Risk-Based Maintenance

How can you establish only carrying out the correct maintenance: no more and no less?

palletising

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SUMMARY

Do you want to get more out of maintenance, but wonder how to approach this? Many asset owners struggle with the challenges of how to optimise the performance of their assets and how to improve their maintenance strategy.
Applying a Risk-Based Maintenance strategy can be beneficial.

Contents

What is Risk-Based Maintenance?

Risk-Based Maintenance

Risk-Based Maintenance (RBM) is a method that primarily focuses on the philosophy of managing maintenance based on risks and their magnitude. Applying this method ensures a maintenance concept that is driven by technical availability as well as machine reliability based on CSi expertise and exponentially growing maintenance data.

Within RBM there are basically two different tools, which are used and combined to create the maintenance concept.

Risk matrix

A risk matrix is used while developing maintenance concepts. This is necessary to determine whether maintenance actions can make a value added (positive) contribution to the company's objectives, such as availability, optimising maintenance costs, maintaining the desired production quality, etc. The risk matrix is determined based on the business objectives of your organisation. An initial determination is made with regard to the acceptance limits of relevant risks. This is basically a classification of the criticality, based on the combination of the probability of a failure and the effect of such a failure. It is carried out for each system and piece of equipment, on the basis that no maintenance is performed at all.
In summary, the risk matrix with its acceptance limits provides the fundamental reasoning for executing maintenance. Eventually, unacceptable situations have to be mitigated or prevented, which is where FMECA (Failure Mode Effect & Criticality Analysis) comes into play.

Assessing Risks

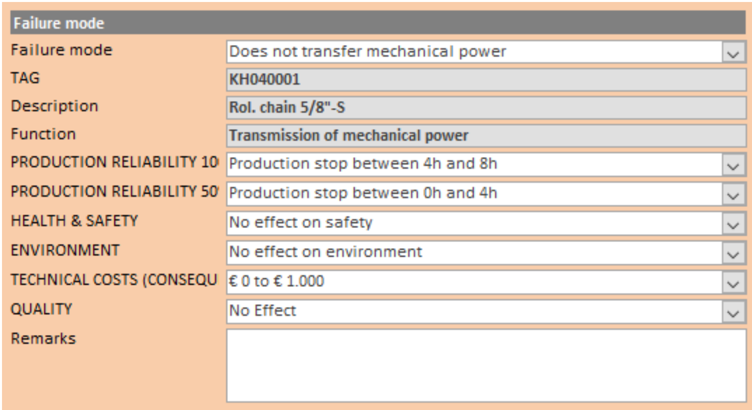
Probability of a failure

Effect of a failure

Probability of a failure X Effect of a failure	Unlikely	Possible	Likely
Low	1	2	3
Medium	2	4	6
High	3	6	9

FMECA

The maintenance concept has to be created once a validated risk matrix has been prepared. This will be realised by applying the Failure Mode Effect & Criticality Analysis (FMECA) method, in which 'Criticality' reflects the risk matrix.
The FMECA method is a systematic analysis that aims to identify all possible causes and consequences related to failures in a technical system before they actually occur. In particular, the effect of any such failure on fulfilling the function of a system is examined. The execution of an FMECA indicates the risk area in which a specific piece of equipment lies. Depending on the criticality of the equipment, the corresponding measures are then taken. These measures refer to defining the correct maintenance strategy and spare parts recommendations, as well as the actual maintenance task that has to be executed to mitigate or prevent the risk. This maps out the 'who, what, when and why'. In this way, the maintenance performed is always based on the strategically chosen objectives that are drawn up in the risk matrix.



Input and output

Input

We are able to import a company's risk matrix into an RBM program. In this way, the FMECA process and functionality is programmed into a database. These two tools ensure that the data in the program remains flexible and is custom-made for each customer.

Output

The program creates databases with all the information from any analysis performed. The program filters the data depending on the information that is required and presents it in the form of reports. The reports give an indication of the following factors:

- Object structure
- Criticality
- Failure causes & failure modes
- Unmitigated & mitigated risks
- Maintenance concept
- Preventive maintenance tasks
- Rounds
- Spare parts

The analysis itself can also be exported, in case it needs to be imported into a Computerised Maintenance Management System (CMMS).

What is the advantage of applying RBM?

