Assignment Guidance and Front Sheet

This front sheet for assignments is designed to contain the brief, the submission instructions, and the actual student submission for any WMG assignment. As a result the sheet is completed by several people over time, and is therefore split up into sections explaining who completes what information and when. Yellow highlighted text indicates examples or further explanation of what is requested, and the highlight and instructions should be removed as you populate 'your' section.

This sheet is only to be used for components of assessment worth more than 3 CATS (e.g. for a 15 credit module, weighted more than 20%; or for a 10 credit module, weighted more than 30%).

To be completed by the student(s) prior to final submission:

Your actual submission should be written at the end of this cover sheet file, or attached with the cover sheet at the front if drafted in a separate file, program or application.

Student ID or IDs for group work	**5569029**

To be completed (highlighted parts only) by the programme administration after approval and prior to issuing of the assessment; to be consulted by the student(s) so that you know how and when to submit:

Date set	6TH January 2025
Submission date (excluding extensions)	**3rd February 2025 by 12 PM UK time**
Submission guidance	Tabula link
Marks return date (excluding extensions)	3rd March 2025
Late submission policy	If work is submitted late, penalties will be applied at the rate of **5 marks per University working day** after the due date, up to a **maximum of 10 working days** late. After this period the mark for the work will be reduced to 0 (which is the maximum penalty). "Late" means **after the submission deadline time as well as the date** – work submitted after the given time even on the same day is counted as 1 day late. For **Postgraduate** students only, who started their **current course before 1 August 2019**, the daily penalty is **3 marks** rather than 5.
Resubmission policy	If you fail this assignment or module, please be aware that the University allows students to remedy such failure (within certain limits). Decisions to authorise such resubmissions are made by Exam Boards. Normally these will be issued at specific times of the year,

	depending on your programme of study. More information can be found from your programme office if you are concerned. **If this is already a resubmission attempt, this means you will not be eligible for an additional attempt. The University allows as standard a maximum of two attempts on any assessment (i.e. only one resubmission). Students can only have a third attempt under exceptional circumstances via a Mitigating Circumstances Panel decision.**

To be completed by the module owner/tutor prior to approval and issuing of the assessment; to be consulted by the student(s) so that you understand the assignment brief, its context within the module, and any specific criteria and advice from the tutor:

Module title & code	WM9F8-15 Quality, Reliability and Maintenance
Module owner	Jane Marshall
Module tutor	Jane Marshall
Assessment type	Essay
Weighting of mark	50%

Assessment brief

Post-module question (50 marks)

The assessment for QRM is designed to assess, in depth, the students' knowledge of the tools, techniques and methodologies that were taught throughout the complete module, including those which were demonstrated practically within group exercises.

The module learning outcomes require confirmation through a written assessment. This assessment is a key demonstrator that the student has understood the application of QRM tools to a real-life scenario. Its purpose is to assess the students' depth of understanding and application of QRM tools. This PMA will meet learning outcomes 3,4 and 5.

1. A new electronic temperature controller for a chemical processing plant is required and must meet a reliability specification for safety compliance. This new product design has incorporated new technology, new features and has different environmental conditions to previous products, develop a Q and R plan for the new design which gives a critical review of the appropriate tools and techniques.

30 marks

2. Critique and identify an asset management plan for the processing plant by developing an appropriate maintenance approach. 20 marks The plan should show the Q&R activities throughout the product life cycle. You should review and critique key Q&R tools that would ensure that the new design will meet the customer reliability and availability requirements. You do not need to implement the tools but explain which tools you think would be most appropriate and justify your choice. The asset management plan should be developed after review of maintenance methods and asset management strategy such as ISO55000. Marks are given for discussion and justification of the activities included in the plan. Key to this is demonstration of knowledge and understanding of each of the suggested tools and techniques. Marks will also be awarded for structure, presentation, flow, argument, spelling and referencing. You should refer to data and information from journals or books to support your answer and include examples to illustrate your points. The word limit for this work is maximum of 2000 words + 10%.

