MAINTMASTER®

# Maintenance Manual

MAINTMASTER®

www.maintmaster.com

# Contents

# Maintenance according to European standards

Maintenance is often considered to be the same as repairing something that has broken, which is an old and outdated definition of maintenance work. The pyramid on the next page shows that corrective maintenance is only a small part of the tasks in a maintenance organisation. A large part of the work involves identifying future maintenance needs and planning and preparing for this to achieve the most cost-effective maintenance possible. The main objective of a maintenance organisation is always to maintain or increase operational reliability.

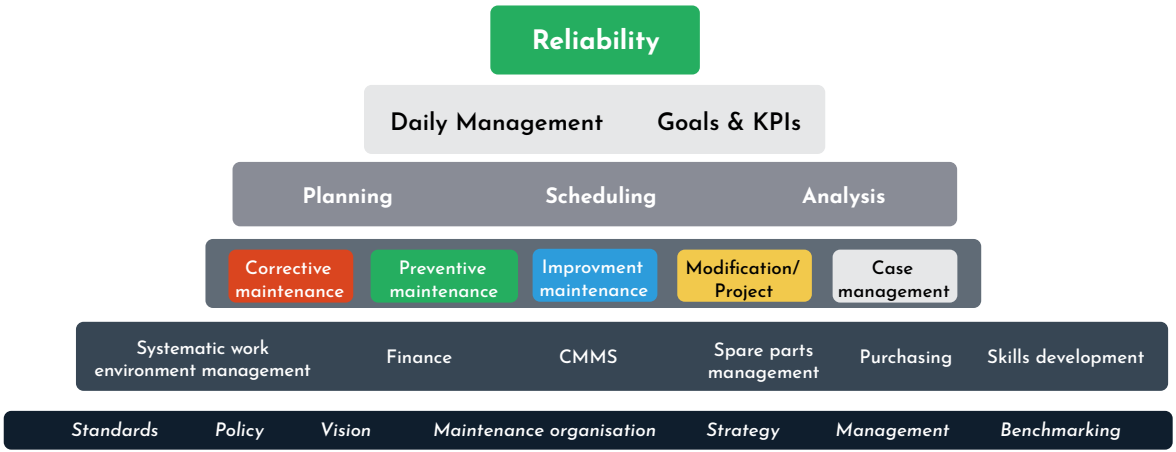
This means that machines and equipment work as expected during planned operation. To achieve this, the maintenance organisation needs a clear vision and strategy with established procedures and goals. An example of a maintenance strategy can be to achieve more efficient production through preventive and condition-based maintenance. It is also important in the daily work that you work long term. One example could be Root Cause Analyses in corrective maintenance in order to eventually increase the degree of planning and thereby create cost-effective maintenance.

This manual can be used as a practical guide and support in the daily maintenance work and as part of the introduction material for newly hired staff. Feel free to contact us if you want help to develop your own maintenance manual for your organisation. It is very important that all maintenance personnel understand the importance of well performed preventive maintenance, as well as the consequences of unplanned production stoppages. They should also be able to assess how improved maintenance, or developed preventive maintenance, can increase asset reliability. The manual has been updated from the first edition in 2016.

**Mikael Andersson**
MaintMaster Systems

# MaintMasters maintenance pyramid

The pyramid below describes some of the most important maintenance processes and functions that form the basis for achieving well-functioning maintenance. All processes must work in order to achieve cost-effective and well-functioning reliablity work.



# Vision, Strategy & Policy

# Maintenance vision, strategy and policy

These are documents forming the foundation for a systematic approach to reach high reliability, and works as a guide when making operational decisions. The vision is a long-term goal that the organisation should actively work towards. The strategy is a plan for how the organisation will achieve the vision,  where as the policy is a declaration of intent and a guideline to steer decisions and achieve the desired goals.

EXAMPLE OF **MAINTENANCE VISION**

- Proper maintenance provides reliability and good availability throughout the plant, and traceability through reporting in the maintenance system provides facts about weaknesses and deficiencies.
- Through all employees' insight into the importance of maintenance for operational reliability, we will achieve cost-effective maintenance of the entire plant.
- This will be made possible through employee engagement, utilisation of the maintenance system and respect for procedures and instructions.

# Maintenance vision, strategy and policy

EXAMPLE OF A **MAINTENANCE POLICY**

- Our maintenance is characterised by safety, efficiency, quality and flexibility.
- Leadership should be visible and supportive.
- We are all teachers, trainers and coaches. Fast feedback is important.
- A maintenance technician should know and understand the maintenance terminology of the European standard (EN 13306), and have the ability to use them in practice.

EXAMPLE OF A **MAINTENANCE STRATEGY**

- Achieve high availability through consistent reliability work with an economic trade-off to meet production targets.
- The European standard for maintenance (EN 13306) and its concepts form the basis of our daily work.
- Preventive maintenance is planned and based on condition-based maintenance. This minimises unplanned maintenance interventions.
- Establish close co-operation between maintenance and operations staff.
- We use the LEAN concept and work with continuous improvement and systematic problem solving to address root causes.

# Maintenance Standard

# Maintenance standard

There are a variety of definitions and explanations of the concept of maintenance. Often, the explanation varies with factors such as industry and the level of the organisation. For a maintenance technician carrying out a practical maintenance action, the term maintenance may mean changing a coupling between a motor and a pump. For someone in management, the concept of maintenance may rather be associated with a tool to increase competitiveness, productivity and profitability.

The following maintenance standards specify general terms and definitions for technical, administrative and management areas of maintenance.

### EN 13306 MAINTENANCE TERMINOLOGY

- Everyone does the same and talks about the same things
- Securing evidence and data for analyses
- Concepts that work internationally

### EN-15341 MAINTENANCE KEY PERFORMANCE INDICATORS

- Key figures based on terminology standards
- International understanding

### EN-13460 DOCUMENTS FOR MAINTENANCE

- Support for new purchases
- Ensure a basis for preventive maintenance

# What is maintenance?

**The Maintenance standard states that:**

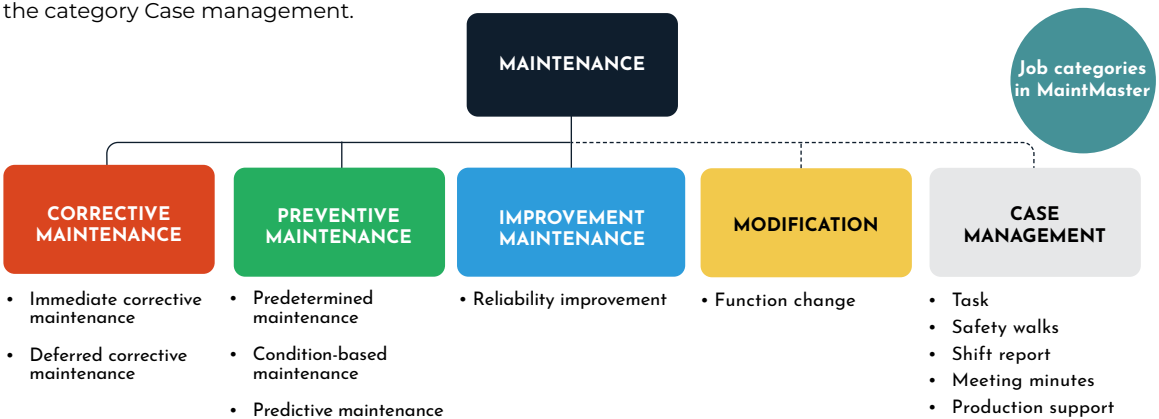
## Maintenance is the combination of all technical, administrative and managerial actions during the lifetime of a device in order to maintain it in, or restore it to, a condition to perform the required function.

A maintenance engineer should know and understand maintenance terminology and standards, and have the ability to use them in practice.

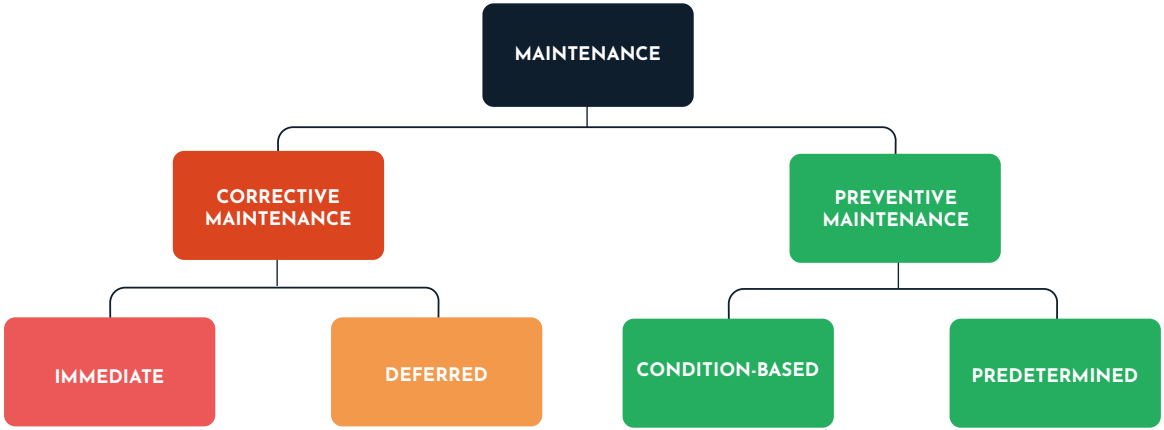
In order to make proper analyses, it is necessary that everyone talks and reports in the same way, and that we understand what the different concepts mean in maintenance terminology. This allows us to measure and make correct and fact-based analyses, which in turn form the basis for the maintenance organisation's decision-making.

# Maintenance categories

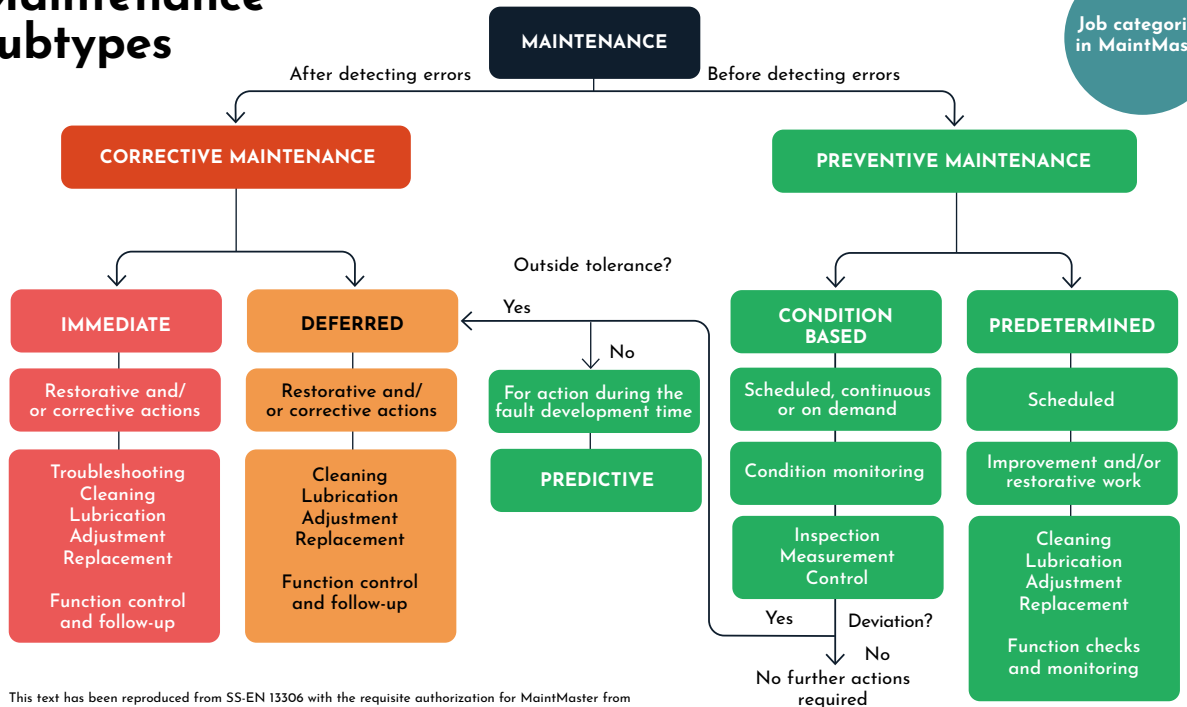
All maintenance work that aims to maintain or improve the reliability of a machine or equipment is divided according to standard EN 13306 into three types of work, corrective, preventive and improvement maintenance. In addition to maintenance activities, the maintenance organisation handles many other projects and other types of support activities for the production organisation. Projects that do not aim to improve reliability are by default a Modification, other support activities are registered in MaintMaster in the category Case management.