Customer feedback before implementation

As described in the text above, RBM is flexible and is able to provide a detailed and customer-specific maintenance concept. Feedback from the customer forms an important part of the development. When developing the maintenance concept there will be regular consultations between the customer and CSi to fine-tune and optimise the maintenance concept. One of the important subjects concerns who will carry out the actual maintenance. Some customers may prefer to do as much as possible themselves, while others prefer to let CSi perform all the maintenance.

Custom made for each installed item

Every analysis made will be based on the actual installed item. Therefore it is possible to take several parameters into account that could influence the maintenance. Using data provided by the customer combined with our experience will result in a better maintenance concept. Hence, each machine can be maintained at a different interval or with a different maintenance strategy. This results in a custom-made plan based on the machines and the production at the customer's site. This level of customisation and flexibility gives the customer an optimal maintenance plan that raises the Overall Equipment Effectiveness (OEE).

Overall Equipment Effectiveness

Used in many companies, an OEE assessment provides an indication of the effectiveness of the machines in use. Basically, the OEE calculation assumes the theoretical maximum capacity on the one hand, and on the other, the actual output. By applying RBM, the OEE should significantly improve over the years, approaching the theoretical maximum capacity.

OEE is measured by three separate components: technical availability, machine performance and product quality.

Complete maintenance strategy

As explained, the criticality of certain equipment is determined by performing an FMECA analysis. Based on the outcome of this, a maintenance strategy will be determined, from which there are three different options:

Usage-Based Maintenance

Usage-Based Maintenance (UBM) is a preventive maintenance strategy that is executed based on the number of operating hours. This strategy entails the periodic replacement of parts. Within RBM, UBM is commonly applied in cases where there is a reliable indication of the number of operating hours that can cause a failure, and in cases where a piece of equipment is less expensive, while its risk factor is unacceptable.

Condition-Based Maintenance

Condition-Based Maintenance (CBM) is a preventive maintenance strategy based on inspections or measurements. The inspection is often followed up by more extensive maintenance (CBM follow-up) after exceeding the value of functioning. The predictability of this maintenance method is high. Within RBM, CBM is commonly applied in cases where the function of equipment can be easily checked or when the equipment is more expensive, while its risk factor is unacceptable.

Run-to-Failure

Run-to-Failure (RTF) or Failure-Based Maintenance is a maintenance strategy that is executed when defects or malfunctions have already occurred. This type of maintenance in effect comprises repairing or replacing. The predictability of maintenance is low. Within RBM, RTF is commonly used when the risk factor of a piece of equipment is acceptable. Another option for applying RTF is in a situation where the risk factor for a piece of equipment is unacceptable, but spare parts are in stock.

Maintenance jobs insight

The assigned maintenance strategy is translated into a maintenance task. The maintenance task describes the actual action that is advised to be executed, including an insight into the mitigating effect of the task with regard to the criticality of the component and the necessity to execute the task.

A known maintenance budget

All material and labour costs are determined during an RBM analysis. This ensures a known (indication) of the required maintenance budget during a specific period of time. Unplanned costs are to a large extent replaced by planned costs, thereby mitigating the likelihood of surprises.

Optional additions

There is a possibility to add some optional functionality at the request of customers. Work instructions and linking drawings ensures an addition to RBM. Basically, the 'how' is also added to the concept.