Word count	2000
Module learning outcomes (numbered)	**1. Develop a critical understanding of Quality Management theories** **2. Analyse lifetime data to measure reliability performance** **3. Develop a conceptual understanding of maintenance philosophies.** **4. Investigate the role of equipment asset management in an engineering business**

	5. Evaluate how quality, reliability and maintenance tools are applied. to aid customer satisfaction **6. Reflect on how the module enhances the product quality, reliability and maintenance of an engineering business**
Learning outcomes assessed in this assessment (numbered)	3,4,5
Marking guidelines	
Academic guidance resources	Module moodle, book list (on moodle), University Library databases

Contents

List of Figures

List of Tables

1.0 Introduction

Quality, Reliability and Maintenance are key factors in any product's life cycle. Quality refers to a product's features and performance standards which directly impacts customer satisfaction and demand. Whereas, Reliability focuses on products ability to perform or function consistently over the time without failure (Bruton, Conway et al. 2000). On the other hand, Maintenance includes all the efforts to keep the product working, functional and safe throughout the lifecycle of the product. These three elements are closely interconnected. That means, typically high-quality products are more reliable and requires less maintenance which help Organisation in cost reduction and improved customer satisfaction (Bhakthavatchalam, Diallo et al. 2015). The 'FRACAS' model is used to develop the Q R plan.

This report will develop a proper Q&R Plan for the controller highlighting main quality and reliability activities through product life cycle. It will critically review and justify the most appropriate tools and techniques of Quality and reliability.

2.0 The Design and Development Stage

2.1 FMEA

Failure Mode Effect Analysis is a structured method used to identify, evaluate and reduce occurred failures in products, processes or systems. This helps to prioritize failures using RPN, Risk Priority Number. RPN is calculated by multiplying three factors. ***Occurrence***, ***Severity*** and ***Detection.*** Implementing FMEA allows early detection of issues which can help to improve the product design, its reliability as well as to reduce cost. However, it can be time consuming and may not cover rare failures. It also requires continuous updates to stay effective but change in design and process can consume more time (Stamatis 2003). These are some positives and limitations of FMEA.

2.2 FTA

Fault tree analysis a graphical method used to identify and assess risks in a complex system. It helps the maintain reliability and prevent failures by showing how different how different component failures can lead to an entire system failure. It uses a fault tree diagram, in which the top event represents the main system failure and the basic failures are connected using logical gates like AND and OR. (Ruijters and Stoelinga 2015). There are various software tools available that helps in efficient FTA implementation which improves its accuracy. However, FTA comes with few limitations, like Complexity with size, large fault trees can be complex to understand. Also, FTA focuses on only failures any it may not other types of risks that can occur (Aslansefat, Kabir et al. 2020). This limits the use of FTA.

2.3 QFD

Quality Function Deployment is used to convert customer needs into specific engineering requirements during the development of the product. It ensures that the voice of the customers is considered at every stage. The process involves identifying customer requirements, creating a QFD matrix which is also known as the House of QFD. QFD offers several benefits which include, better quality of product, shorter development time by streamline communication and improved decision making, improved customer satisfaction and improvement in teamwork. Regardless of its benefits, it comes with some limitations as well. Complexity of implementation , dependency on quality of data and also it requires managing large amount of information (Cristiano, Liker et al. 2001). These are the limitations of QFD.

3.0 Manufacturing Stage

3.1 SPC

SPC is method used to monitor and improve the quality of the products by reducing variations in the process and to achieve process stability. It operates by first collecting data on process parameters, then analyzing this collected data using variety of statistical tools which include, control charts, histograms and cause and effect diagram which helps to understand behavior of the process. (Oakland and Oakland 2007). Furthermore, **Cp** (process capability index) and **Cpk** (corrected process capability index) significantly improve SPC by measuring and evaluating process performance. Cp measures how well a process can produce within the set limit but doesn't consider if the process is centered. While Cpk, checks both the capability and how process is close is close to the target. (Dudek-Burlikowska 2005). Together, Cp and Cpk play crucial role for SPC.