# Maintenance types



# Maintenance subtypes




Job categories in MaintMaster

# Preventive Maintenance

# Preventive maintenance

Effective preventive maintenance increases operational reliability, which leads to increased profitability. In the long run, it also reduces maintenance costs. We normally aim at condition-based maintenance, which is based on optimising the availability of the company's processes by anticipating the critical points in our equipment and thus preventing problems before they occur.

Cost efficiency has always to be considered. Sometimes Predictive Maintenance could be a preferred approach.

Maintenance activities that are "unnecessary" are eliminated by systematically ensuring that the work performed provides increased reliability at a lower cost. We also ensure that maintenance is a coherent entity, which includes secure access to spare parts and a functioning network of maintenance providers.

# Preventive maintenance

Preventive maintenance is the maintenance performed at predetermined intervals or according to predetermined criteria in order to reduce the probability of failure or degradation of a device's function. Preventive maintenance can consist of Condition-Based, Predetermined and Predictive maintenance.

### CONDITION-BASED MAINTENANCE

Preventive maintenance which include assessment of physical conditions, analyses and the possible ensuing maintenance actions.

Note. The condition asessment may be by operator observation, and/or inspection, and/or testing, and/or condition monitoring of system parameters, etc., conducted according to a schedule, on request or continuous.

### PREDETERMINED MAINTENANCE

Preventive maintenance, carried out in accordance with established intervals of time or number of units of use, without previous condition investigation.

Note. Intervals of times or number of unit of use may be established from knowledge of the failure mechanisms of the item.

### PREDICTIVE MAINTENANCE

Condition-based maintenance carried out following a forecast derived from repeated analyses, or known characteristics and evaluation of the significant parameters of the degradation of the item.

# Condition-based maintenance (CBM)

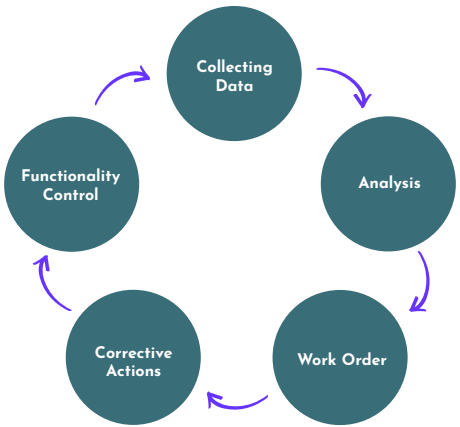
Is a methodology to acquire information on the health status of individual machines in order to identify the correct maintenance action at an optimal time. Condition-based maintenance therefore requires methods to obtain information about the health of the machine. This usually involves various measurement techniques, such as vibration measurement, thermography, ultrasonic measurement and oil analysis. The maintenance process for condition-based maintenance consists of five process steps: Collecting Data, Analysis, Work Order, Corrective actions and Functionality Control.

ADVANTAGES

The right maintenance action at the right time
Planned maintenance measures instead of immediate measures
Minor machine faults are detected well in time, and corrected
Decrease of breakdowns due to wear and tear
High competence development rate of maintenance staff
Core maintenance knowledge is built up in the organisation

DISADVANTAGES

May involve high initial investment costs
Risk of machines beeing refurbished to early
Need for concept understanding and acceptance from the production



# Predetermined maintenance

Refers to preventive measures, scheduled per calendar or operating time, such as replacing oil, belts, clutch elements and other ware parts. The term also includes scheduled inspections where machines and components are dismantled for inspection.

ADVANTAGES

Reducing the risk of breakdowns
Improved operational reliability
Increases the level of planning of maintenance activities
Professional development of staff
Reduced maintenance costs

DISADVANTAGES

Cost of unnecessary spare parts and labour time
Risk of excessive maintenance of machinery
Costs of unnecessary downtime
Often static maintenance planning with limited feedback of experience to the maintenance plan

# Predictive maintenance

According to the standard, predictive maintenance strives for finding the failure during its failure development time by predictions from repeated analyses or by evaluating known properties and parameters of a unit's degradation. Using today's technology, it is common to have some intelligent monitoring system that analyses and processes various measurements. This allows you, for instance, to determine when to change bearings in a unit.

In the maintenance system, we handle this by connecting wireless sensors directly via "plug and play" to measure, for example, temperature, pressure or humidity. Through a simple configuration, you set a trigger for when you want to create a work order with an appropriate instruction for what to check or perform.

Condition checks can also be done by visual inspections or collecting data, those are then analysed and decisions are made on planned and Predictive maintenance.  This can be scheduled inspections and collecting data by operators or maintenance personnel. The goal of predictive maintenance is to reduce downtime and to predict when it is time to replace a device, for example, at an optimised time to take advantage of its full lifespan.

ADVANTAGES

Minimising downtime and increase planning efficiency

Reduction of service and material costs

Extends the use of components and machines

Status-based maintenance replaces time-based maintenance

Reduced maintenance costs

DISADVANTAGES

May increase initial costs

# Autonomous maintenance

Autonomous (Operator) maintenance aims to increase the operational reliability of production equipment by establishing close cooperation between maintenance technicians and operators. Operators have a unique insight and knowledge of daily operations that is very valuable for maintenance. At the same time, maintenance has unique understanding of care and function. By exchanging and transferring knowledge closer to the equipment, unwanted variations can be detected and corrected before faults occur. Maintenance technicians have a very important role as supervisors, teachers and coaches in this work.

Involving operators in the execution of certain maintenance actions also provides more opportunities for daily supervision and weekly maintenance. Examples of maintenance actions that can be carried out by operators includes checks, lubrication, replacements and simple repairs.

Autonomous maintenance will eventually also free up time for maintenance staff to work more on improvement maintenance, such as specialised maintenance and improvements to increase operational reliability.

Production should be responsible for ensuring that the planned autonomous maintenance is carried out according to the applicable procedures and intervals and that the work is reported according to instructions. If a deviation is detected during an inspection, this is handled via a follow-up job in the maintenance system.

# Corrective Maintenance

# Corrective maintenance

Corrective maintenance is maintenance carried out after a malfunction has been detected, and to bring the unit into a condition to perform the required function.

*Corrective maintenance can consist of both deferred (plannable) and immediate (unplanned) corrective maintenance.*

**DEFERRED CORRECTIVE MAINTENANCE**
Corrective maintenance which is not immediately carried out after a fault detection but is delayed in accordance with given rules.

**IMMEDIATE CORRECTIVE MAINTENANCE**
Corrective maintenance that is carried out without delay after a fault has been detected to avoid unacceptable consequences.

# Corrective maintenance

ADVANTAGES

Suitable for machines that are easy to replace or have a low purchase cost.

Suitable for specific machines or parts in redundant systems where no costly side effects can be expected in case of failure.

Requires no or limited investment in skills or technology.

DISADVANTAGES

Involves unforeseen breakdowns.

Difficult and sometimes impossible to plan maintenance activities.

Higher cost - minor machine problems go undetected and develop into costly breakdowns.

Low or no professional development of staff

Higher risk for injuries in case of breakdown.

Increased environmental impact.

Higher energy consumption.

# Work order flow (example)

**Fault Report**
To report non-urgent faults, you normally report directly into the maintenance system by clicking on the "Corrective Maintenance" button and selecting the priority of the job, as explained in the following pages. The work order is then forwarded to the maintenance department or respective area manager for further processing. In cases where the reporting person cannot, or feels uncertain, the responsible technician or manager shall assist in handling the fault report. In some organisations you report faults by phoning a dedicated person/role who creates the work order in the system. In case of a Breakdown, you always report the fault by phone before you report into the system. Reporting a fault into the system can also be done afterwards when the fault in question has been rectified, but the basic principle is that jobs should only be carried out in exceptional cases unless an order has been placed in the maintenance system.

**Recipient of the fault report**
The person in charge of the relevant line, area or equipment is responsible for the planning, execution and reporting of these jobs.

**Completion of work orders**
After completing the maintenance operation, the job must be reported immediately with the time spent and a simple analysis of the action taken to correct the problem. In the case of emergency measures using the job category "Corrective maintenance" and the completion code group "Immediate corrective maintenance", you must also state how much downtime the fault in question has caused before the job is completed in MaintMaster.

# Priority levels

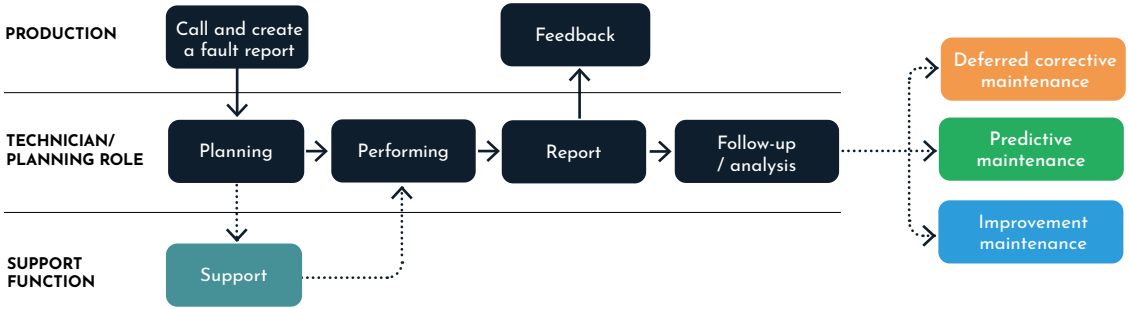
PRIORITY LEVELS FOR FAULT REPORTING (JOB CATEGORY "CORRECTIVE MAINTENANCE")

**Breakdown** – The machine is at a standstill, the fault needs to be handled immediately.

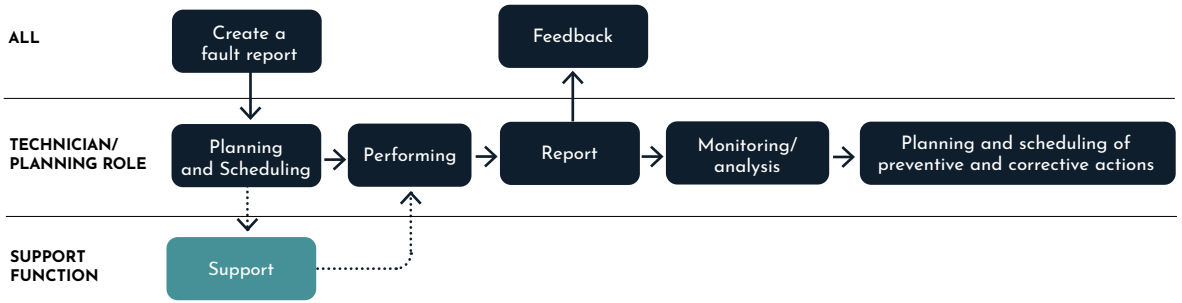
**Production disturbance** – The machine is working but perhaps not very well.

