

Evaluating the Effectiveness of Chosen Maintenance Strategies for Dedicated Equipment

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Module:	ACMA 6007 - Plant and Asset Engineering
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Glossary

CMMS	Computerised maintenance management system
EOT	Electric overhead travelling
FMEA	Failure modes effects analysis
FMECA	Failure modes, effects, and criticality analysis
FRACAS	Failure reporting, analysis, and corrective action system
HAZOP	Hazard and operability
LOLER	Lifting Operations & Lifting Equipment Regulations
M1	Type of notification raised: malfunction report
M2	Type of notification raised: maintenance report
M3	Type of notification raised: activity report
P-F curve	Graph to show the interval between potential and functional failure
P1	Priority of notification: High, within 24 hours
P2	Priority of notification: Medium, within 14 days
P4	Priority of notification: Low, within 12 weeks
RAM	Risk assessment matrix
RTF	Run to failure
SAP	Tata's CMMS program

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Introduction

Tata Steel Port Talbot is an integrated steel plant with two blast furnaces producing iron for the steel making process. As part of this process, there are a number of critical assets which are crucial to the production of the iron. The chosen asset to be considered in this report is the No5 Blast Furnace cast house crane MA48 which was manufactured in 2002 so is considered to be at its end of lifecycle stage (see Appendix 1 for technical drawing). This EOT crane is essential to the process and carries out activities such as removing iron runner covers, trough cleaning and general production movements over an intermittent working period. The crane is required to work in a harsh environment which includes heat exposure, dust and potentially gaseous environments. Throughout this report, critical evaluations will be carried out on the maintenance activities and practices that are currently in place and suggestions for improvement will be made which could potentially increase the availability of the crane, and, in turn, the productivity of the asset and process. Careful consideration will be made to the selection of the improvements, including cost, criticality and environment to ensure the suggestions are feasible and beneficial to the overall production process. Finally, the report will be drawn to a conclusion to summarise the main discussions for recommendation.

1. Critical Review of Current Maintenance Practices

MA48 crane, as with other Tata steel assets, has its maintenance controlled by a CMMS called SAP. In order to critically review the maintenance activity, a partial FRACAS has been carried out to identify potential improvements to current strategies (Smith & Keeter, 2011). After scrutiny of the cranes maintenance plans, (see Appendix 2) it can be seen that since 2020 there are 11 live maintenance/examination plans which would indicate that the crane is currently being managed with a frequency based preventative maintenance strategy. These scheduled plans range from statutory thorough examinations, electrical/mechanical inspections and visual inspections. Each has a varying frequency ranging from 1 month to 12 months which should invariably dictate the depth of inspection, however, it is currently very difficult to understand if this is the case. This is due to the realisation that there is not data i.e. no inspection checklists, within many of the maintenance plans and this raises questions as to what measurements are being taken and how these are actually monitored through their component life cycle. The only maintenance checklists that have been made available are stemming from M3 activity notifications that are raised post maintenance activity which can be seen in Appendix 3. These checklists do take into account some wear aging parts, however, do not comprehensively monitor the wear rates and furthermore they are missing critical measurement points which renders the reports primarily qualitative.

In addition to the maintenance plan investigation, the notifications have also undergone scrutiny where the priority and reason for notification has been identified. The type of defect and priority of notifications can highlight many clues to a maintenance method and uncover whether the chosen method is effective.