However, SPC requires a lot of time, planning, resources and proper training to implement effectively. Additionally, successful implementation of SPC depends on the accuracy of collected data, which means although it's an effective approach, it is still dependent on accurate input (Thor, Lundberg et al. 2007). Despite of these challenges, SPC remains a powerful tool in quality management.

3.2 Six Sigma

In the manufacturing stage of the temperature controller, precision, smoother operation is really important to meet performance and safety standards. Six Sigma provides a structured approach to achieving this by reducing defects, lowering process variations and improving overall efficiency. Through the DMAIC process which is ***Define, Measure, Analyse, Improve and Control*** methodology, issues in production process are systematically identified and addressed to improve the consistency in the process. The main highlight of Six sigma is it helps to achieve the accuracy by reducing defects up to 3.4 defects per million opportunities. Further integration of Lean principles with six sigma improves reduction in waste during the process (Venkatesh and Sumangala 2018). However, implementation of six sigma for new product can be challenging because it mainly focuses on existing process. Also, it requires significant resources for training, initial investment and mainly the resistance to change approach from employees makes its application for new product questionable.

4.0 Testing Stage

4.1 HASS

Highly Accelerated Stress Screening is a critical testing method in the manufacturing stage to identify hidden defects and weaknesses is a product before it reaches to customers. It uses extreme but controlled stress conditions which include rapid temperature change and vibrations to identify the defects which may not appear under normal operating condition. (Silverman 1998). Additionally, the feedback from HASS can be used for continuous improvement in the manufacturing process. Also, if the recurring defects are detected, further adjustments can be made to refine production techniques or selection of components.

However, the HASS testing requires specialized equipment making it an expensive investment. Also, if not observed carefully, there's always a risk of overstressing which can cause serious damage to the product or entire system (McLean 2008). These limitations make the HSS implementation limited.

4.2 ESS

Environmental Stress Screening is a testing method used in manufacturing to detect the hidden defects by exposing the product to extreme environmental conditions which include thermal cycling and random vibration within its specified limits. It helps identify weaknesses in materials or in the products itself before its deployment. The process involves rapid temperature changes which reveals certain defects. ESS plays a vital role for the temperature controller as it ensures reliability of the product. However, it still lacks in capturing all of the defect. Also, it does not fully replicate the real-world condition and its dependency on test parameters makes it restricted to implement (Zhao, Zhang et al. 2011). These are some of the limitations of ESS.

5 The Quality and Reliability plan for Electronic temperature Controller

To ensure the Quality, Reliability and safety of the Electronic Temperature Controller for a chemical processing plant requires a structured Q and R plan. The below plan is created by considering the different processes the controller goes through, the environmental conditions it will operate in and to maintain the quality for better customer satisfaction. This Q and R plan consists of three stages and each stage consists of different tools which are already discussed above.

Design and development Stage

Tools Used – FMEA, FTA and QFD

The aim of the stage is to create a reliable, safe design that aligns with needs of customers and regulatory requirements. Every tool used in this has a different benefit.

- ***FMEA*** - Failure Mode Effect Analysis helps to identify possible failures early in the design process, which helps to address the failures before they occur.
- ***FTA*** – Fault Tree Analysis examines how failures in individual components could lead to broader system failures. This tool allows to target improvements in the design phase only.
- ***QFD*** - Quality Function Deployment translates customers need and prioritize them which helps to make design changes if necessary before proceeding for actual production.

Altogether, above used tools help to minimize the risk of design errors and ensure that the product is safe and up to expectations of customers before going to manufacturing.

Manufacturing Stage

Tools Used - SPC and Six Sigma

This stage is critical in order to manufacture controller to meet the required quality standards and safety standards with remembering the cost parameter in mind.