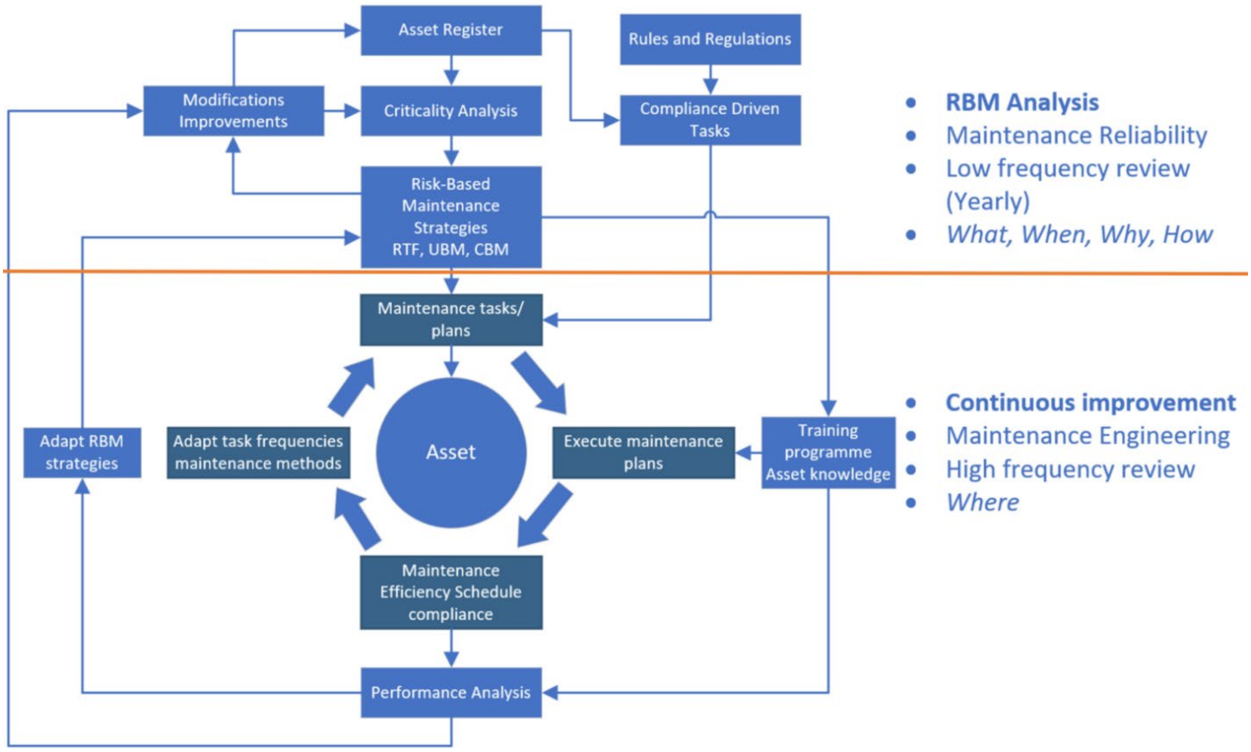
- Work instructions
  Work instructions can optionally be provided if a customer requires this for a specific maintenance task. Primarily if customers want to execute the maintenance (partly) themselves.

- Drawings
  The drawings of each system/component, and thus the part that needs maintenance, can be incorporated in the system. By having this output available, it is always known which drawing belongs to which part, with its included maintenance task.

Continuous Improvement

The output of an RBM analysis, which is termed the maintenance concept, is ready for operation once the initial analysis has been performed. It should be noted that a maintenance concept is always 'dynamic', and should be constantly improved based on the experience accumulated by working with it. This is where continuous improvement comes into play. The use of a CMMS application can be effective in managing the maintenance plan and applying continuous improvement. The figure below shows the Reliability and Maintenance model and its process.

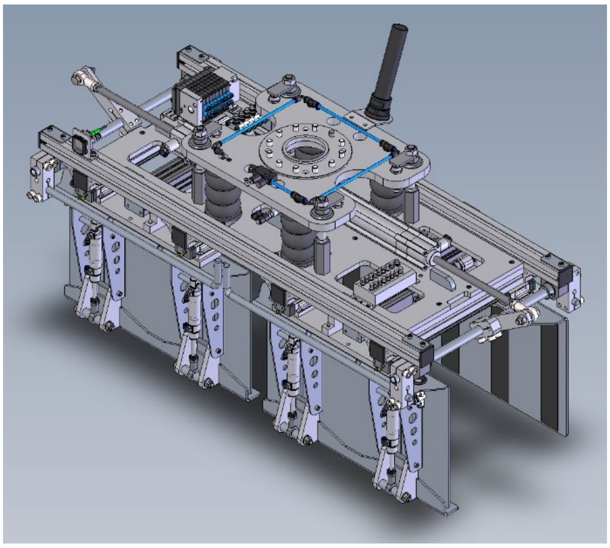
Reliability and Maintenance model

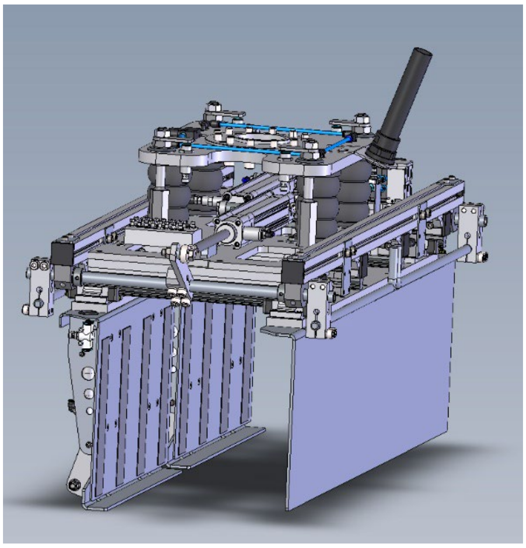


Example case

Note: The purpose of this example case is to give an insight into the approach of RBM in practice with CSi equipment. The data used for this example are fictional.

