and spaces represent different characters.

When a barcode scanner is passed over the barcode, the light source from the scanner is absorbed by the dark bars and reflected by the light spaces. A photocell detector in the scanner receives the reflected light and converts the light into an electrical signal.

This signal can be “decoded” by the barcode reader’s decoder into the characters that the barcode represents. The decoded data is then passed to the computer system in a traditional data format.

Some Countries include in their bar code labels not only material code, description and storage location but whether or not the material is critical and their functional location.

Figure 9.16: Example of a bar code label

Barcode Readers

There are three basic types of barcode reader: fixed, portable batch, and portable Radio Frequency (RF).

- Fixed readers remain attached to their host computer and terminal and transmit one data item at a time as the data is scanned.
- Portable batch readers are battery operated and store data into memory for later batch transfer to a host computer. Some advanced portable readers can operate in non-portable mode too, often eliminating the need for a separate fixed reader and
- Portable RF readers are battery operated and transmit data real-time and on-line which allows the host to instruct the operator immediately.

RF Readers are like on-line terminals, but wireless. The user can roam around his local facility scanning and keying data and getting a response from the computer with each entry.

The introduction of barcodes requires a small investment in hardware and software but, since the introduction of “RFID” technology (Radio Frequency Identification via smart tags that store information), the cost of bar-coding and radio frequency has decreased drastically.

The initial effort of labeling the warehouse with barcodes can be combined with an inventory counting process.

Proper implementation of bar-coding minimizes the workload related to handling materials and increases the accuracy of the data in the system.

9.3 Spare parts storage recommendations

In order to guarantee optimal storage conditions, maintenance of spare parts held in the warehouse must be done on a regular basis to suit the individual part/equipment. A work order in SAP can be created so maintenance is planned ahead.

When a new part is delivered to the warehouse, the maintenance team should be invited to advise on how it should be stored and how often maintenance should be done on it.

9.3.1 Lubricants

Lubricants are toxic substances that have to be handled with care in order to prevent any damage to health or the environment.

Lubricants have to be kept in a well-illuminated, separate room with proper ventilation in order to minimize the effect of temperature fluctuations. The room air volume has to be renewed 20 times per hour.

Suitable fire extinguishers have to be available and emergency exits have to be marked. Warning signals are needed to communicate dangers. Smoking and eating are prohibited in the area. The material safety data sheet (MSDS) for each lubricant must be available in the storeroom for quick reference. MSDS sheets should be located in a safe area. These could also be available via internet where feasible. It is a good practice to indicate the major hazards at the entrance of the storage room for use in case of an accident. Any country-specific regulations for the storage of lubricants have to be respected under all circumstances.

Main considerations:
- The area must remain perfectly illuminated;
- Fire retardant lamps should be installed;
- The floor should be uniformly painted with a light colored epoxy coating;
- Storage area must have “spill-clean-up” kit;
- Installation of adequate visual aids with the corresponding color code should be confirmed;
- Personal protective equipment kit should be available too.

The following table shows some suggested storage times for different lubricants. Note that a 10°C increase in storage temperature doubles the oxidation rate of the lubricant.

Table 1: Recommended maximum storage times for different lubricants

Product	Max. Recommended Storage Time
Lithium Greases	12 months
Calcium Complex Greases	6 months
Lubricating Oils	12 months
Emulsion Type Fire-resistant Fluids	6 months
Soluble Oils	6 months
Custom Blended Soluble Oils	3 months
Wax Emulsions	6 months

Each lubricant must have its own area and be correctly identified. Within the areas where the lubricant is used it should also have small containers under the valves to catch all drippings. The water draining system of the storage room must be equipped with an oil recovery system in order to avoid polluting the environment. Drums must be kept horizontal and must be properly marked to prevent mixing up lubricants. One of the best practices is to have retention ponds to store the primary containers. If this is not possible, the whole storage room should be designed as retention pond, i.e. sealed concrete floors and a step at the entrance.

Figure 9.27 Storage shelf for lubricants

Figure 9.28: Lubricant drum with breather

Figure 9.29: Examples of retention ponds for environmentally hazardous liquids

For each type of oil, different containers with hermetic covers should be used. These must be properly labeled. Each bin should only be used for one type of lubricant in order to avoid contamination.

Figure 9.30: Oil storage with filling station

Since drums are heavy, proper handling equipment has to be available on bins for small amounts.