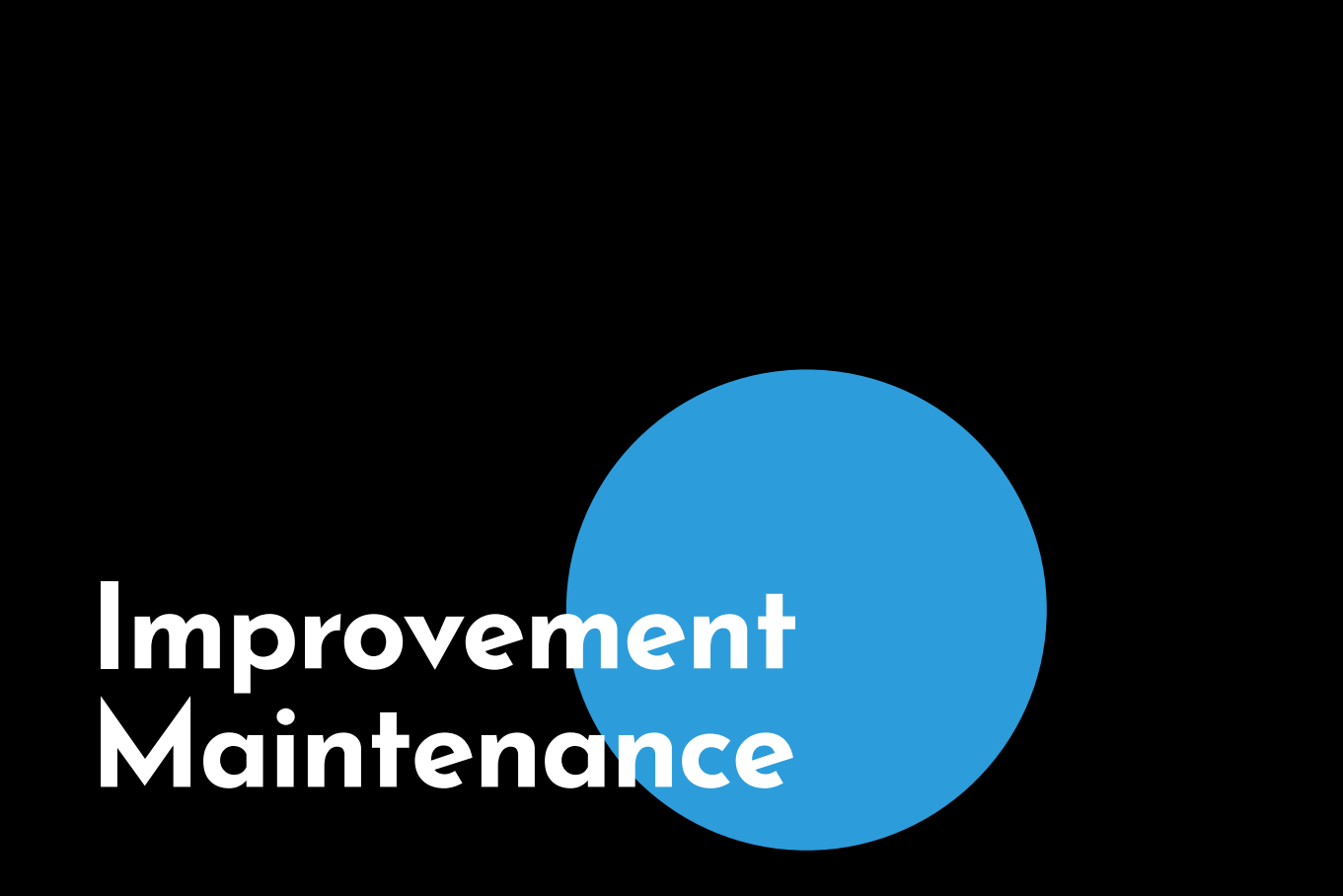
**Errors & shortcomings** – For handling deviations and things that do not directly affect operations but should be handled.

# Immediate corrective maintenance



# Deferred corrective maintenance




Improvement
Maintenance

# Improvement - Dependability improvement

According to the European standard, improvement is defined as: "Combination of all technical, administrative and manegerial actions, intended to ameliorate the intrincic reliability and/or maintainability and/or safety of an item, without changing the original function.

Note. An improvement may also be introduced to prevent misuse in operation to avoid failures.
For Maintenance, this means all actions aimed at extending the service life and eliminating future failures.

Within the framework of Improvement Maintenance, one should exclude actions where the purpose of the activity is to improve the speed or quality output of machinery or equipment. The same applies to the adaptation of equipment for a new product or packaging. We register and report these actions as a Modification in MaintMaster.

EXAMPLES OF ACTIVITIES FOR IMPROVEMENT MAINTENANCE

- Building away errors
- Training activities
- Organisational changes
- Developing work instructions
- Implementation of a maintenance system
- Improve the maintainability of a piece of equipment

# Modification

# Modification

According to the standard, modification is defined as: "The combination of all technical, administrative and managerial actions intended to change one or more functions of an item."

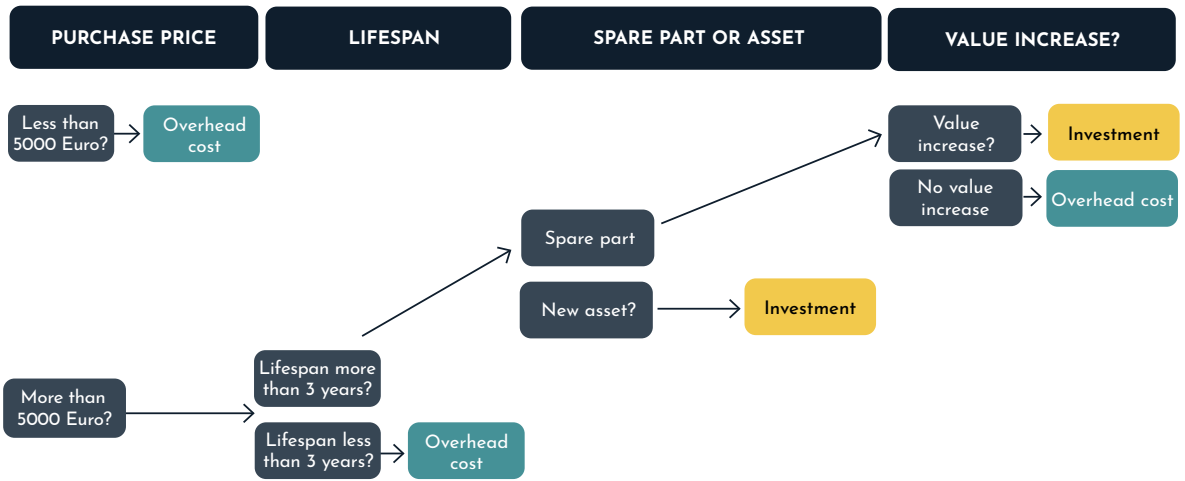
For maintenance, this means any action to improve product quality or speed. It also applies when we adapt equipment for a new product or packaging. These actions should be costed separately from the maintenance budget and are usually costed as an investment.

COMMENTS

- Modification is not a maintenance action but refers to changing the required function of an item to a new one. Any changes made during a modification may affect the reliability characteristics of an item, but since the purpose is to change, the activity is still classified as a modification.
- Modification does not imply replacement with an equivalent unit
- Modification of a unit may be a task for the maintenance organisation

# **Decision support data:** Overhead costs or investment

It can sometimes be difficult to determine whether a planned activity should be recognised as an investment (modification) or as an expense (improvement). The diagram below is intended to serve as an aid in determining when a similar issue arises. The economical levels in the model below are examples.



# Case Management

The maintenance organisation works primarily with maintenance-related issues and activities to maintain and improve the dependability of the plant through corrective, preventive or improvement maintenance. In addition, it is common to participate in, or project manage dependability modification projects or quality or speed improvement projects. Right or wrong? You can have long discussions about this, and about who should do what in an organisation. The question is based on what decisions and strategy choices have been made previously in management. In order to make the right decisions about different responsibilities and tasks, it is not always easy for a maintenance manager to justify to a management team why the maintenance organisation is structured the way it is, and what tasks they should be responsible for in order to reach set goals.

Good data always facilitates the decision-making process and makes it easier to decide on important changes that promotes dependability. This, and a maintenance plan derived from the overlaying company goals will tell you where the focus should be.

You will face expectations that the maintenance organisation should do other tasks as well, not related to maintenance. It could be simple tasks like moving furniture, putting up whiteboards in an office etc. It could be right but it could also be totally wrong aiming for creating reliability in your production assests. It is always important to document what is done, and the time spent to facilitate future, fact based decisions. The job category "Case management" in MaintMaster can be used to report this type of work, see model on page 12.

# Organisation

# Business plan for maintenance

Your company normally has a business plan to describe the company's goals and visions and how this is to be implemented during a set period of time. This plan is then the basis for the maintenance business plan. It should specify activities supporting the company business plan, and also the development necessary of the maintenance organisation, everything to achieve the set goals of the company. Below is an example of how to specify the maintenance organisation's selected activities for the next three years. At the top of the business plan, we also show selected KPIs to be able to follow the development.

# Operational plan for maintenance

## Key performance indicator

| KPI | Last year | This year | Next year | Year 2 |
|---|---|---|---|---|
| • Percentage of fault reports from operators | - | 20% | 50% | 75% |
| • Reported time on completed jobs | - | 50% | 75% | 85% |
| • Preventive maintenance backlog | - | TBD | TBD | TBD |
| • Unplanned compared to planned maintenance | - | 70/30 | 60/40 | 40/60 |
| • Completed breakdowns with reported down time | - | 65% | 75% | 97% |

## Activities

**This year**
- Implementation of MaintMaster
- Develop Vision, Strategy and Policy for maintenance
- Create a maintenance manual and a training plan for maintenance staff.
- Train maintenance staff in simple root cause analysis
- Develop process for root cause analysis in MaintMaster.
- Start with meetings for daily management

**Next year**
- Conduct maintenance inventory on lines 3 and 4
- Set up plan for condition-based maintenance on lines 1 and 2
- Start weekly meeting for planned maintenance stops
- Include spare parts in recurring maintenance jobs

**Year 2**
- Start Pit-Stop process on lines 3, 4 and 5
- Start with IoT sensors on selected objects

# Roles and responsibilities in a "reliable" maintenance organisation

One of the most important goals of the maintenance organisation is to achieve high operational reliability through cost effective maintenance. An important part of this is that you have the right resources and an organisation supporting the chosen strategy to achieve your goals. Depending on the size of the organisation, you may need to combine different roles to make it work. However, it is important that it is clear which roles are responsible for different tasks and responsibilities in maintenance.
Always strive for redundancy in the organisation to handle the daily work if someone is absent.