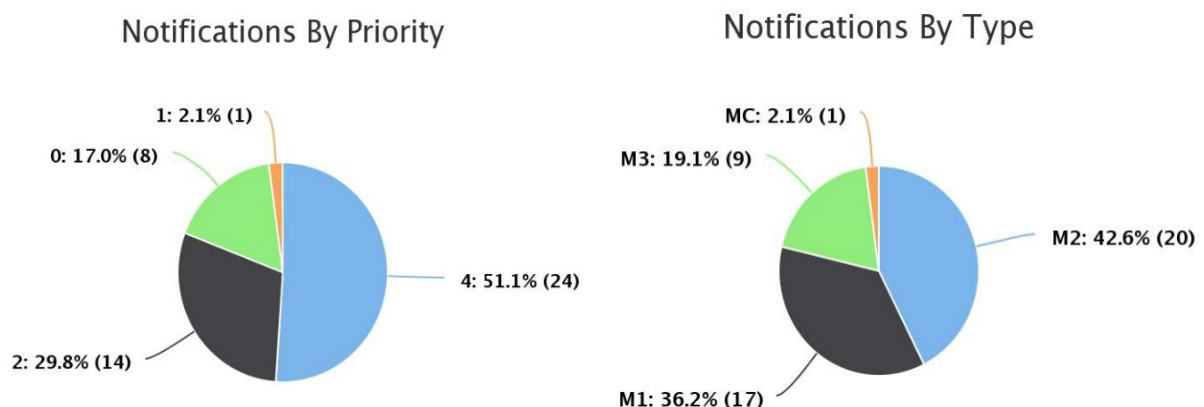


Figure 1 – Notifications by priority and type

Figure 1 highlights that over 30% of notifications raised are of medium and high priority which gives a clear indication that the current maintenance plan, even though intended to be a preventative strategy, is likely to be operating within the corrective maintenance/RTF strategy. This can be seen in the P-F curve whereby the failures are required to be repaired in a very short time frame and tend to require complete replacement rather than specific maintenance which is not cost effective.

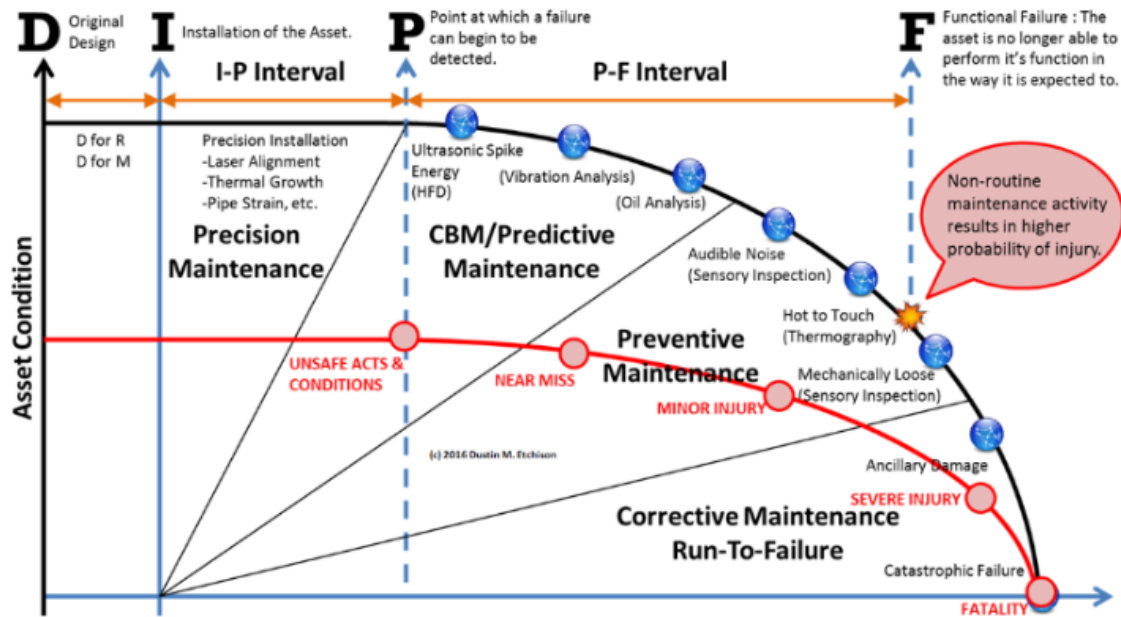


Figure 2 - P-F curve (Riddell, 2022)

To further bolster this opinion, Figure 1 also highlights that 42% of the notifications that were raised are M2 notifications. M2 notifications are classified as malfunction reports and as such, the part has already failed or is due to fail in a short time period. It is also clear that the notifications that have been raised have not been identified by the frequency maintenance routines carried out. The notifications are primarily raised via an ad-hoc process rather than the work feedback process within SAP, i.e. on a breakdown or by production. This can be seen in Table 1. However, it must be noted that this could be due to lack of feedback training within the SAP system and incorrect feedback is occurring.