Figure 9.31: Handling a drum with a small crane

Figure 9.32: Drum carrier

9.3.2 Bearings

Bearings need to be protected against dust, dirt, humidity and vibration so should be kept in their original packaging (which will include technical references) and stored horizontally. If the original package is not available, roll the bearing in some greased paper and store it in a closed, dust-free box.

It is good practice to keep all bearings on a common shelf or even in special drawers.

Figure 9.33: Bearing storage on shelves

New bearings may be coated in a rust preventative/preservative solution in order to protect them during shipment and storage. This coating must be removed from the bearing before mounting. An all-purpose industrial strength cleaner can be used for this purpose.

Bearings should not be kept in stock for more than five years.

9.3.3 Electrical Motors

Motors shall be stored in their original crates. The storage area has to be free from any vibration. The recommended storage temperature is 5 to 35°C and humidity should be non-condensing.
All external parts and motors subject to corrosion have to be protected by a corrosive-resistant coating. This specially applies to the shaft, where it has proven to be a good practice to use a protection cap (see below picture).

The following points about bearings must be taken into consideration:

- Ball and roller bearings (anti-friction re-greasable type): The bearings are to be fully greased before they are put into extended storage. Motor shafts are to be rotated manually every 6 months and additional grease is to be added in the bearings cavities (in some places this happens even every 3 months). Rotate shaft by hand before putting into service. In order to monitor the shaft rotation it is a good practice to apply a color code on the shafts as shown in the picture below
- Ball (anti-friction non-greasable): No additional precautions are necessary.

Figure 9.34: Electrical motor with protection cap on shaft and color code to monitor rotation of shaft during storage

All drains have to be fully operable while in storage, and/or drain plugs must be removed. The motors have to be stored so that the drain is at the lowest point. All breathers and automatic "T" drains must be operable to allow breathing at points other than through the bearing fits.

Where a large quantity of motors is stored, inspection or sampling should be carried out by removing the end brackets and visually inspecting for the presence of water in the grease, or rust on the bearing. If present, replace the bearing and re-lubricate.

All motors with a power greater than 500 kW have to be permanently equipped with a heater, which has to be switched on during the storage period. In order to monitor the condition of the insulation during storage it is recommended that the following procedure is followed:

- Before storing a motor, measure the insulation resistance (phase to ground) using a suitable insulation tester such as a megohmmeter. The winding or copper resistance should also be measured using a low-resistance ohmmeter. Measure the ambient temperature and humidity at the same time. These measurements will serve as a reference for later checks. In order to ensure that the readings are not misplaced, they should be recorded on a tag, which is physically attached to the motor; and
- Repeat these measurements on a yearly basis and before using the motor.

The resistance measurement should not change over time (remember that measurements have to be adjusted if temperature or humidity varies). However, if there is a change in the measurements the motor probably needs electrical or mechanical drying.

Instead of carrying out the measurement described above, it is also possible to do a PI (Polarization Index) measurement. However, the application of a Hi-Pot or surge test is not recommended.

When handling a motor larger than 250 kW, ensure that the motor safety belts are properly tightened before moving.

The pictures below show how electrical motors can be stored on a shelf. Each motor is kept on a wooden pallet, which facilitates handling by forklift. Shafts are facing the front part of the shelve so these can be rotated accordingly. The bigger a motor is, the closer it should be kept to the floor.

Figure 9.35: Electrical motors on shelf

9.3.4 Electronic Parts

Electronic parts (e.g. cards) should be kept in a separate room, which is either pressurized or air-conditioned. The temperature range should be between 5 and 35°C, and humidity should be non-condensing.

During storage, the cards should always be kept in their antistatic bags (see pictures below), which should be properly labeled. Only remove electronic equipment from the bag when it is about to be installed.

Figures 9.36: Electronic cards in antistatic bags

Grounding straps, as provided by PLC suppliers, must be used. If there are no straps installed, the body should be discharged by touching grounded metal. Some technical experts suggest to have these items stored within a Faraday cage.

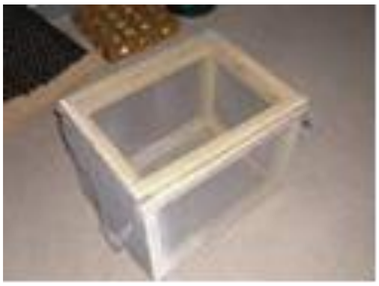


Figure 9.37: Faraday cage

Additionally it is vital that the cards kept in stock are of the latest version actually used.