At MaintMaster, we are convinced that this is a very important part of building a reliable maintenance organisation. The picture below shows an example of allocating different responsibilities within maintenance. Another important part is that everyone in the organisation understands their role, not just management. Focus on what your role needs to deliver. For example, as a manager or leader, you need to spend more time planning in the long term than helping out daily with a tool in your hand. Attendance is important, but evaluate how much of your working time is spent on day-to-day activities. Meetings are very important. Make sure that every meeting is meaningful. Everyone knows how easy it is to get tied up in meetings that have no meaning for you or your organisation.

# Roles and responsibilities in a "reliable" maintenance organisation

The maintenance organisation is responsible for executing, planning, managing and developing maintenance activities to ensure high reliability and availability of sites, machinery and equipment.
The organisation can have different sizes, structures and competencies depending on the needs, resources and goals of the company, and different forms of cooperation with external factors, such as suppliers, contractors or consultants.

This may involve outsourcing some parts of the maintenance to other parties, either fully or partially. It may also involve the use of external expertise for specific tasks or projects. Whichever form of co-operation is chosen, it is important to have clear agreements, communication and follow-up between the parties involved.
There is no template for what an optimal maintenance organisation should look like; it depends on many factors such as the size, type, complexity, level of maturity and objectives of the business. However, it is important that the maintenance organisation carefully considers its maintenance strategy and adapts it to the needs and conditions of the Company business plan, and constantly strives to improve and develop its work.

A well functioning maintenance organisation is an important factor in achieving high operational reliability and availability, as well as contributing to the profitability and competitiveness of the business.

**The following roles are examples of commonly used roles in a maintenance organisation.**

**Maintenance manager**
Has overall responsibility for the maintenance management and its performance. The maintenance manager leads and manages the maintenance organisation in accordance with the company's vision, strategy and policy. The Maintenance Manager is also responsible for monitoring and reporting maintenance KPIs, budget and costs.

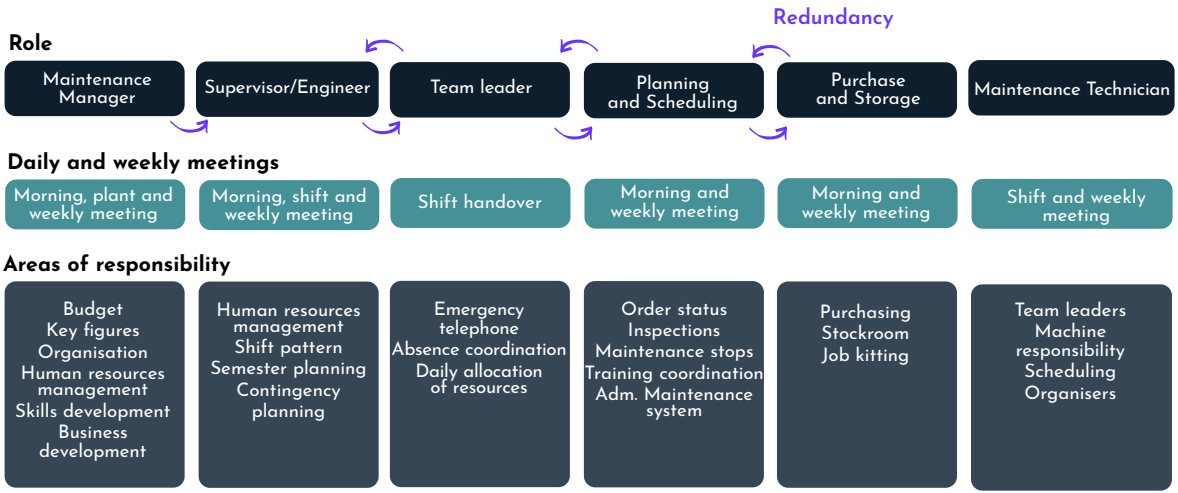
**Maintenance supervisor**
Leads and allocates tasks to technicians. May also provide support and assistance to various roles within the maintenance organisation. Supervisors usually also have personnel responsibilities for maintenance technicians.

**Maintenance planner**
Plans and coordinates maintenance work in co-operation with production, suppliers and maintenance staff. The maintenance planner is responsible for optimising the use of resources, minimising downtime and maximising maintenance efficiency. The maintenance planner is also responsible for documenting and archiving maintenance information in a maintenance system.

**Maintenance technician**
Carries out the actual maintenance work on the plant, machinery or equipment. The maintenance technician may have different specialisations, such as mechanical, electrical, automation or instrumentation. The maintenance technician is responsible for following the planned maintenance activities, reporting deviations and faults, and suggesting improvements.

**Maintenance engineer**
Has technical skills and knowledge in one or more areas of maintenance. The maintenance engineer supports and guides the maintenance staff in technical matters, analyses the causes of faults and malfunctions, and develops and implements solutions to prevent or correct faults. The maintenance engineer is also responsible for evaluating and updating maintenance plans, instructions and procedures.

# Roles and responsibilities in a "reliable" maintenance organisation



# Professional maintenance

Efficient maintenance is about value-creating maintenance from a preventive, planned and improvement perspective, where work that requires immediate corrective action is seen as a quality deficiency, and measures are taken to reduce the risk of the event occurring again. An essential part of ensuring that professional maintenance tasks is that the activities are coordinated with the work carried out by operational staff.

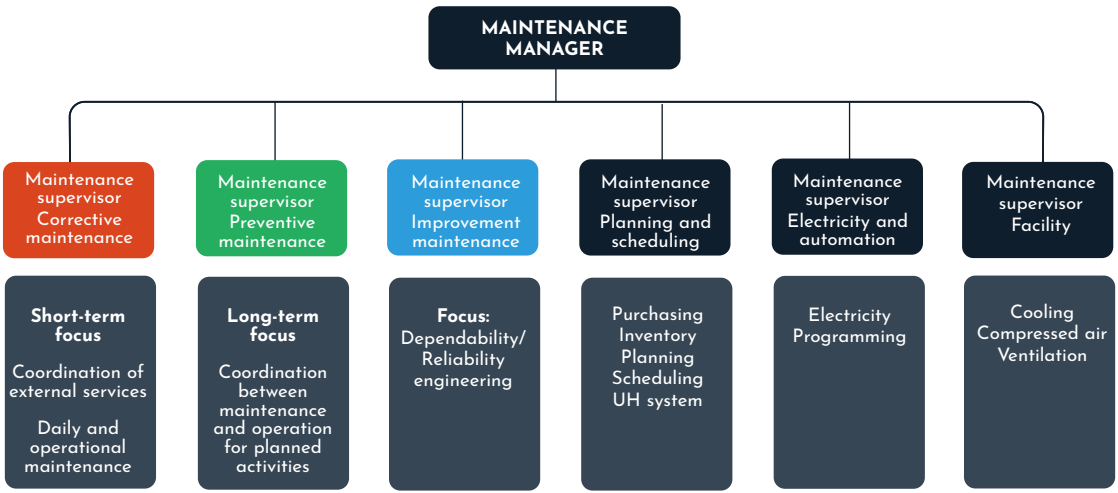
Professional maintenance is goal-oriented maintenance that constantly aims at improving operational reliability based on the needs of production by measuring and directing operations toward results. This is created by standardising how improvement activities, target management and result measurement are carried out, and by building in continuous optimisation of existing maintenance plans and processes.

**Below are examples that can be included in Professional maintenance:**

- Goal-oriented maintenance and monitoring using key performance indicators.
- Budget work
- Standardised approach
- Corrective and preventive maintenance
- Planning and scheduling of maintenance activities
- Maintenance strategy
- Analysis (6-sigma, FMEA, SPL, Root Cause Analysis)
- Skills development
- Vibration and oil analyses
- Thermography
- Spare parts management
- Documentation
- LCC (Life Cycle Cost)

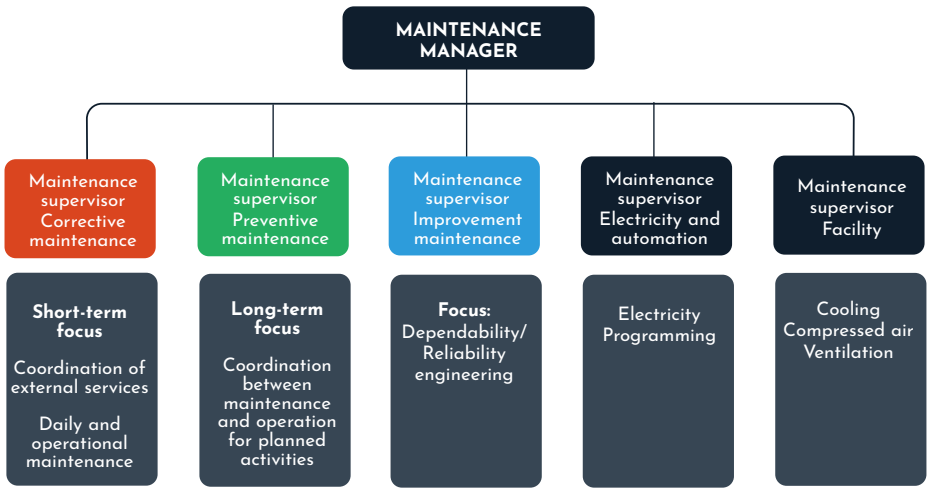
# Maintenance organisation, based on EN 13306

Approximate organisation (100+ people)



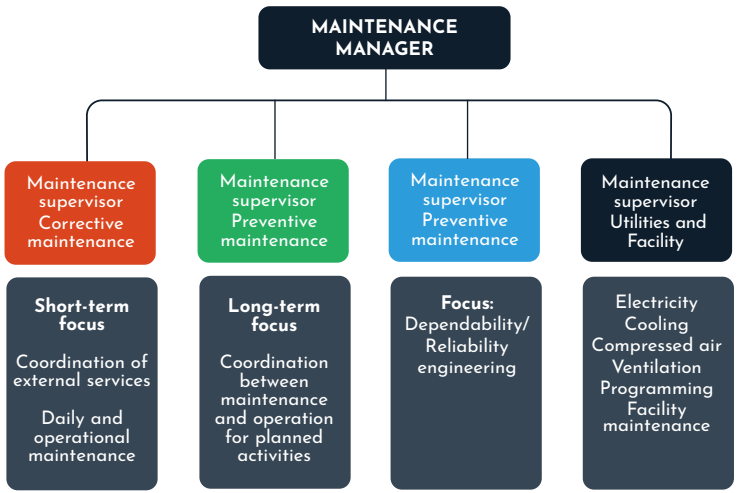
# Maintenance organisation, based on EN 13306

Approximate organisation (70-100 persons)



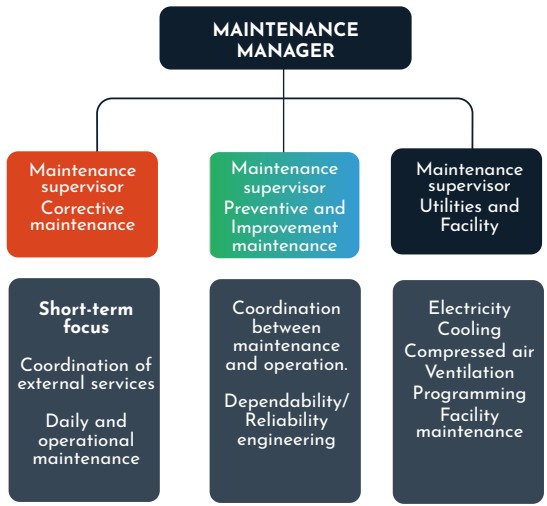
# Maintenance organisation, based on EN 13306