Notification Breakdown					
Proactive M1	Proactive M2	Proactive M3	Ad Hoc M1	Ad Hoc M2	Ad Hoc M3
9	0	2	8	20	7

Table 1 - Circumstance in which notifications are raised

Finally, the timeline of notifications raised over the past two years against the asset clearly highlights trends within the reporting. As Figure 3 indicates, there is a clear trend where the peaks of notifications occur and it coincides with the dates for the statutory LOLER 1998 Report of Thorough Examination. Since the competent person only examines the crane once every 12 months and is identifying defects, again shows an ineffective maintenance plan.



Figure 3 - Notifications created by month since 2021

To summarise, the chosen maintenance method does not appear to be effective in preventing unplanned breakdowns of the crane and this is backed with data to show that the notifications raised are for breakdowns and high priority in nature. This, coupled with the often late and low completion rate for maintenance routines, is clearly causing further degradation to this item of aged lifting equipment.

2. Evaluation of How Current Maintenance Approaches Could be Improved

The critical evaluation highlights that the main focus should be on getting the asset initially from a RTF strategy to a basic preventative state. Once this is achieved, a combination based approach could then be adopted whereby reliability centered maintenance (RCM) is recommended. Firstly, for the short term strategy, the low cost and quick win options should be addressed. Missed inspections have been identified within the maintenance plans as shown in Appendix 2 and only 15% of the inspections were completed for the 10 week mechanical and electrical inspections which clearly does not provide a robust maintenance plan for this aged crane. The bathtub curve highlights that an increased level of maintenance is required to minimise the number of breakdowns of the equipment.

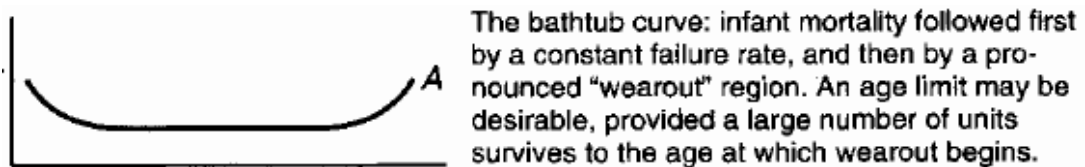


Figure 4 - Bathtub curve showing failure trends (y) compared to age (x) (Klutke, et al., 2003)

The main reason for this is that production dictate the release of the asset and this would need to be addressed as it is vital that maintenance is carried out to increase asset uptime. Delaying or denying maintenance activities has a larger impact on future costs in regards to repair and safety. Secondly, the maintenance plans will be required to have maintenance checklists which are jointly drawn from manufacturers recommendations, experience and history. These check sheets should have trigger points and comprehensive task descriptions within them, enabling maintenance teams to understand wear rates and plan the changeout of ageing items at a time to minimise production disruption and prior to catastrophic failure. An example of descriptions can be seen in Table 2. It would also be prudent to ensure that hidden failure items are identified early (such as backup limit devices) and that routine testing of these mechanisms is carried out to prevent multiple failure modes (Mowbray, 1997).

Wrong description	Right description	Notes
Check coupling	Check main hoist first motion coupling for loose bolts and replace if necessary (8 off).	e.g. 2x bolts tightened, 1 sheared and replaced.
Check hoist gearbox oil level	Check main hoist gearbox oil level, if top up required note how much oil is added.	e.g. 2 litres added
Check wheel flange wear	Measure wheel flange thickness, 10mm minimum allowed.	