- ***SPC*** – By monitoring variations using Cp and Cpk indices, this tool makes sure that the manufacturing process is stable and each unit produced meets the required quality standards.
- ***Six Sigma*** – It aims to improve the quality of the manufacturing process by identifying and removing sources of variation. Its high accuracy level helps to reduce the process variation and further helps in better profitability.

With help of these tools, we can minimize the production process variations while keeping the cost under control and make sure that temperature controller meets the expected quality standards.

Testing Stage

Tools used – HASS and ESSs

Testing is a critical step done before deployment of the product. It ensures the product is performing correctly in real world scenarios. It allows find hidden defects and failures occurred in a product which helps to maintain customer satisfaction and reputation of the Organisation.

- ***HASS*** – Highly Accelerated Stress Screening helps to identify hidden defects that could cause damage to the product. With the help of rapid temperature variations and vibrations, it can find the defect which could be neglected by normal operating condition.
- ***ESS*** – Environmental Stress Screening uses extreme environmental conditions like, thermal cycling and random vibration within the specified limits to detect the unseen or hidden failures.

In conclusion, the above created Q and R Plan ensures the electronic temperature controller meets high safety, quality and reliability standards. Tools used in design stage reduce the risk and align the product with customers' requirements. SPC and Six Sigma in manufacturing help to maintain the quality of the controller while keeping the cost parameter in mind. At the last, testing phase with HASS and ESS makes sure that the controller performs well under real life conditions.

Q2.

6.0 Asset Management

Asset Management is the organized approach a company uses to get the most value from its assets while maintaining efficiency and sustainability. It involves making smart decisions which align with the goals of a business to improve performance and risk (Diop, Abdul-Nour et al. 2021). Effective asset management is important because of rising competition, market changes and mainly profitability.

Fig. 1. Asset Management. (Hovhannissian 2013)

7.0 ISO 55000

ISO 55000 is an international standard for asset management which provides guidelines for Organisations to efficiently manage their assets throughout their lifecycle. It defines asset management as a coordinated activity of an Organisation to realize value from assets and performance optimization. PAS 55 which is Publicly Available Specification introduced in 2004, was a British standard that provided guidelines for managing physical assets effectively. It served as the foundation for ISO 55000 series (Ruiter 2015) ISO 55000 was further categorized into 3 branches.

1. **ISO 55000** – It provides an overview, principles and terminology for asset management.
2. **ISO 55001** – It specifies requirements for an asset management system that Organisation can adopt and get certified for
3. **ISO 55002 –** It offers guidance on how to apply ISO 55001 effectively in different industries.

ISO 55001 provides a structural framework for managing assets effectively. It covers key areas like leadership, planning, support, operations, performance evaluation and continuous improvement. Each clause represents that asset management aligns with Organisational goals, meets the requirements and enhance overall efficiency (Hastings 2021). Give below are the clauses of ISO 55001.

Clause 4 – Context of the Organisation
Clause 5 – Leadership
Clause 6 – Planning
Clause 7 – Support
Clause 8 – Operation
Clause 9 – Performance Evaluation
Clause 10 - Improvement

Table 1. Clause of ISO 55001

The table mentioned above states the list of Clauses of ISO 55001. Starting off with the clause 4 which focuses on the context of the Organisation followed by clause 5,6,7,8 and 9 which focus on leadership, planning, support, operations and performance evaluation respectively. And the last clause 10 focuses on improvement. These clauses contribute to effective asset management, ensuring alignment with Organisational goals.

Tools like RCM, TPM and CBM are essential after implementing ISO 55001 to keep assets reliable and efficient. These tools help to reduce failures, lowers cost and improve performance.

8.0 Critical Analysis of Maintenance tools

8.1 TPM

Total Productive Maintenance works by involving all employees, from the management to shop floor workers, in maintaining equipment. It promotes a culture of ownership where operators handle basic management tasks like cleaning, lubricating and inspecting machines to avoid breakdowns which is known as Autonomous Maintenance. TPM and Continuous Improvement and closely linked with Kaizen philosophy (Chan, Lau et al. 2005). TPM is built on 8 pillars which are based on 5S methodology. This approach helps Organisation to maintain their maintenance strategy. The below mentioned 8 pillars of TPM help to improve the reliability and performance.