Capacitors in specific equipment such as VFD (variable frequency drives) and UPS (uninterruptible power supplies) have to be “formed” or rejuvenated at least every two years. This should be done as described in the supplier manual.

Any electronic equipment kept in stock that contains chemically active parts (e.g. batteries) has to be checked on a yearly basis. Acid leaks can ruin the entire unit, so it is recommended that batteries are isolated by sealing them in a separate bag.

9.3.5 Belts of Conveyors

Belts should be protected against contamination, moisture, chemicals, extreme temperatures and UV light. The ideal storage temperature is between 10 and 20°C. Long exposure at temperatures even slightly below 4°C can harden or stiffen the compounds, and extreme temperature variations can have a negative effect on belts.

Sunlight and ozone deteriorate any exposed rubber over time. So belts should be stored out of direct sunlight. Electrical generators or arc welders can sometimes generate ozone. So belts should be stored some distance away from this type of equipment. It is wise to keep any unused belt stored in its protective factory packing until it is ready for installation.

Belts should be stored on a pallet or a cradle, not on the floor.

Before storing used belts, thoroughly clean and dry them, then dust them with tire talc or insert kraft paper between the layers.

Conveyor belts deteriorate over time, so stock quantities should be kept at the appropriate level to avoid long-term storage.

Figure 9.38: Storage of large and heavy belts

Heavy rolls should be suspended with the aid of a steel bar or laid on a thick, soft rubber foam bedding. Rolls should not be stood on end or leaned against a wall. Ideally heavy rolls should be rotated 90° minimum once per year.
They should be contained so they cannot accidentally roll and become a safety hazard.

Figure 9.39: Storage of joined belt

Figure 9.40: Vertical storage of narrow belts

Joined belts should be rolled on a hard tube (no smaller than the recommended minimum pulley diameter for the belt) to prevent them from crimping.

Rolls of narrow belts can be stored horizontally on boards or pallets. Several rolls of such products can be stacked as long as the resulting weight does not crush or deform the belts. Note that this only applies to narrow belts.

Figure 9.41: Belt handling

To lift a large roll of belts, insert a steel bar through the hole at the core of the role and attach it to a hoist with two rope slings or chains attached to a crossbeam. To prevent damage to the belt edges by the ropes or chains the cross beam must be longer than the width of the roll.

Belt rolls can also be transported using forklift trucks. If this is done ensure that the outer belt layers are not damaged by the fork edges. It is not safe practice to apply a sling around the circumference of a roll of belting.

9.3.6 V-belts

V-belts can be stored on a wall as shown below in the pictures below. In order maximize space and sort by size. This principle is mainly applicable to smaller size v-belts. Storage protection against UV rays should be secured.
Note that the area of support should at least be 10 times the v-belt height. This way you can avoid the v-belt becoming damaged on a narrow support due to its own weight.

Figures 9.42: Storage of V-belts

9.3.7 Chemicals

Chemicals must be kept in a separate ventilated room. Fire extinguishers must be available and emergency exits marked.

The chemicals must be segregated into hazardous classes first (starting with physical state) and then sorted alphabetically.

Figure 9.43: Paint and aerosols shelving

Incompatible chemicals in the same class that must be stored in close proximity to one another should be placed in trays (or other containment devices) to keep them segregated.

9.3.8 Gearboxes

Gearboxes should be filled with the lubricant as recommended by the supplier and periodically checked for leaks.

In order to prevent corrosion, all surfaces need to be covered with an anticorrosive layer.

Shafts have to be turned from two to four times a year. Rotation should be for 360° to secure all teeth are fully covered in grease followed by a quality inspection.

Gearboxes should be stored on wooden pallets or supports. This will prevent humidity from accumulating underneath the gearbox (corrosion) and facilitate handling with a forklift. Avoidance of storage within vibrating environment is a major plus.

The heavier a gearbox is, the closer to the floor it should be kept.

Figure 9.44: Storage of gear boxes

9.3.9 Impellers

When storing impellers that are still mounted on the shaft, the shaft should be supported as close as possible to the impeller in order to prevent the shaft from bending. Body and shaft should be properly covered against corrosion.

Figure 9.45: Impeller

9.3.10 Tools

When storing tools, ensure that fast and easy access is possible. It is good practice to store them on “tool-boards” to enable easy viewing of available equipment, quick identification of damaged equipment, and to maximize space. All tools should be tested and inspected periodically.