Table 2 – Right and wrong task descriptions (Mowbray, 1997)

These first three activities should be monitored closely at the start to ensure effectiveness and can easily be tracked via the maintenance notifications raised. The produced maintenance reports should be quantitative to provide useable data going forward (Lizarraga & Sinha, 2016) and this will help in moving the asset to an efficient state.

After the initial suggestions to stabilise the crane maintenance program, an RCM audit/decision exercise should be carried out which would identify the following:

1. Select an asset RCM analysis

Considerations should include how critical the asset is to operations, its repair costs in the past, and its previous preventive maintenance costs.

2. Outline the functions of the system for the selected asset

Understand the function of the crane, its inputs and outputs. For example, the inputs of the crane are the production movements and energy that powers the crane.

3. Define the failure modes

Understand the different ways in which the crane can fail. For example, the crane may not transport the load fast enough or completely fail to transport them from one end to the other.

4. Assess the consequences of failure

What will happen in the event of a failure? Asset failure can result in safety concerns and poor business performance. It also can affect other equipment. Plant operators, equipment experts, and technicians should work together to identify the root causes of individual asset failure. This process determines how to prioritize tasks and FMEA, FMECA, HAZOPS, etc. should be used.

5. Determine a maintenance strategy for each failure mode

Select a maintenance strategy for each critical failure mode. The strategy should be economically and technically feasible. Condition-based maintenance (CBM), preventive maintenance, or predictive maintenance (PdM) could be utilised. If a given strategy is unable to be implemented for a particular failure mode, a redesign of the system could be done to eliminate the failure mode

completely. Non-critical failure modes can be considered for a run-to-failure maintenance strategy.

6. Implement the strategy and perform regular reviews

For the RCM program to be effective, regular reviews will help to improve the systems and performance. Whichever maintenance strategy is chosen for each asset, new data will be generated to improve the system.

(Eisner, 2022)

RCM decision worksheet: Sample										Unit	xxxxxxx
Subsystem/xxxxx											
Component-xxxxx										(a) xxxxx	(b) xxxxx (c) xxxxx (d) xxxxx
Information reference	Consequence evaluation					H1	H2	H3	Default action		
						S1	S2	S3		Proposed task	
						O1	O2	O3			
F	FF	FM	H	S	E	O	N1	N2	N3	H4	H5 S4

Figure 5 - Example of an RCM decision worksheet (Gania, et al., 2018)

Implementing the preventative maintenance routine correctly could alone save approximately 52% on downtime, and implementing a mixed strategy (RCM) would clearly lead to further cost savings along with large safety improvements (Thomas & Weiss, 2021) and, ultimately, energy efficient operations. Finally, the consideration of human error will always be present and this can lead to a functional failure. This can be accounted for within the FMEA, but only if it's a credible reason for the failure (Mowbray, 1997). It has to be noted that all of the proposed implementations to the maintenance strategy would require a management of change to document all associated hazards. This would be particularly important for the components classified as RTF from step 5 above. The management of the change is imperative for the monitoring and review of the changes to ensure they are effective (Lister, 2003).

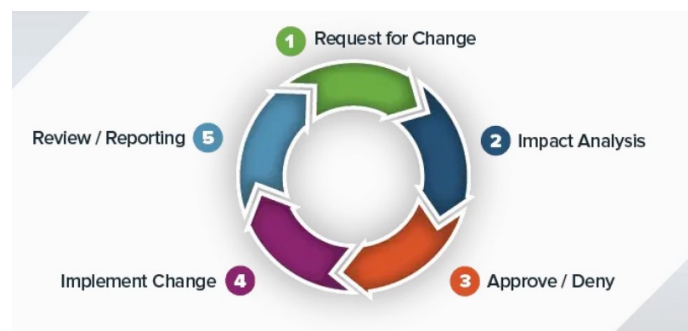


Figure 6 - Management of change cycle (Ramos, 2016)