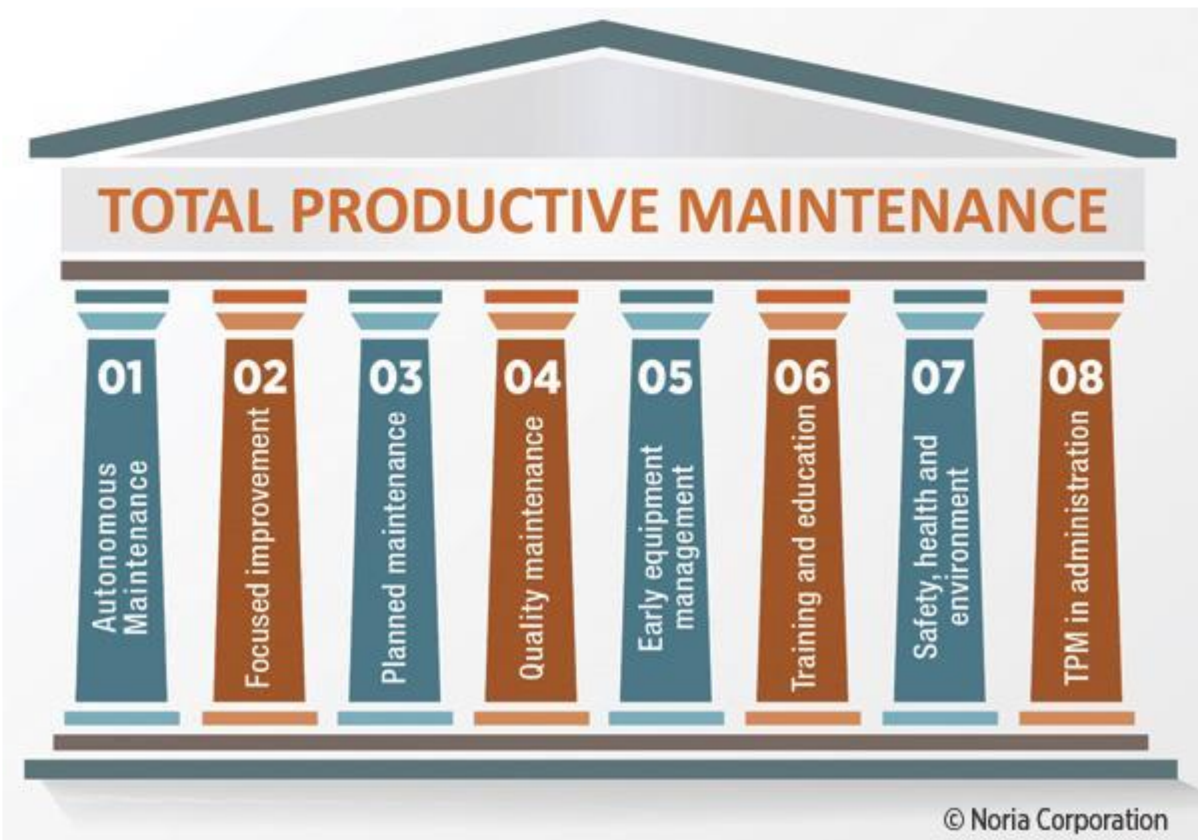

Fig. 2 Pillars of TPM (Jonathan Trout 2020).

Benefits and Limitations of TPM

TPM benefits include improvement in availability of equipment, reduced downtime and improved overall operational efficiency. It promotes employee environment, encourages works to take the ownership of workers which helps to improve product quality and teamwork between production and maintenance teams.

