

University of Wales Trinity Saint David
School of Engineering

Failure Mode & Effect Analysis
Technical Report



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Shay Quinn

2319936

BEng Mechanical Engineering Degree

12/02/2024

Engineering Applications & Study Skills
ACMA4007 (PT)

Table of Contents

1 Introduction.....	3
1.1 Scope.....	3
1.2 Aims & Objectives.....	3
2 Failure Modes & Effect Analysis Literature Review.....	3
2.1 Regulations & Standards.....	4
3.0 Operation of Process.....	5
3.1 General Arrangement.....	5
3.2 FEP Bag Filter Plant FMEA.....	6
4 Conclusion.....	7
5 References.....	7
6 Appendices.....	8
6.1 Personal Development Plan.....	8
6.2 Technical Poster.....	9

1 Introduction

Failure Modes & Effect Analysis is commonly used throughout the engineering industry as an analysis tool to ensure every customer or consumer receives an adequate item. I chose to conduct my analysis on the Fume Extraction Plant Bag Filter Plant. I chose this process within Tata Steel as this is where my current area of work is, regularly inspecting and performing certain inspection maintenances on these systems. In this technical report I will provide information on Failure Modes & Effect Analysis, I will also provide an FMEA done by myself on my chosen process/system and demonstrate my knowledge and use of it then explaining my findings and numbers from the FMEA conducted.

1.1 Scope

The scope of this report is to show my knowledge and research conducted on Failure Modes & Effect Analysis and to also show my use of FMEA on a chosen process and to display the findings accordingly. This analysis will be applied to the Fume Extraction Plant within Tata Steel Port Talbot and I will demonstrate the advantages of using it and providing better understanding of the system to identify potential and ongoing risks or failures and try to mitigate them to a lower average or completely eliminate them all together. The use of FMEA will provide a better understanding of an FEP system allowing better knowledge of the Asset as well as making it safer for workers near the steel making processes or in the general vicinity by adequately extracting dust and gases away from the area creating a safer environment within the steel making plants.

1.2 Aims & Objectives

I aim to produce an accurate FMEA of the FEP systems within Tata Steels Port Talbot site for a better understanding of the system, its functions, and inner components and aim to improve these aspects with the use of this analysis tool to potentially aid in a lower fault amount or eliminate failures within the system with my findings. Along with this I aim to demonstrate my knowledge on the subject with the first part of the technical report produced, and the second part showing my findings and using knowledge from the first part applied to it.

2.0 Failure Modes & Effect Analysis Literature Review

Failure Modes & Effect Analysis (FMEA) is a step by step approach for identifying all possible failures in a system, design, assembly process, product or service, this includes where the failure can occur and on what part or component. Once all the failures are identified they are assessed based on a scale relative to their impact each scale for each FMEA can be different. Failure Modes identifies the ways or modes of which an item can or might fail. Failures can be anything from a defect of an inner component, or error of electrical system, that can affect the customer, this can be potential or actual. Effect Analysis of it is understanding the consequences and/or failure of the item. Failures are highlighted by their severity, the frequency at which they occur and the ease of detectability. An FMEA is to identify the failures/potential failures and mitigate them to a lower amount or none at all, this is done using an 3 categories and then a total from the 3 categories the highest overall value is the highest priority. This is called an RPN (Risk Priority Number). The RPN is found by

the Severity of failure, Occurrence of failure & Detection of failure (These are the 3 categories), and is then calculated by (Severity) X (Occurrence) X (Detection) this will then give the RPN of the failure. This has to be done for each individual failure.

FMEA can also be used in continuous improvement of the item using prior knowledge. FMEA is typically applied within the design phase of the asset/item to prevent failures from occurring upon the making or placement of the item but can still be applied to an ongoing operation or process. FMEA isn't just used in the early stages of an operations life but is ongoing to improve the system over time across its life span, this can then lead to an improved system/process if it were to be replaced. If a continuous failure occurs later in the system/ process this can then be applied into the FMEA of the system and actions can be taken upon using analysis.