3. Implementation Costs and Resources for Proposed Changes

The implementation of RCM not only considers the actual condition of a piece of equipment, but also the relative importance of the equipment to the whole system and is expected to be more cost effective than the traditional approaches. However, it will always come with an initial cost (Chan, et al., 2005). Primarily, there is the resource required to plan, risk assess and implement the changes that have been identified in the early discussions such as asset identification, operating conditions and criticality assessments. The team to carry out these discussions should come from all levels of the business, including operators, maintenance technicians and management to ensure all viewpoints are captured. This would severely limit the team in their ability to carry out their day to day tasks (Mowbray, 1997). RCM could also potentially identify areas where engineering out a problem could be the best option to take and this comes with significant costs such as design engineers and large changes to plant. Another consideration is the potential implementation of condition based monitoring where the start up and monitoring costs can be very high. An initial feasibility and cost benefit analysis helps in establishing accurate key performance indicators and benchmarks to measure the effectiveness of any condition monitoring programme that may be implemented and items to consider include the following:

- a) life cycle cost;
- b) cost of lost production;
- c) consequential damage;
- d) warranty and insurance.

In regards to overall cost, the initial outlay should be returned within a time period given that an increase of asset availability means higher production, less spares and less man hours required in the longer term for repairs. Finally, reviewing the proposed changes and realising whether the applied techniques have been effective takes time and as such may potentially become fruitless, in which case time and money will be lost. However, with correct preparation, this can be avoided as the evidence gathered would support the changes through a time proven RCM approach.

4. Conclusions

Equipment failures have been viewed differently throughout the years where initially a higher rate of failure was expected at the end of an assets life, however, it can be seen that this has now changed with the second and third generation views on equipment failure. Now it can be seen only 11%-23% of failures are actually age related (Baer, 2020).

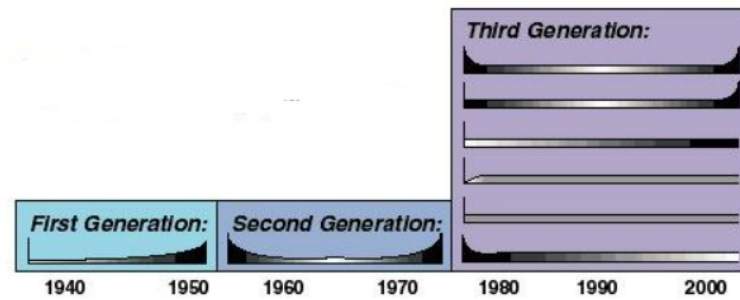


Figure 7 - Change in views on equipment failure (Mowbray, 1997)

This clearly gives an indication that a multi targeted approach needs to be taken as each asset has its own criticalities and failure modes. As per the comments within section 2 of this report, the blast furnace crane is required to have early actions taken against it to ensure the crane does not degrade further, but moving forward, the crane is required to have an RCM approach taken. An RCM approach will offer the crane its best chance of getting a tailored maintenance package which should increase safety, operating performance and a better cost effectiveness as the RCM approach focuses on techniques which have the best effect for the performance of the asset. One of the largest benefits of the aforementioned approach is that a comprehensive database can be built in order to understand the assets needs for the future which will offer a longer lifespan. This can be particularly useful when considering future upgrades as the information will already be collated for consideration.

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(2) Maintenance plans for MA48 crane