Approximate organisation (30-70 people)



# Maintenance organisation, based on EN 13306

Approximate organisation (15-30 people)



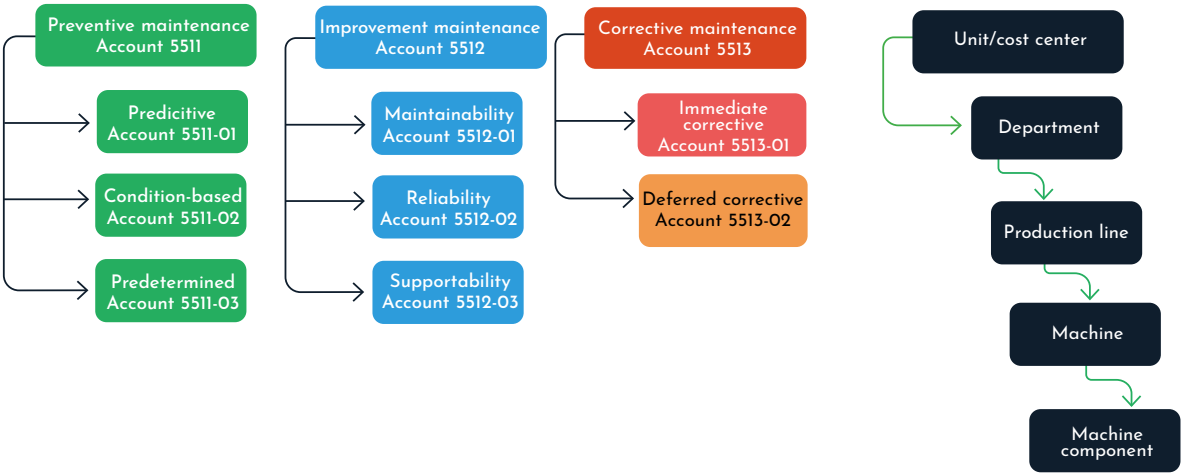
# Finance

# Account setup for maintenance costs

Financial follow-ups of maintenance costs are usually posted to account 5510 as according to the Swedish BAS chart of accounts. Account 5510 is an account for "Maintenance of machinery and other technical installations". But it is also common in maintenance to have different accounts for other types of maintenance work, such as electrical work or mechanical repairs. In MaintMaster this is not necessary, as it is possible to link users to different work groups such as "Electrician" or "Mechanic". This allows you to easily follow up on different types of work via selections in MaintMaster. In the picture on page 46 you can see how we link account numbers to job categories in order to make cost follow-ups for each category. By extension, this can significantly facilitate the budget work by, for example, following and/or calculating cost outcomes for the various categories per line or machine.

*Note: The flexibility of MaintMaster enables you to configure the system to mirror any chart of accounts. The example is from the Swedish chart of accounts.*

# Account setup for maintenance costs



# Goals & KPIs

# Goals & Key Performance Indicators (KPIs)

The maintenance organisations must always strive to improve operational and personal safety, which in turn has positive effects on availability. Operational safety depends on the combined characteristics of reliability, maintainability and maintenance supportability. These can be measured according to the following metrics:

EXAMPLES OF METRICS

- Relation between planned and unplanned maintenance activities
- Maintenance cost divided by production volume or number of units produced.
- Number of stops per machine or line
- Downtime per object
- MOTBF: Mean Operating Time Between Failures.
- MTTR: Mean Time To Restore.
- MMDT: Mean Maintenance Down Time (MMDT).
- MWT: Mean Waiting Time.

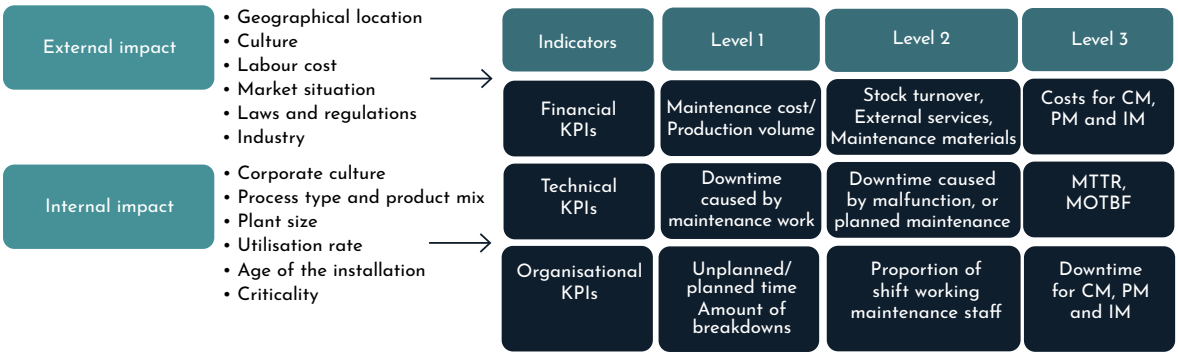
**High operational reliability provides:**

- Lower maintenance costs
- Higher profitability
- More stable production
- Less loss of quality
- Lower energy costs
- Improving the working environment
- More time for improvements

# KPIs:

## EN 15341 - Maintenance Key Performance Indicators

To effectively manage maintenance activities, it is important to measure what we do, how much and how well we do it. To do this, you need to identify a number of metrics, these are often referred to as key performance indicators (KPIs). The image below shows some examples from the standard, which contains pre-defined KPIs divided into 3 categories; financial, technical and organisational indicators. Choose an overall KPI from each category that adds value to the maintenance operation over time and that all staff can relate to.



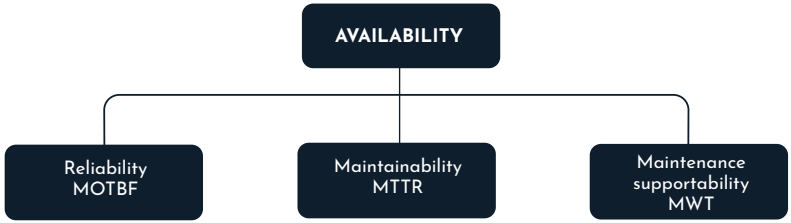
# **Goals & KPIs:** Dependability

According to European Standard, dependability is defined as: Dependability includes availability, safety, durability, economics, and their influencing factors (reliability, maintainability, Maintenance supportability, conditions of use and operators influence).

**Availibility**

According to European Standard availability defines as: The ability of a unit to perform the required function under specified conditions at a given time or within a set time interval, provided that the required support functions are available.

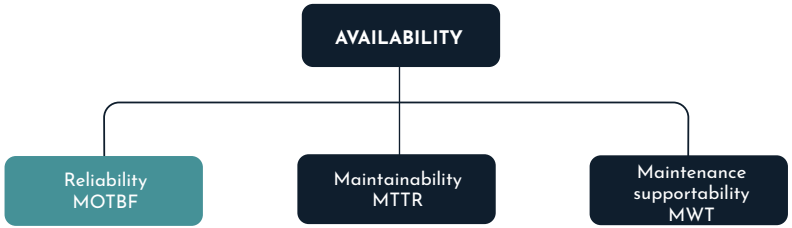
*Note: Availability depends on the combined characteristics of reliability, maintainability, and maintenance supportability.*



# **Goals & KPIs:** Reliability

**Reliability**
The ability of a unit to perform the required function under given conditions during a given time interval.

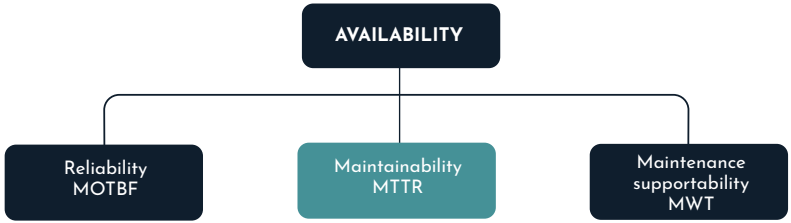
A measure of reliability is the Mean Operating Time Between Failures (MOTBF). That is the time that elapses between the last corrective actions for a failure until the next failure occurs. Through regular condition checks of machines and planned actions to correct deviations, the time between failures can be increased, leading to higher functional safety.



# **Goals & KPIs:** Maintainability

**Maintainability**
The ability of a unit, under given conditions of use, to be maintained in or restored to a condition that enables it to perform the required function, where maintenance is carried out under given conditions and using established procedures and resources.

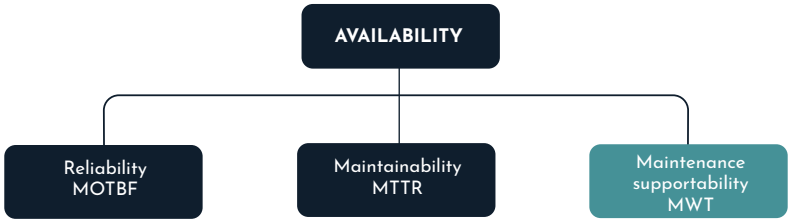
An example of a key performance indicator to measure Maintainability is Mean Time to Restore (MTTR). MTTR is the mean time to resolve a fault and one way to influence this can be for maintenance to be involved in the design of a new asset to ensure that wear parts are easy to replace and that the necessary resources such as lifting equipment are available in the design of a machine.



# **Goals & KPIs:** Maintenance supportability

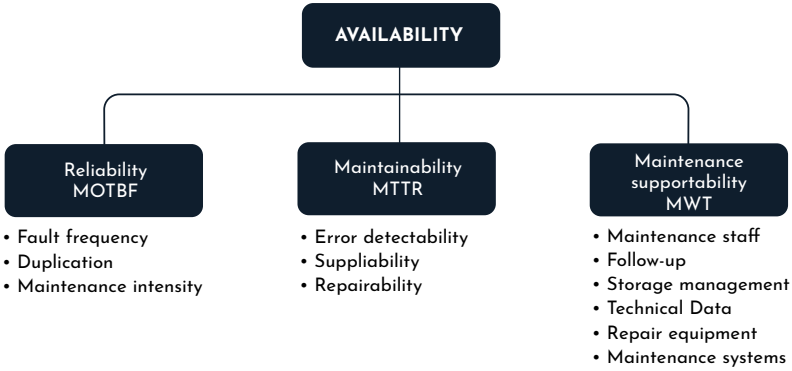
**Maintenance supportability**
The ability of a maintenance organisation to provide the right maintenance support at the required location so that the required maintenance activity is performed when required.

Maintenance supportability describes the ability of the maintenance organisation to provide the resources required to perform maintenance activities, and can be described as the Mean Waiting Time (MWT) for a maintenance task. Some things that lead to increased Maintenance supportability are the planning of maintenance activities and ensuring the availability and high quality of technical documentation.



# **Goals & KPIs:** Availability

Reliability and maintainability take into account the ability of the technical system to meet dependability, while maintenance supportability describes the ability of the maintenance organisation to effectively address failures. These three factors are in turn determined by a number of sub-factors and maintenance activities.