Figure 9.46: Tool boards

9.3.11 Special Tools

“Special tools” refers to tools that are used for special jobs (e.g. hydraulic keys or cylinders).

These tools should be checked and maintained on a regular basis. Since proper operation in many cases can only be verified when using the tools in the field, feedback should be invited from users when they return them to the warehouse.

9.3.12 Consumables

Consumables such as screws, nuts or bolts should be easily accessible. A good practice is to keep consumables in small boxes as shown in the pictures below. If they are kept this way, the boxes should be properly labeled.

Consumables may be handed out over the main counter or issued through a self-service arrangement, depending on the individual plant situation.

Figure 9.47: Consumables cabinet

Figure 9.48: Consumables in vending machine

9.3.13 Welding Material

Welding materials (e.g. welding rods) need to be kept in a dry and warm place to prevent absorption of humidity. The material should be kept in its original boxes. It is good practice to use infrared light for heat, or keep the rods in an approved rod oven in order to maintain the necessary temperatures.

In places with higher levels of humidity it is recommended to keep the welding materials 10° Celsius above average temperature. This temperature will ensure evaporation and better storage conditions.

Figure 9.49: Welding rods oven

9.3.14 Kiln Rollers

In order to prevent surface corrosion, kiln rollers should be stored indoors. If this is not possible, they should be kept in a waterproof box. In this case it is important to ensure that there is no humidity in the box.
Even when kept indoors, surfaces should be protected with an anticorrosive agent and periodically checked.

Figure 9.50: Storage of kiln roller

9.3.15 Girth Gear

The girth gear has to be leveled to ensure that it is stored perfectly horizontally, thus preventing any deformation under its own weight. It should not be laid directly on the ground but on wooden supports. Check the levelling once a year, since the wooden support may warp over time.

In order to prevent corrosion, it is advisable to store the girth gear indoors and to protect it with an anticorrosive agent.

Figure 9.52: Storage of girth gear

9.3.16 Kiln Shell

If space permits, kiln shell pieces may be stored next to the kiln. This will facilitate handling and avoid complicated and time-consuming transport. If storage next to the kiln is not possible, the pieces can be stored in the outdoor storage yard.

Figure 9.53: Kiln shell

They should be stored horizontally in order to prevent any deformation under their own weight.

Additionally it is important that crossbars are mounted, so the shell is kept in shape. If long-term storage is foreseen, it is vital to protect the shell with an anticorrosive layer/paint or a solid plastic cover.
If the kiln shell is stored some distance from the kiln and therefore needs to be transported by truck, it is good practice to store the shell on poles so it is at the same height as the truck.

9.3.17 Rubber Hoses

Rubber hoses can be divided into the following two groups:
- Pneumatic and hydraulic pressure hoses and
- All other hoses such as hydraulic return line and instrument hoses

Hoses made of polytetrafluoroethylene (PTFE) material do not normally have a specified storage life but the storage life of rubber or synthetic rubber hoses is limited to 5 years (provided they are stored under standard conditions). The storage life of hose supplied in bulk is calculated from the cure date. The storage life of hose assemblies is calculated from the date of manufacture or assembly. Both ends of the hoses ideally are covered and protected, especially with relation to hydraulic equipment related hoses.

During storage, periodic visual inspections should be carried out once a year for signs of deterioration, weather cracks, corrosion of end fittings, etc..
Before installation, pressure tests should be carried out at 1.5 times the maximum working pressure.

9.3.18 Refractories

Magnesia products, refractory lightweight bricks and all unburnt chemically-bonded grades of bricks should be stored in dry and well ventilated spaces.

Basic bricks deteriorate with hydration (contact with water). The original packaging provides optimum protection against any damage during transport and damage caused by splashing water. Despite this, hydration is sometimes unavoidable in extremely warm and humid weather conditions. Such conditions may lead to hydration after half a year. In tropical/subtropical climates the (local) supplier should be asked for advice on the maximum storage life of refractory bricks in the local conditions. In any case, a “first in – first out” management of stock items is advisable. Hydrated bricks are characterized by cracks extending from the brick centre (like a web) over the surface. These cannot be used but should be disposed of according to local regulations. Bricks that have become wet but do not show any cracks should be stored – in small stacks with 20 to 50 mm space between the bricks – in an enclosed space, where they should be allowed to dry at room temperature in an adequate air current. After having thoroughly dried out, the bricks can be used. However, it is important to ensure that they are free from any cracks before installing them.