However, the biggest challenge to adopt TPM is resistance to change. The initial resistance from employees make the implementation of TPM questionable. Moreover, the need of extensive training and continuous support from management are also the major challenges. (Agustiady and Cudney 2018). These are the limitations of TPM.

8.2 Reliability-Centered Maintenance

Reliability Centered Maintenance is a method used to choose the best maintenance strategies to keep the system safe, reliable and efficient. It works by identifying Maintenance Significant Items through Failure Mode Effect Analysis, highlighting the effects of potential failures and then applying logical decision-making processes which is RCM Logic. This approach helps to maintain balance between maintenance cost while ensuring the system works properly (Selvik and Aven 2011) which benefits the Organisation.

Benefits and Limitations of RCM

RCM systematically identifies critical components and failures which helps to improve system reliability. By prioritizing maintenance tasks based on their importance, RCM also helps to reduce maintenance costs. It focuses on the items that impact the most which further helps to reduce unnecessary tasks. However, it has some limitations as well which include incomplete risk assessment, high time and resources demand, also it is more dependent on accuracy of data (Tale 2019). Additionally, Organisations may resist the adoption of RCM due to cultural barriers.

8.3 Condition Based Maintenance

Condition Based Maintenance (CBM) is a visionary approach which uses real-time data to decide when maintenance is actually required instead of following the fixed schedules. It works with the help of sensors, tests and performance analysis to monitor the equipment and predict failures before they happen. The P-F interval plays a key role as it helps to determine how often monitoring should be done to find the issues and to keep the operations running smoothly (Sethiya 2006). The disadvantages of CBM include, high cost of diagnostic equipment and staff training. Also, it can be complex as it requires specialized knowledge.

Moreover, CBM system may generate false alarms, which can increase the maintenance cost and time and will significantly reduce the trust from the system (Ahmad and Kamaruddin 2012). This makes the usage spread limited.

8.4 P-F Curve

The P-F curve illustrates the timeline of an asset's wear and tear. Furthermore, it highlights when exactly it starts to show the signs of failure which is the P point, before it actually fails which is the F point. This curve helps to plan proper maintenance for assets by guiding when to inspect and fix the equipment before it breaks down. By spotting the P point early, maintenance teams can respond faster which helps to reduce the downtime and repair costs (Josebeck and Gowtham

2022). Using the P-F curve correctly, it will help assets to last to last longer which makes it an important tool for maintenance.

Limitations of P-F Curve includes, it uses past data doesn't adapt well to real time changes which CBM does. Also, it focuses on one point only and may miss the other complex factors. There are chances that curve can be misinterpreted which may lead to wrong timing for maintenance and also it relies heavily on skilled labors (Ochella, Shafiee et al. 2021). This limits the use of P-F Curve.