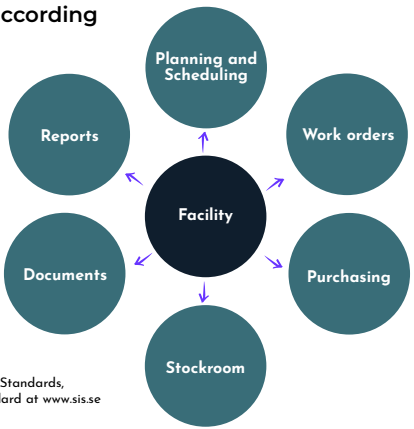


# Implementation in MaintMaster

# Why do you need a maintenance system?

The management and planning of maintenance requires a systematic approach. The information that can be collected in a maintenance system provides invaluable support in planning and executing all types of maintenance activities, and helps to ensure operational reliability. Regardless of the strategy, some form of preventive maintenance is always required, and for this to work documentation, planning and follow-up are required to get the intended return on investment. A maintenance system is also the hub for all the information a maintenance technician or planner needs. What has been done previously, which spare parts are suitable, have we carried out inspections according to routine, what deviations have we found?

**In MaintMaster, job categories and completion codes are customised according to standard EN 13306. This enables easy monitoring and value-adding decision-making.**

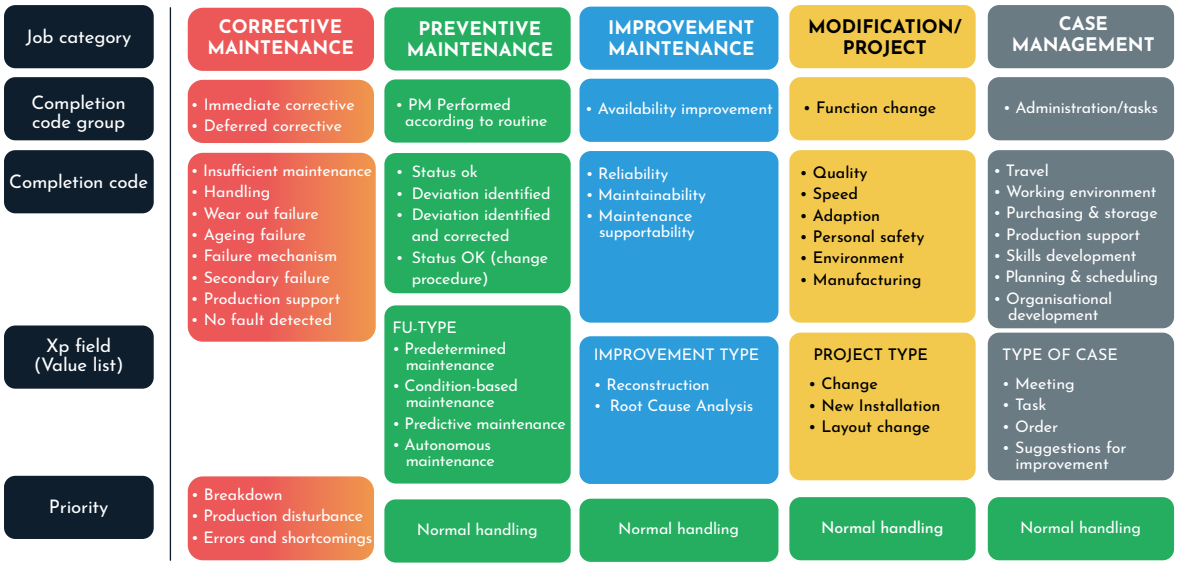



## MAINTENANCE ACCORDING TO EUROPEAN STANDARD

In order to make correct analyses, it is necessary that the staff reports in the same way and that they understand what the different definitions mean in the maintenance system. MaintMaster is adapted to the *EN 13306 Terminology for maintenance*, where it is clear what the different terms mean. The following pages show different terms and concepts in the standard with an explanatory text, and how this is implemented in MaintMaster.

# Job categories, completion code groups and completion codes in MaintMaster

## Based on standard EN 13306



# **Completion code groups:** Corrective maintenance

**Completion code group: Immediate corrective maintenance**

Maintenance performed immediately after a defect has been detected in order to avoid unacceptable consequences.

*The machine is down, fix now! Downtime must always be specified before completion with this completion code group.*

**Completion code group: Deferred corrective maintenance**

Corrective maintenance that is not carried out immediately after the detection of a malfunction but is deferred in accordance with the given maintenance directives.

*The machine works, but not very well. The job can be scheduled for a later date.*

Always strive to move actions from unplanned to planned maintenance activities. Initially, this is the fastest way to achieve higher reliability and more efficient maintenance work.

# Completion codes for completion code group:
## Immediate and deferred corrective maintenance

**The following completion codes are used in this example to indicate the reason why an error has occurred.**

### Insufficient maintenance
Defects arising from improper or unperformed maintenance.

### Handling
Errors resulting from improper handling of equipment or machinery.

### Wear out failure
Faults whose probability of occurrence increases with the operating time or the number of completed work cycles or the load to which a unit is subjected.

### Ageing failure
Faults whose probability of occurrence increases with time. This time is independent of the operating time of the unit.



### Failure mechanism
Physical, chemical or other process that leads to, or has led to failure. e.g. design failure, incorrect choice of materials or method failure.

### Secondary failure
Failure of a unit directly or indirectly caused by the failure of another unit, e.g. power failure, loss of compressed air, etc.

### Production support
Used for reporting support services to production that are not directly maintenance related, such as assistance with changeover or machine start-up.

### No fault detected
Completion code for those occasions when no fault can be found. Can be used, for example, when a "loose contact" is suspected and when restarting or resetting equipment. The error cannot be recreated.

# **Completion code group and completion codes:** Preventive maintenance

**Completion code group:**

**PM Performed according to routine**

All maintenance activities regarding preventive maintenance are completed with the completion code group "PM Performed according to routine", followed by one of the following completion codes to facilitate the follow-up of completed PM activities.



**Status OK**

Action or inspection is carried out according to plan/ instruction, and the equipment is in a satisfactory condition and authorised for continued use.

**Deviation identified**

Control is carried out according to instructions and deviation is identified. Deviation management is planned and managed via follow-up jobs.

**Deviation identified and corrected**

Control is carried out according to instructions and a minor deviation is identified. Minor non-conformities can be addressed directly without a follow-up job, as the follow-up of these actions does not add much value.

**Status OK (change procedure)**

The equipment is in good condition and approved for continued use but the routine or intervals need to be adjusted in the original job.

# Property to indicate the type of Preventive maintenance

It is easy to specify different types of preventive maintenance in MaintMaster. It is equally easy to create reports showing what has been performed. This is done by using an extra property on the job category Preventive Maintenance, containing a valuelist/dropdown with captions as shown below.

**Create a Property in MaintMaster, data type Value list, with the name Type of PM action. Enter the following captions as optional values.**

**Predetermined maintenance**
Preventive maintenance carried out at specified intervals or after a specified use without regarding condition.

**Condition-based maintenance**
Preventive maintenance which consists of checking and monitoring the condition of a unit in terms of its operation and characteristics.

**Predictive maintenance**
Maintenance action following a condition-based maintenance, when a prediction of a unit's deteriorating performance based on analysis and evaluation of key characteristics is made.

**Operator maintenance**
Maintenance carried out by the user or operator of the machinery

# **Completion code group and completion codes:** Improvement maintenance

**Completion code group:** **Availability improvement**
The following completion codes are used to indicate the purpose of the improvement work.

### Reliability
Ability of a unit to perform the required function under given conditions during a specified time interval.

### Maintainability
The ability of a unit, operating under specified conditions, to be maintained in, or restored to, a state capable of performing the required function when maintenance is performed under specified conditions and using established procedures and resources.

### Maintenance supportability
The ability of the maintenance organisation to provide the right maintenance resources at the required location, to perform required maintenance actions on a unit, at a specified time or during a specified time interval.

# **Completion code group and completion codes:** Modification

**Completion code group: Function change**
The following completion codes are used for completion of cases where the purpose has been personal safety improvements, cycle time or quality improvements of the product.

Alternative modification of machine for a new product, packaging or environmental measures.

### Quality
For reporting back an action where the purpose is or has been to improve the quality output of a machine or equipment.

### Speed
For reporting back on an action where the purpose is or has been to improve the speed or cycle time of a machine or equipment.

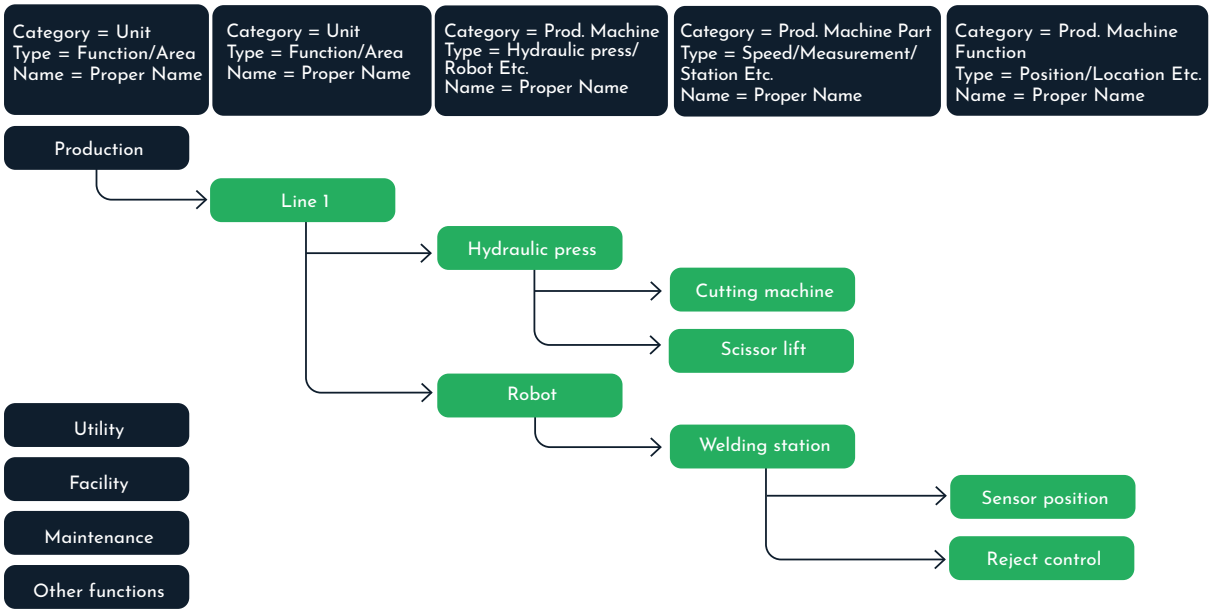
### Adaptation
Used to report back an adaptation or adjustment of a piece of equipment for example for a new product or packaging.

### Personal safety
Used to report back on cases where the aim is to improve personal safety. Including ergonomic improvement activities.