Burnt high alumina, alumina and fireclay bricks that have become wet can likewise be used after thorough drying. Unburnt chemically-bonded brick grades may absorb moisture from the air even when being properly stored. As a result, the bricks may appear somewhat moist on the surface, and they give off a dull sound when struck with a hammer. However, their serviceability is in no way impaired. The bricks do not need to be dried before use. In doubtful cases, bricks that have become wet and been dried out can be sent to the supplier, who will test whether they are still suitable for use.

Mortars and monolithic refractories should be stored in dry, well-ventilated spaces. Such materials are rendered unfit for use if they get wet or are stored for too long (i.e. more than one year). For additional information please refer to the instructions for using monolithic refractories.

Bricks and other products supplied as palletized unit loads should not be stacked too high (accident hazard). More particularly, the following heights for stacking the loaded pallets should not be exceeded:

Refractory products	Maximum Stacking height
Basic bricks such as PERILEX', ALMAG', MAGPURE', MAGNUM'	2 to 5 pallets
High alumina and fireclay bricks such as KRONEX'. REFRALUSIT'	2 to 5 pallets
Lightweight bricks/insulating bricks such as REFRATHERM'150	2 pallets
Mortars, castables	2 pallets

The safe height of the stack will also depend on the bearing capacity of the surface on which it rests. On ground which is not surfaced or paved, the lowest of the above stacking heights should be used. In order to avoid any excessive edge pressure on the bricks, pallets stacked on top of one another should always bear over their entire area.

Figures 9.54: Refractory storage

9.3.19 Steel Plates and Profiles, Pipes

These types of materials are used for several different purposes. Since they tend to be large and heavy, handling is not easy. Therefore a forklift and special machines for cutting should be available in close proximity. Depending on the climatic conditions these materials may be stored in the outdoor storage yard. However, in countries with heavy and frequent rainfall or high humidity it is advisable to store these materials indoors.

Figure 9.55: Outdoor storage of various pipes

Figure 9.56: Outdoor storage of steel plates

In the case of pipes, it is necessary to ensure that no water builds up on the inside of the pipes since this would facilitate corrosion.

9.3.20 Cables, Chains and Hooks

Cables, chains and hooks that are being used for supporting and lifting heavy materials (e.g. on cranes) have to be kept in a dry place to prevent corrosion.

In order to guarantee maximum safety and optimal working conditions they have to be checked by an independent and qualified party minimum once per year.

The maximum load that these items can support needs to be clearly stated on the specific equipment.

Figure 9.57: Hooks

Figure 9.58: Various short lifting cables

Figure 9.59: Chain blocks

Figure 9.60: Cable reel as used for long cables

9.3.21 Gas Cylinders

Gas cylinders should not be stored for excessive periods of time. Only purchase sufficient quantities of gas to cover short-term needs. Stocks of gas cylinders should be rotated to ensure first in is first used.

Store gas cylinders in a dry place on a flat surface in the open air. If this is not possible, store in an adequately ventilated building or part of a building specifically reserved for this purpose. Gas cylinders containing flammable gas should not be stored in a building used for other purposes. Keep gas cylinders in a place that can be locked so access can be controlled. Store cylinders where they are not vulnerable to hazards caused by impact (e.g. from vehicles such as forklift trucks). Keep incompatible classes of gas separately. Keep flammables separated by at least 7 m from non-flammables.

Protect gas cylinders from external heat sources that may adversely affect their mechanical integrity, and store them away from sources of ignition and other flammable materials. When transporting cylinders of compressed gases, the cylinders should always be strapped to a cylinder cart and the valves protected with a cover cap. Cylinders should be kept in vertical position.

The cylinders must be clearly marked to show what they contain and to indicate the hazards associated with their contents.

Full and empty cylinders must be kept separately. A “full/empty” tag on each cylinder is recommended. The storage place has to be clearly marked – including appropriate warning signs (e.g. “no smoking”) and fire extinguishers have to be available. The valves of empty cylinders must be closed in order to prevent contamination.

Figure 9.61: Storage cages for gas cylinders. Full and empty cylinders are separated, and warning signs are in place

9.3.22 Filters and Bag Filters

Filters should be stored in a very clean place and in their original packaging.
If the original packaging is not available, they should be stored in a closed box. Humidity avoidance, proper building insulation and free of dust environment are strong considerations for proper storage.