Mainten ance Plan	Mainten ance Item	Description	Work Centre	FLoc	FLoc Description	Type	MAT	Frequen cy	Man Hours	Completi on Percenta ge	Complete On Time Percenta ge	Avg Actual Hours	Next Open Order	Order Start	Order End	Call Number
30814	34921	CRANE - EOT MA48 ROPE & HOOK INSP	M20-4-M	3001-320- 2553-000Z	NORTH CAST HOUSE CRANE MA48	ZUM2	1	52 wks	1	100	100	0.5				16
30815	34922	CRANE - EOT MA48 12 MTH STAT INSP	M20-4-M	3001-320- 2553-000Z	NORTH CAST HOUSE CRANE MA48	ZUM2	S44	52 wks	1	100	100	1				16
30816	34923	(50W) TESTING EMERGENCY STOP	D66-1-E	3001-320- 2553-000Z	NORTH CAST HOUSE CRANE MA48	ZUM2	S40	50 wks	0.5	100	0	1				17
30817	34924	(10W) MA48 TRAPPING POINT INSPECTION	D66-1-M	3001-320- 2553-000Z	NORTH CAST HOUSE CRANE MA48	ZUM2	S65	10 wks	0.5	100	100	0.6	29740863	17/04/2023	17/04/2023	78
30818	34925	(8W) VIS INSP GUARDS CRANE MA48	D66-1-M	3001-320- 2553-000Z	NORTH CAST HOUSE CRANE MA48	ZUM2	S40	8 wks	1	100	86	0.74	29769749	28/04/2023	28/04/2023	89
30821	34928	(M) VIS INSP NORTH CASTHOUSE CRANE	D5E-4-E	3001-320- 2553-000Z	NORTH CAST HOUSE CRANE MA48	ZUM2	1	1Mths	4	92	15	0.08	29674845	22/03/2023	22/03/2023	615
153318	180127	(3M) CRANE MAINTENANCE/INSPECTION	D5E-4-E	3001-320- 2553-000Z	NORTH CAST HOUSE CRANE MA48	ZUM2	2	12 wks	16	100	50	0	29724262	10/04/2023	10/04/2023	78
153354	180273	MA48 ULTIMATE LIMIT TEST EAST CASTHOUSE	D5E-4-E	3001-320- 2553-000Z	NORTH CAST HOUSE CRANE MA48	ZUM2	1	26 wks	2	100	0	0	29266250	10/04/2023	10/04/2023	28
308657	381071	(10W) MECH/PM NORTH CASTHOUSE CRANE MA48	M41-4-M	3001-320- 2553-000Z	NORTH CAST HOUSE CRANE MA48	ZUM2	2	10 wks	24	14	14	3.43	29391749	28/11/2022	28/11/2022	23
308658	381072	(10W) ELEC/PM NORTH CASTHOUSE CRANE MA48	M41-4-E	3001-320- 2553-000Z	NORTH CAST HOUSE CRANE MA48	ZUM2	2	10 wks	16	13	13	3	29391750	28/11/2022	28/11/2022	23
315937	390475	(12W) CLEANING CASTHOUSE CRANE & GANTRIES	DOP-4-P	3001-320- 2553-000Z	NORTH CAST HOUSE CRANE MA48	ZUM2	22	12 wks	37	0	0	0	28492850	20/12/2021	20/12/2021	11

(3)

Port Talbot Cranes & Lifting Mechanical Maintenance Report



CRANE:	Ma 48	Date	08.09.22
NAME (S):	A. Waters, C. Phillips		

SAP Functional Location: 3001-320-2553-0007

associated document with regards to the work being carried out.

Any other work carried out not included in these documents Must be assessed with a POWRA/Take 2 document and signed as understood by personnel involved.

PROCEDURE FOR:

MECHANICAL INSPECTION AND MAINTENANCE OF MAIN HOIST

Edit box as appropriate Y or N

☐	
Y	Check all holding down bolts on motors; gearboxes; bearing pedestals; brake units; rope drum pedestals; Replace as necessary
Y	Check all brake units for wear in all pivot points and mating surfaces including securing components such as tie bar pivot pin split pins and base/shoe bolts wiring/locking washers
Y	Check all brake linings /brake drums for wear /damage; Replace as necessary report as required;
Y	Check all bolts on gearbox end covers/ bearing pedestals for tightness;
Y	Check all oil levels in gearboxes; fill to correct level as required;
Y	Check that all rope clamps are tight ;Inspect rope for damage; report as to condition;
Y	Check rope compensating device for any signs of wear, pins/fixings security and functional movement of device;
Y	Check all rope sheaves; bottom block / intrados of hook for wear and damage and report;
Y	Check the hook top nut securing devices;
NA	Check the hook anti-rotate devices if fitted
Y	Check Parmer limit for freedom of movement and lubricate pivot points as required;
Y	Check all guards are in good repair and secure; repair if possible/report;