In this short case study we will analyse a CSi Clamp Hook Pallet Gripper, while applying Risk-Based Maintenance.





Clamp Hook Pallet Gripper

1. In the first step, the BOM information has to be collected, in order to perform the analysis on the actual machine data. Once this data has been gathered, a distinction must be made between Maintenance Significant Items and Maintenance Insignificant Items since only the parts that are subject to maintenance should be analysed. Screening would provide the following object structure:

2. Before the analysis can be performed, the risk matrix with the company objectives has to be clear and imported into the RBM program. A risk matrix is always company specific, therefore in this example the CSi template is used.

- 1200 - Clamp hook pallet gripper
  - 1200.0 - Electrical parts
    - 1200-K51–0 - Auxilary relay 31E
    - 1200-K51–1 - Suppressor S00
    - 1200-K52–0 - Auxilary relay 31E
    - 1200-K52–1 - Suppressor S00
    - 1200-K53–0 - Auxilary relay 31E
    - 1200-K53–1 - Suppressor S00
    - 1200-K54–0 - Auxilary relay 31E
    - 1200-K54–1 - Suppressor S00
    - 1200-S17–2 - Contact element 01E
    - 1200-S17–3 - Contact element 01E
    - 1200-U21–1 - Safety light barrier M4000 A/P standard
    - 1200-U21–2 - Mirror M4000 pasive
    - 1200-U31–1 - Safety light barrier M4000 A/P standard
    - 1200-U31–2 - Mirror M4000 pasive
    - 1200-U41–1 - Safety light barrier M4000 A/P standard
    - 1200-U41–2 - Mirror M4000 pasive
  - 1200A - Clamp hook pallet gripper
    - 1200.10.10.70A - Air bellow W01-R58-4081
    - 1200.10.20.40A - Rail BRH-25-N
    - 1200.10.30.40A - Safety Walk Rubber Ref310
    - 1200.10.40.110A - Safety Walk Rubber Ref310
    - 1200.10.40.80.10A - Cylinder DSNU-25-40-PPS-A
    - 1200.10.40.90.30A - Bearing MFM-1016-16 Igus
    - 1200.10.50.30A - Cyl ADN-32-140-A-PPS-A
    - 1200.10.60.30A - Cyl ADN-32-140-A-PPS-A
    - 1200.10.70.30A - Cyl. ADN-40-125-A-PPS-A
    - 1200.10.80.30A - Cyl. ADN-40-125-A-PPS-A
    - 1200.10.90.10A - Housing + slide bearing
    - 1200.10.90.110.10A - Cyl. DSBC-40-215-C-PPVA
    - 1200.20.10A - Valve terminal CPV10-VI
    - 1200.20.120A - Input module
    - 1200.20.20A - Pressure regulator
    - 1200.20.30A - Non Return Valve
    - 1200.20.40A - One-way flow contrl valve
    - 1200.20.50A - Speed reducing valve
    - 1200.20.60.10A - Pressure sensor SPAB
    - 1200.20.70A - Proximity sensor
    - 1200.30.300.10A - On/off valve 3/2
    - 1200.30.300.120A - Pressure switch
    - 1200.30.300.130A - Proximity sensor
    - 1200.30.300.20A - Filter regulator
    - 1200.30.300.30A - On/off valve 3/2
    - 1200.40.10A - Robot head connector Devi
    - 1200.40.30A - Proximity switch 8mm b NO
    - 1200.40.40A - Photo electric cell proxi
  - 1200B - Robot + socle IRB660 H=2100
    - 1200.10B - Robot socle IRB660 H=2100

1. Object structure

Criticality Matrix

Criticality Matrix AVAILABILITY

	Risk = Chance x Effect		Chance					
			10y >	5y - 10y	1y - 5y	6m - 1y	3m - 6m	0 - 3m
		Weegfactor	1	2	4	8	16	32
EFFECT	1. No effect	2	2	4	8	16	32	64
	2. Production stop between 1/2h and 1h	6	6	12	24	48	96	192
	3. Production stop between 1h and 4h	18	18	36	72	144	288	576
	4. Production stop between 4h and 12h	54	54	108	216	432	864	1.728
	5. More than 12 hours production stop	162	162	324	648	1.296	2.592	5.184
	Risk-Line	162						