Any contamination of the filters by dust or other contaminants must be strictly avoided since this will not only affect the filter performance and lifetime, but also the performance of the system where the filter will be used.

Cages for bag filters must be stored vertically and protected against crushing hazards.

Figure 9.63: Cages for bag filters

Figure 9.62: Bag filters stored in original package.

The warehouse is not just an area to store items. It also has to guarantee that items are stored in proper conditions to support plant reliability. This is done through proper warehouse layout, proper operational processes and proper maintenance of spare parts held.

9.4 Warehouse Routines

In order to guarantee the sustainability of optimal storage and safety conditions, warehouse housekeeping on a regular basis and Preventive Maintenance Routines (PMR) of spare parts held in the warehouse should be done as well (see table 2).

The table below shows the recommended the minimum warehouse routines that should be conducted by the Inventory Officers in collaboration with Maintenance, in order to ensure sustainability.

Table 2: Warehouse routines and Preventive Maintenance Routines (PMR)

#	Part Type	Task description	Visual Check	PMR	Frequ. [weeks]
1	General	Ensure proper housekeeping is in place	X		24
		Ensure driving ways are free of obstacles	X		24
2	Lubricants	Ensure lubricant drums are stored horizontally	X		24
		Ensure drip trays are available	X		24
		Ensure that tools are kept very clean	X		24
		Ensure proper housekeeping is in place and the storage location is free of dust	X		24
3	Bearings	Ensure bearings are kept in a very clean environment	X		24
		Ensure bearings are kept in a closed bag and stored horizontally	X		24
4	Electrical motors	Ensure shafts of electrical motors are turned on a regular base		X	24
		Ensure heating system for motors bigger than 500 kW is connected		X	24
5	Electronic cards	Ensure all cards are kept in anti-static bags	X		24
6	Belts of conveyors	Ensure big belts are kept suspended on a steel bar	X		24
7	Welding Material	Ensure welding rods are kept in a dry place	X		24
8	Kiln rollers	Ensure kiln rollers are kept under a roof	X		24
		Ensure surfaces are covered with an anti-corrosive layer	X		24
9	Girth gear	Ensure girth gear is kept under a roof	X		24
		Ensure girth gear is kept horizontally (levelled!)	X		24
		Ensure surfaces are protected with an anti-corrosive layer	X		24
10	Kiln shell	Ensure cross-bars to support kiln shell are in place	X		24
11	Steel plates, profiles and pipes	Ensure steel plates, profiles and pipes are stored under a roof	X		24
12	Cables, chains and hooks	Ensure cables, chains and hooks are regularly inspected (visually and NDT)		X	52
		Ensure cables, chains and hooks are protected against corrosion	X		24
13	Gas cylinders	Ensure full and empty cyliders are clearly separated	X		24
		Enure gas cylinders are properly labelled	X		24
14	Filters and bag filters	Ensure filters are kept in a closed box	X		24
		Ensure filters are kept in a dust free environment	X		24

10 Conclusion

The application of the concepts and methodologies explained in this document will help to optimize tactical and strategic activities related to inventory management at LafargeHolcim. Inventories account for a significant portion of the net working capital improvement program. Therefore, by improving the management of inventories we are contributing to the improvement of NWC at LafargeHolcim.

11 Glossary

BOM	Bill of Materials
CAPEX	Capital Expenditures
EDI	Electronic data interchange
EOQ	Economic Order Quantity
ERP	Enterprise Resource Planning
FMEA	Failure Mode Effect Analysis
GI	Goods Issuing
GR	Goods Receipt
IM	Inventory Management
IMSC	Inventory Management Scorecard
JIT	Just in Time
MPS	Material Planning Schedule
MRO	Maintenance, Repair and Operating Inventory
MRP	Material Requirement Planning
MTP	Mid-term Planning
NWC	Net Working Capital
H&S	Health & Safety
PCS	Product Classification System
PDP	Plant Development Plan
PMR	Preventive Maintenance Routine
PO	Purchase Order
PPE	Plant Property and Equipment
RF	Radio Frequency
SAP	System Application Program
SRM	Supplier Relationship Management
TCO	Total Cost of Ownership
VMI	Vendor Managed Inventory
WO	Work Orders

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