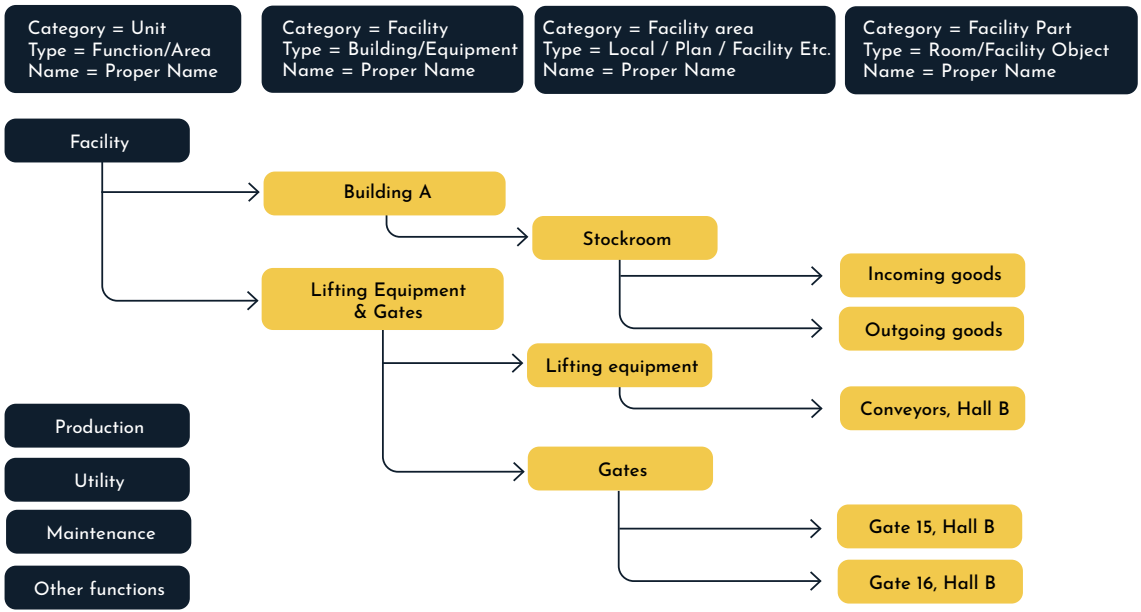
### Environment
For reporting environmental improvement cases.

### Manufacturing
Manufacture of new machinery, tools or spare parts.

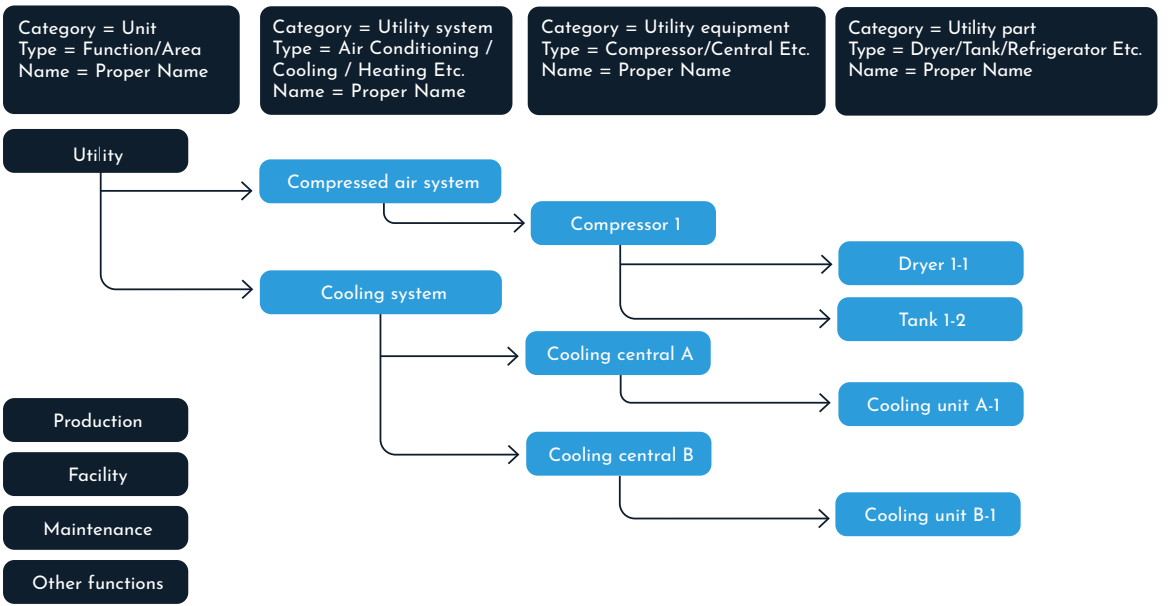
# Build your site explorer: Production (green icons)



# Build your site explorer: Facility (yellow icons)



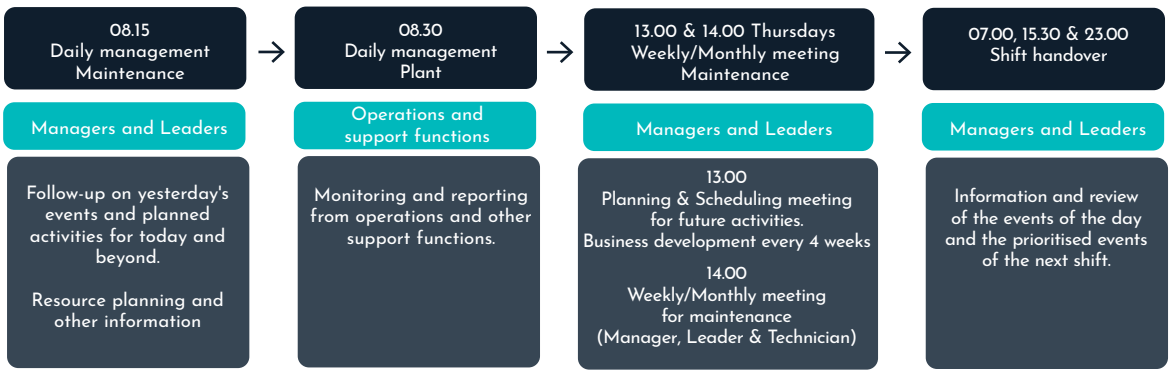
# Build your site explorer: Utility (blue icons)



# Planning & Scheduling

# Daily management

Follow-up of past events, and daily management of planned activities or newly emerged problems are important parts of the maintenance organisation's everyday life in order to maintain a functioning dialogue between different teams. Establish an agenda for each meeting and think about who should attend each meeting. Feel free to use a white board or a summary page with selections in MaintMaster to visualise which activities are ongoing or recently completed. Below is an example of a meeting structure that not only includes daily management, but more a basic planning for several different recurring meetings in a maintenance organisation. If you do not have a meeting structure in place, a tip is to start on a small scale with a morning meeting every day and then develop the process.



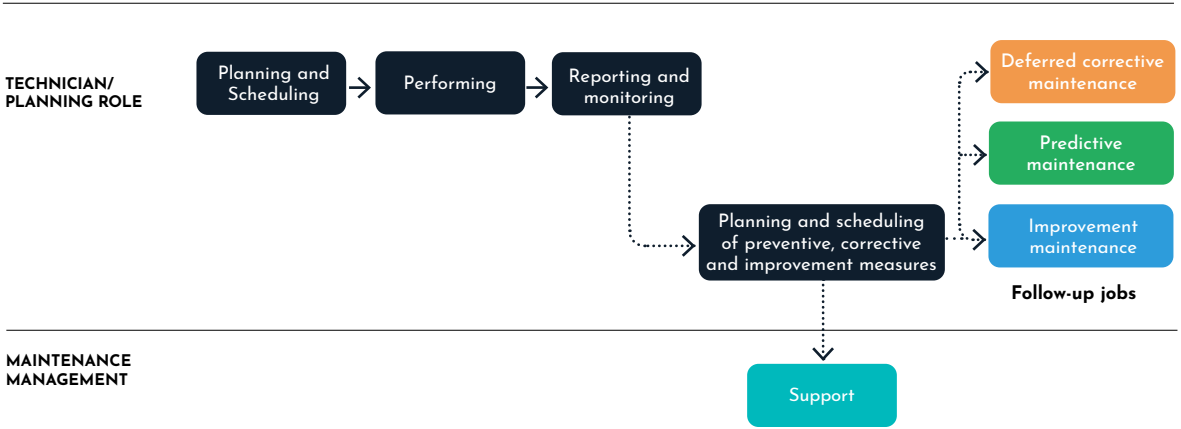
# Planning and scheduling, maintenance activities

It is very important that preventive maintenance activities are well prepared in order to ensure quality efficiency and a safe work environment. This includes spare part needs, time and other necessary resources.

**Some of the steps in the preparation process are:**

- Registration and updating of asset records including picture navigation in the maintenance system.
- Decision and recording of spare parts to be stored, and linking them to objects in the maintenance system.
- Assesing the need for spare parts, and time consumption for recurring maintenance activities.
- Develop/update instructions for preventive maintenance.
- Labelling assets in the form of inventory numbers and lubrication points, etc.

# Planning and scheduling



# Spare Parts Management

# Spare parts management

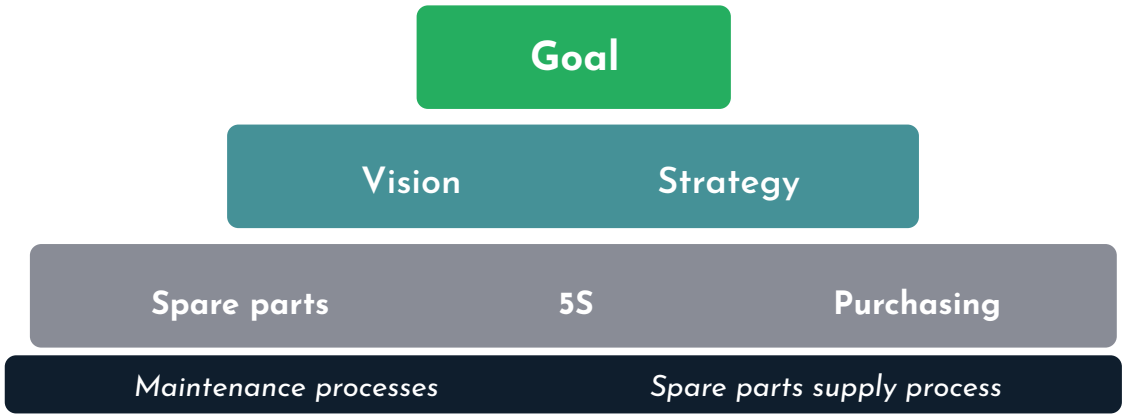
Spare parts management is about how spare parts should be systematised and structured to enable efficient inventory management that will lead to increased operational reliability and reduced tied-up capital.

When maintenance is performed, it often involves some form of material consumption. A breakdown often causes major problems and can be further worsen if spare parts are not available.

Without access to adequate spare parts, there is a risk of downtime, which can lead to lower quality outcomes, environmentally hazardous emissions and safety risks to personnel. One reason can be that it is often difficult to plan the consumption of spare parts as they have a varying demand. This is usually contradicted by building up an inventory of a large number of spare parts, which then often leads to a large amount of capital being tied up. It is therefore important to have a good system for storing and managing parts. This reduces the risk of unplanned downtime and simplifies the maintenance of the equipment. The aim of spare parts management is to minimise the total cost of ownership.

The total cost includes costs for storage, administration and various forms of shortage costs.

# Spare parts management




The pyramid shows the different main processes of spare parts management. Which, in turn, is derived from the vision, strategy and policy of the maintenance department.

# **Spare parts management:** Vision

AN EXAMPLE OF **SPARE PARTS MANAGEMENT: VISION**

- We will achieve a cost-effective spare parts handling together by combining methods, systems and staff effort.
- We have clear and concrete key figures that reflect our success in implementing working methods and costs in the stockroom.
- Spare parts management is a strong contributor to increased reliability in production.
- We work in a structured manner and have good order and tidiness in all storage areas, where the labelling of spare parts is also clear and functional.