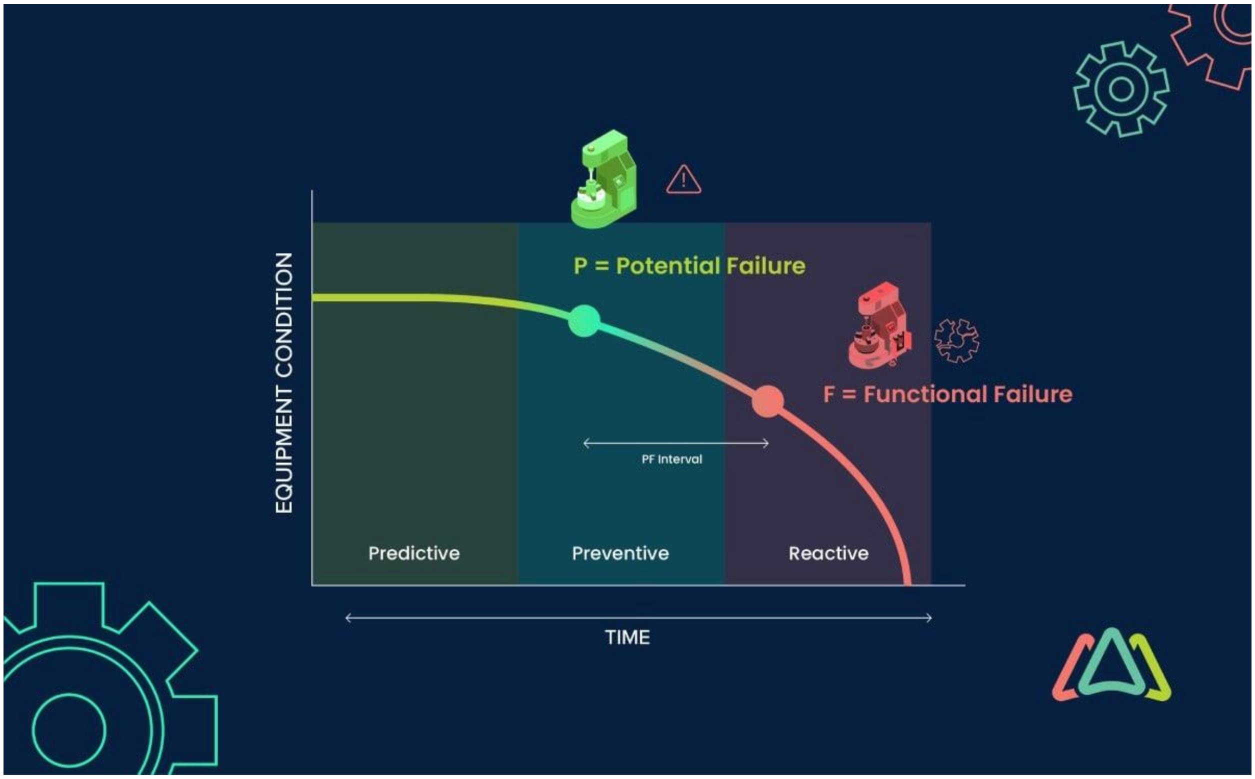

Fig. 3 P-F Curve. (Green, 2023)

9.0 Asset Management Plan

To effectively manage the electronic temperature controller, below is the proper asset management plan which covers its maintenance as well using various maintenance tools. Tools include, TPM, RCM, CBM and P-F Curve.

Total Productive Maintenance –

The main reasons of including TMP in the plan are, it provides improved equipment effectiveness and also focuses on employee involvement. It helps operators to take responsibility of tasks like lubrication, cleaning. The Autonomous Maintenance helps to reduce risk of failures and ensures quick detection of occurred issues. TPM also supports continuous improvement which falls under the umbrella of ISO 55000.

Reliability-Centered Maintenance –
RCM further identify critical components and defines the most effective maintenance strategies based on the failure reasons. Equipment like pumps and compressors are prioritized based on their failures. Using FMEA, the failures are addressed and maintenance efforts are implemented. This helps to reduce the downtime of the process and also reduces the maintenance cost.

Condition Based Maintenance –
Afterwards, CBM is used to monitor the real time condition and predicts when actually the maintenance is required. Continuous monitoring can be performed for pump and temperature controller using sensors and real time data. It ensures to minimize the unnecessary interventions by focusing on actual performance data.

P-F Curve –
At last, P-F Curve is used to map to identify early stage equipment degradation for the assets like conveyor belt, valves and compressor. This will help to predict the right time for the maintenance before failure actually occur. With the help of point P which denotes the early sign of failure, maintenance can be scheduled accordingly. This will help to minimize downtime and repair cost.

Conclusion
In conclusion, above mentioned tools are critical in order to maintain the electronic temperature controller operates reliably, safely and cost effectively. They provide a structured, data driven approach to maintain the high-performance standards at the same time, minimizing the downtime and maintenance cost.

10. References

Agustiady, T. K. and E. A. Cudney (2018). "Total productive maintenance." Total Quality Management & Business Excellence: 1-8.