Criticality Matrix HEALTH & SAFETY

	Risk = Chance x Effect		Chance					
			10y >	5y - 10y	1y - 5y	6m - 1y	3m - 6m	0 - 3m
		Weegfactor	1	2	4	8	16	32
EFFECT	1. No effect on safety	2	2	4	8	16	32	64
	2. Almost accident	6	6	12	24	48	96	192
	3. Accident with medic, no perminent injury	18	18	36	72	144	288	576
	4. Accident with absence, no perminent injury	54	54	108	216	432	864	1.728
	5. Severe accident with perminent injury	162	162	324	648	1.296	2.592	5.184
	6. Fatal injury	486	486	972	1.944	3.888	7.776	15.552
	Risk-Line	64						

Criticality Matrix ENVIRONMENT

	Risk = Chance x Effect		Chance					
			10y >	5y - 10y	1y - 5y	6m - 1y	3m - 6m	0 - 3m
		Weegfactor	1	2	4	8	16	32
EFFECT	1. No effect on environment	2	2	4	8	16	32	64
	2. Internal reporting / Pollution within gate	6	6	12	24	48	96	192
	3. External reporting / Complaints	18	18	36	72	144	288	576
	4. Fine / Warning / Penalty	54	54	108	216	432	864	1.728
	5. Withdraw permit / Incident with major impact on environment	162	162	324	648	1.296	2.592	5.184
	Risk-Line	64						

Criticality Matrix TECHNICAL COSTS

	Risk = Chance x Effect		Chance					
			10y >	5y - 10y	1y - 5y	6m - 1y	3m - 6m	0 - 3m
		Weegfactor	1	2	4	8	16	32
EFFECT	1. 0 to € 500	2	2	4	8	16	32	64
	2. € 500 to € 2.000	6	6	12	24	48	96	192
	3. € 2.000 to € 5.000	18	18	36	72	144	288	576
	4. € 5.000 to € 15.000	54	54	108	216	432	864	1.728
	5. € 15.000 and more	162	162	324	648	1.296	2.592	5.184
	Risk-Line	162						

Criticality Matrix REPUTATION

	Risk = Chance x Effect		Chance					
			10y >	5y - 10y	1y - 5y	6m - 1y	3m - 6m	0 - 3m
		Weegfactor	1	2	4	8	16	32
EFFECT	1. No influence on reputation	2	2	4	8	16	32	64
	2. Limited influence, reporting within organisation	6	6	12	24	48	96	192
	3. Large influence; Reputation damage by customer complaint	18	18	36	72	144	288	576
	4. Large influence; Reporting in local news	54	54	108	216	432	864	1.728
	5. Verry large influence; Reporting in (inter)national news	162	162	324	648	1.296	2.592	5.184
	Risk-Line	100						

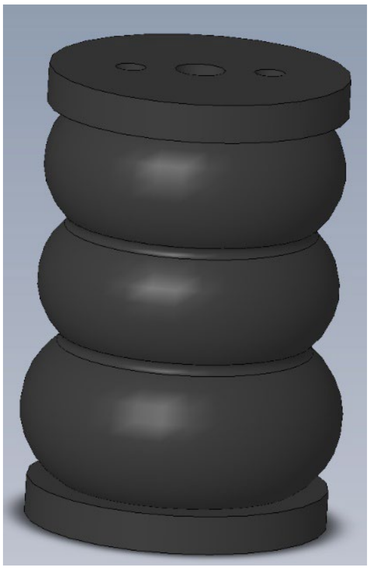
2. Risk matrix

3. Now that the object structure and risk matrix are known, it is possible to carry out the RBM analysis. In this example, one part of the Clamp Hook Pallet Gripper will be analysed.