# **Spare parts management:** Strategy

AN EXAMPLE OF **SPARE PARTS MANAGEMENT: STRATEGY**

- Our spare part strategy is based on secure access to the right spare parts at the right time. Not all spare parts always.
- Spare parts are registered and linked to objects in the maintenance system by technicians. Consumable and insurance spare parts withdrawals are recorded directly to jobs in the maintenance system.
- To optimise inventory, we conduct needs assessments and classify spare parts to determine whether they should be kept in stock or procured when needed.

# Objectives and key performance indicators for spare parts management

The aim for spare parts management is to keep the total cost of maintaining spare parts as low as possible, without compromising operational safety in any way.

High operational reliability requires that spare parts are available, or that the delivery time is as short as necessary. When faults do occur, it is important to find and rectify them as quickly as possible. The total cost includes costs for inventory, administration and various forms of shortage costs.

**SOME EXAMPLES OF KPIs WE CAN USE TO MEASURE SPARE PARTS MANAGEMENT:**

- Inventory value and quantity
- Number of unplanned purchase orders
- The value of discarded material
- Total cost (storage cost + shortage cost)
- Downtime (Depending on lack of spare part)
- Cost for storaging
- Turnover rates (Excluding insurance spare parts)
- Inventory value / Insurance value of the production equipment

# Spare parts management

**Assessing the need for spare parts**

Maintenance activities often imply a need for replacement parts to be available in the stockroom. Therefore, to avoid unnecessary production downtime caused by long lead times, selected spare parts should be kept in stock. Spare parts not kept in stock should also be registered and linked to objects to reduce lead times when ordering. For recurring maintenance linked to appropriate objects, activities such as predetermined maintenance, spare parts should be ordered for the planned event instead of being kept in stock. Costs for storaging should be weighed against costs arising from shortages, but there are several other parameters to take into account in order to make a proper needs assessment, for instance material prone to ageing.

EXAMPLES OF DATA FOR NEEDS ASSESSMENTS:

- Consumption statistics
- Supplier integration
- Commitment from maintenance technicians and management
- Classification of spare parts

# Assessing the need for spare parts

### Classification of spare parts

To make it easier to optimise the stock, the spare parts could be divided into the following classes:

CONSUMABLES

- **Items that cannot be considered as a spare part and may have a high consumption rate or low value.**

CONSUMABLE SPARE PARTS

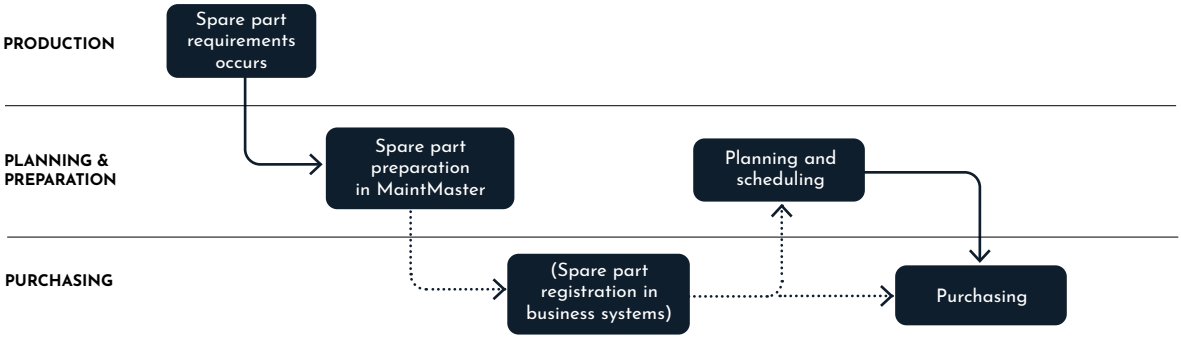
- Standard items such as sensors, cylinders and valves that can be used on several types of equipment, often with a lower value and a short lead time.

INSURANCE SPARE PARTS

- Spare parts that are kept in stock to avoid long and costly downtime. These can be expensive and often have a long lead time.

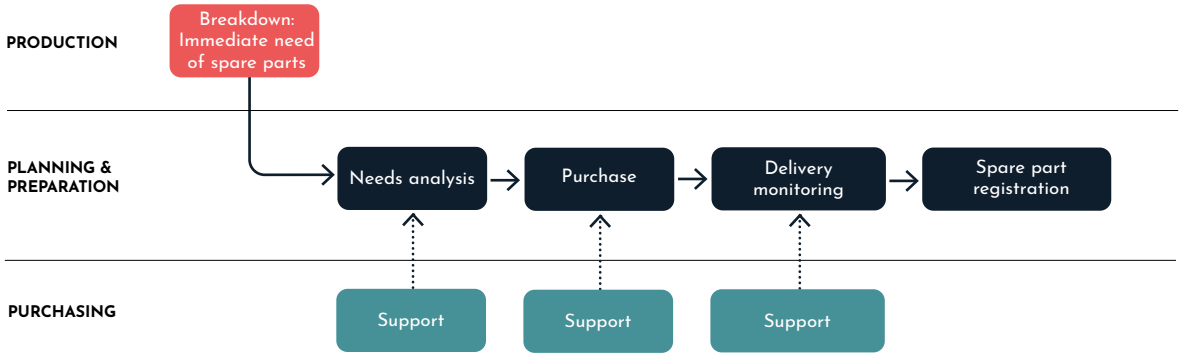
# Spare part preparation and registration

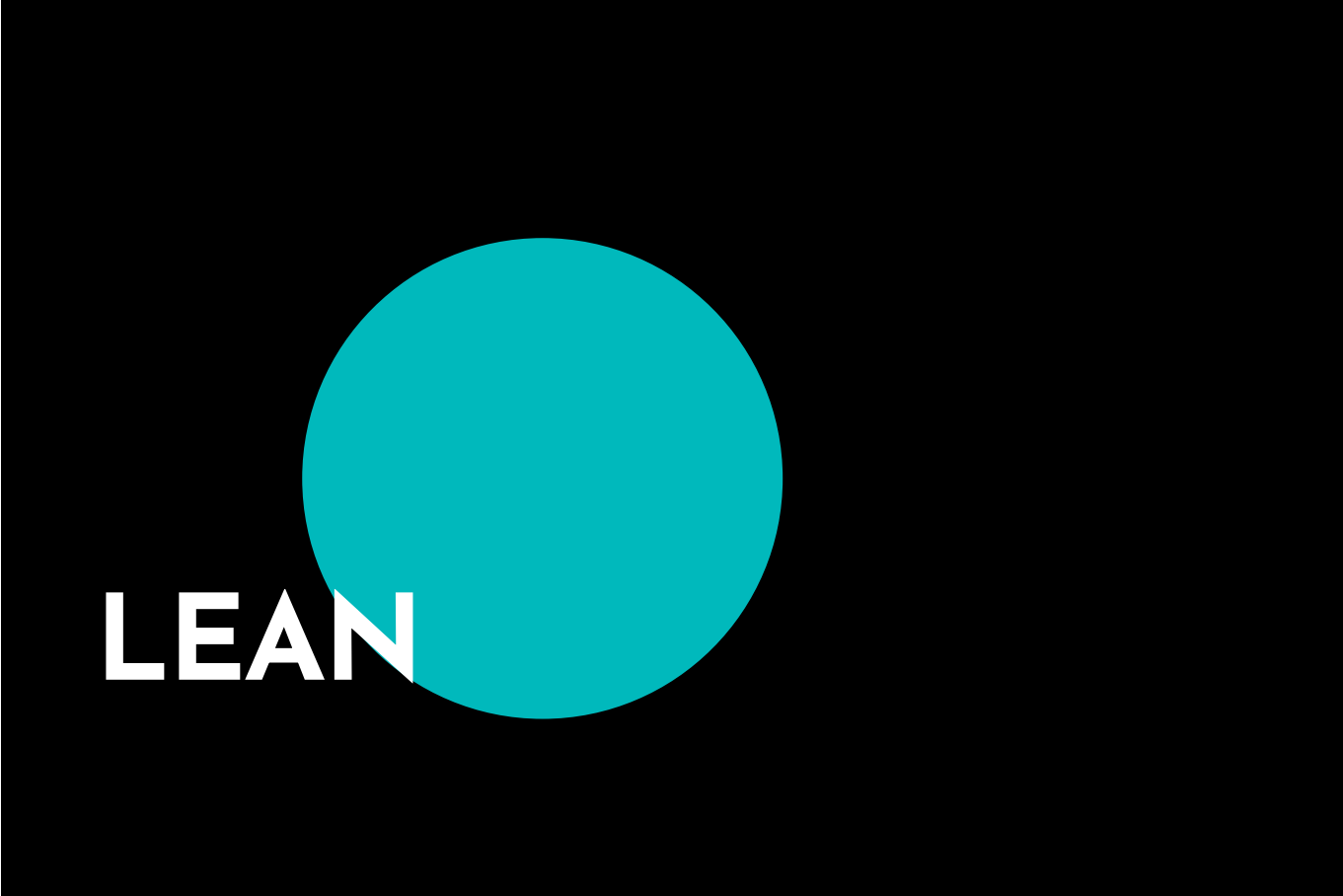
The process map below shows the responsibilities and procedures for registering and purchasing spare parts in a normal situation. The scheduler or technician is responsible for ensuring that spare parts preparation is carried out for the line or equipment within their given area of responsibility. Support for this work may be called upon from maintenance management.



# **Immediate spare part need** (non-stock item)

The process map below shows the responsibilities and procedures for registering and purchasing spare parts in case of a breakdown. The responsibility for an emergency purchase lies with the maintenance or department manager. Fact finding and ordering is delegated to the maintenance technician who can invoke the support of the maintenance management.

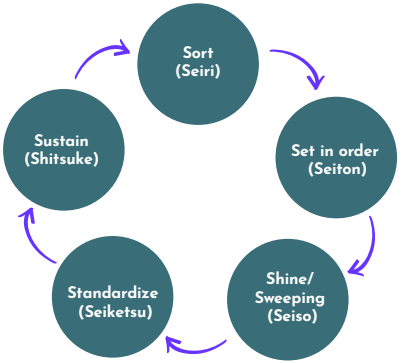



LEAN

# LEAN - 5S

5S is a method for creating and maintaining an efficient, safe and orderly workplace. 5S can be introduced equally well in an office as in production, and is based on everyone's participation. 5S comes from five Japanese words, which have been translated into English, see explanation below.

A well-organised workplace makes work easier and significantly reduces the risk of injury. It also increases opportunities for better maintenance and reduces waste such as long changeover times and rejects. Above all, it makes for a more pleasant workplace and a more stable processes.



# Systematic Work Environment Management

# Systematic work environment management

**Safe maintenance work**

Maintenance aims to reduce disturbances and interruptions in production. All countries have legislation covering health and safety at work. All work must be planned and organised so that it can be carried out in a healthy and safe environment. Also extraordinary work, such as repairs due to a machine breakdown, must be planned and prepared so that it does not pose a risk to maintenance technicians or people in the vicinity. Machinery, equipment and other technical devices must be designed, positioned and used in such a way as to provide adequate protection against ill health and accidents.

**Coordination responsibilities**

A contractor's activities has always been ordered by someone within your organisation. It should be established who has the coordination responsibility for the work carried out by any subcontractor. The coordinator must schedule the work and ensure that the responsibility for protective devices, barriers and other protective measures, such as hot work permits are clearly divided between the orderer and the contractor. Communication and joint planning are needed to reduce the risks that may arise during ongoing maintenance work. The person ordering the service is normally responsible for ensuring that the contractor has knowledge of, and complies with all applicable regulations.

# Notes

# Notes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