Ahmad, R. and S. Kamaruddin (2012). "An overview of time-based and condition-based maintenance in industrial application." Computers & industrial engineering **63**(1): 135-149.

Aslansefat, K., et al. (2020). "Dynamic fault tree analysis: state-of-the-art in modeling, analysis, and tools." Reliability management and engineering: 73-112.

Bhakthavatchalam, S., et al. (2015). "Quality, reliability, maintenance issues in closed-loop supply chains: A review." IFAC-PapersOnLine **48**(3): 460-465.

Bruton, A., et al. (2000). "Reliability: what is it, and how is it measured?" Physiotherapy **86**(2): 94-99.

Chan, F., et al. (2005). "Implementation of total productive maintenance: A case study." International Journal of Production Economics **95**(1): 71-94.

Cristiano, J. J., et al. (2001). "Key factors in the successful application of quality function deployment (QFD)." IEEE transactions on engineering management **48**(1): 81-95.

Diop, I., et al. (2021). "Overview of strategic approach to asset management and decision-making." International Journal of Engineering Research & Technology **10**: 64-89.

Dudek-Burlikowska, M. (2005). "Quality estimation of process with usage control charts type XR and quality capability of process Cp, Cpk." Journal of materials processing technology **162**: 736-743.

Hastings, N. A. J. (2021). Physical asset management: With an introduction to the ISO 55000 series of standards, Springer Nature.

Hovhannissian, M. (2013). "DCIM Tools Comparison – IT asset management." DCIM Tools Comparison – IT asset management. Retrieved 1/2/2025, 2025, from https://www.device42.com/blog/2013/12/04/dcim-tools-comparison-it-asset-management/.

Jonathan Trout, N. C. (2020). "Total Productive Maintenance: An Overview." Total Productive Maintenance: An Overview. Retrieved 2/2/2025, 2025, from https://www.reliableplant.com/Read/26210/tpm-lean-implement.

Josebeck, G. and A. Gowtham (2022). Demystifying the PF Curve & Augmenting Machine Learning for Maintenance Optimization. 2022 Annual Reliability and Maintainability Symposium (RAMS), IEEE.

McLean, H. W. (2008). HALT, HASS, and HASA explained: accelerated reliability techniques, Quality Press.

Oakland, J. and J. S. Oakland (2007). Statistical process control, Routledge.

Ochella, S., et al. (2021). "Adopting machine learning and condition monitoring PF curves in determining and prioritizing high-value assets for life extension." Expert Systems with Applications **176**: 114897.

Ruijters, E. and M. Stoelinga (2015). "Fault tree analysis: A survey of the state-of-the-art in modeling, analysis and tools." Computer science review **15**: 29-62.

Ruiter, R. (2015). Do we need the ISO 55000?: the added value of the ISO 55000 standard series for road infrastructure asset management, University of Twente.

Selvik, J. T. and T. Aven (2011). "A framework for reliability and risk centered maintenance." Reliability engineering & system safety **96**(2): 324-331.

Sethiya, S. (2006). "Condition based maintenance (cbm)." Secy. to CME/WCR/JBP.

Silverman, M. (1998). Summary of HALT and HASS results at an accelerated reliability test center. Annual Reliability and Maintainability Symposium. 1998 Proceedings. International Symposium on Product Quality and Integrity, IEEE.

Stamatis, D. H. (2003). Failure mode and effect analysis, Quality Press.

Tale, T. (2019). "Reliability Centered Maintenance (RCM): Methodology and Benefits." International Journal of Commerce and Management **4**(3): 1-8.

Thor, J., et al. (2007). "Application of statistical process control in healthcare improvement: systematic review." BMJ Quality & Safety **16**(5): 387-399.

Venkatesh, N. and C. Sumangala (2018). Success of manufacturing industries–Role of Six Sigma. MATEC Web of Conferences, EDP Sciences.

Zhao, M., et al. (2011). ESS profiles with step stress level. The Proceedings of 2011 9th International Conference on Reliability, Maintainability and Safety, IEEE.