Air bellow

- Part properties

Properties		
Object type	Equipment	
TAG / Parent TAG	1200.10.10.70A	1200A
Description	Air bellow W01-R58-4081	
Function	Convert air to movement	
Drawing	A148082	
Criticality system		Status OPERATING
Typical	E092.423	
Remarks		
Mutations	Altered ☐ Added ☐ Moved ☐	367134
Free fields		
Article number	E092.423	
Extended description	DR Size 2 3/4 x3 Al Assy	
Drawing norm	Firestone	
Quantity used	4	
Unit	pc	
BOM-level	5	
Delivery time rush (days)	5	
Delivery time normal (days)	15	



- Failure mode properties and effect on risk matrix

Failure mode	
Failure mode	Does not convert air to movement
TAG	1200.10.10.70A
Description	Air bellow W01-R58-4081
Function	Convert air to movement
PRODUCTION RELIABILITY 10	Production stop of 5d and higher
PRODUCTION RELIABILITY 50	Production stop between 0h and 4h
HEALTH & SAFETY	No effect on safety
ENVIRONMENT	No effect on environment
TECHNICAL COSTS (CONSEQU	€ 0 to € 1.000
QUALITY	No Effect
Remarks	

	Unmitigated
PRODUCTION RELIABILITY 10	E-5
PRODUCTION RELIABILITY 50	A-5
HEALTH & SAFETY	A-5
ENVIRONMENT	A-5
TECHNICAL COSTS (CONSEQU	B-5
QUALITY	A-5
Risk Level	=> Overall risk level

- Failure cause properties and MTBF

Failure cause		
Failure cause	Dehydrated bellow	
Failure mode	Does not convert air to movement	
Condition	Aging	
Failure type	Used based	
MTBF (unmitigated)	4	Years

- Task details for risk mitigation

Task			
Strategy	CBM	Condition Based Maintenance	
Task description	Inspect bellow		
Remarks	Depending on condition inspection interval could be shortened.		
Work instruction			
Adjustment data			
Round Number			
MTBF (unmitigated)	4 Years	MTBF (mitigated)	20 Years
Impact spare part	☐		
Task type	Inspection		
Consequence	Down		
Execution	Plannable		
Interval	6 Months		
Duration / Downtime (Hrs)	0,1	0,1	
Trade	CSi Field support eng		
Num. workers	1		
Costs material	€ 0,00		
Costs external	€ 0,00		
Costs total	€ 9,60		
Mandatory	☐		
Selected	☑		

Follow-up Task			
Task description	Replace bellow		
Remarks			
Work instruction			
Adjustment data			
Strategy	CBM Follow-Up	Spare part ?	☐
Task type	Replace component		
Consequence	Down		
Execution	Plannable		
Trade	CSi Field support engi		
Duration / Downtime (Hrs)	1	1	
Num. workers	1		
Costs material	€ 165,00		
Costs external	€ 0,00		
Costs total	€ 261,00		

- Task effect on risk matrix

	Unmitigated	Mitigated
PRODUCTION RELIABILITY 10	E-5	E-8
PRODUCTION RELIABILITY 50	A-5	A-8
HEALTH & SAFETY	A-5	A-8
ENVIRONMENT	A-5	A-8
TECHNICAL COSTS (CONSEQU	B-5	B-8
QUALITY	A-5	A-8
Risk Level	=> Overall risk level	=> Overall risk level

In the case of the air bellow, **Condition-Based Maintenance** is applied in order to mitigate the risk of failure and unplanned downtime. Inspections are performed in order to prevent the part from failing (i.e., being aware that a failure is going to occur in the event that the part is not replaced). Thus, in this case the part is replaced <u>before</u> the failure would take place.

Conclusion

To conclude, applying a Risk-Based Maintenance strategy would ensure added value to your asset, by only carrying out the appropriate maintenance, determined based on your business objectives. The availability of a customer specific risk matrix, in combination with applying a Failure Mode & Effect Analysis, will generate several outputs such as:

- Object structure
- Criticality
- Failure causes & failure modes
- Unmitigated & mitigated risks
- Preventive maintenance tasks
- Rounds
- Spare parts strategy

The complete set of these outcomes is termed the 'maintenance concept', which leads to:

- Fewer unplanned breakdowns in the systems
- Reducing interruptions within the production process
- Leading to greater safety
- Increased machine reliability
- Higher technical availability
- A known maintenance budget

How can we help you?

Are you interested in optimising your maintenance strategy and adding more value to your assets? Applying a Risk-Based Maintenance strategy would lead to several benefits.

CSi has almost 60 years of experience in realising all forms of projects around palletising and conveying equipment. Based on that history, CSi is highly capable of executing all types of palletising projects. Having built experience with both robotic palletising and layer palletising since the beginning of the 1980s, CSI has truly become a specialist in this field. We are always happy to be able to share our wealth of knowledge and experience with customers that are thinking about automatic palletising.

If you would like to receive more information, please do not hesitate to contact us.

CSi palletising

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