2.1 Regulations & Standards

ISO 31000: Risk Management framework that provides organizations with guidelines and principles for risk management. This would be followed when conducting an FMEA to increase the odds of identifying risks and properly planning to allocate resources to mitigate them.

ISO 9000: Quality Management this provides a standardization for organizations to aim for when for production of goods and services, which meet a globally acceptable level of quality.

ISO 9001: ISO 9001 requires the organization to identify potential product or process risks and establish controls to manage these risks effectively.

These regulations should be followed by any organization when conducting FMEA to ensure the process or product is at a globally recognised acceptance and standard.

Risk Management:

As per the Managing Risk and Risk Assessment at Work, Under the Management of Health and Safety at Work Regulations, the minimum you must do is:

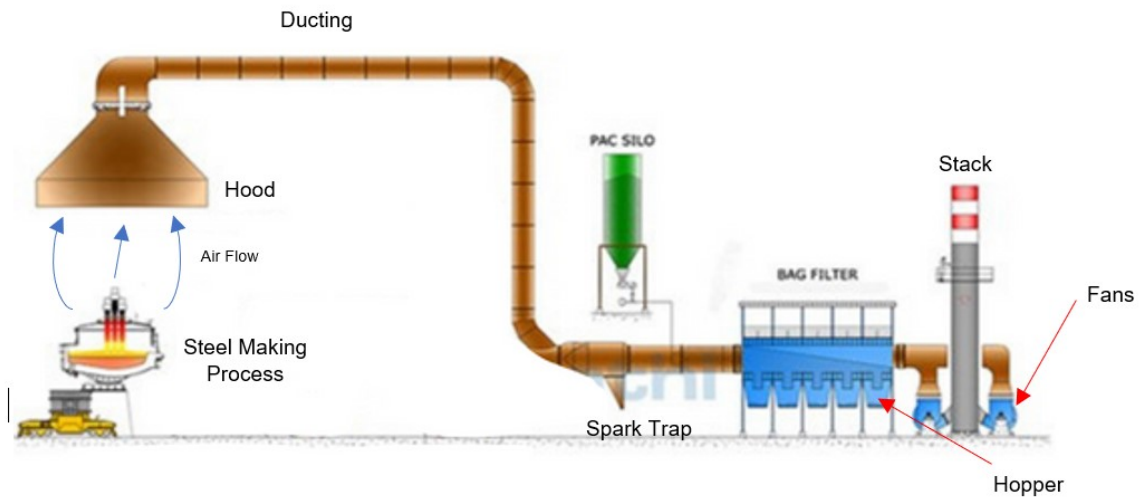
- Identify what could cause injury or illness in your business (hazards)
- Decide how likely it is that someone could be harmed and how seriously (the risk)
- Take action to eliminate the hazard, or if this isn't possible, control the risk

(HSE, 2023)

3.0 Operation of Process

The Bag filter plant serves the main purpose of a Fume Extraction System, air, dust and gas are drawn in through hoods over the steel making process or other processes which require it, through ducting and is then filtered through the bag filters at the Bag Filter Plant, which clean the air and release the clean air into the atmosphere via the stack. The unfiltered air is drawn in by a fan behind the Bag Filter Plant which pulls air through the bag filters which in turn clean the air and then the outlet of the fan is then lead through ducting towards a stack which is released into the atmosphere. This process is essential for everyone, the workers inside and people outside, this makes it a safer work environment and stops the release of dust and gas into the air and nearby surroundings. The air extracted and released through the stack is then monitored, to ensure it is of safe capacity.

3.1 General Arrangement of a Fume Extraction System



3.2 FEP Bag Filter Plant – Failure Mode & Effect Analysis

FAILURE MODE AND EFFECTS ANALYSIS									
Item	FEP Bag Filter Plant				Responsibility:				FMEA number:
Model:				Prepared by:	Shay Qum			Page:	
Core Team:							FMEA Date (Orig): 12.02.24		
Process / Function	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s)/ Mechanism(s) of Failure	Occurrence	Current Controls	Detection	R P N	Recommended Action(s)
Bagfilters	Filters Ripping	Unfiltered dust being released	8	Filters not being inserted correctly	7	Scheduled maintenance of the system every 20 Weeks and monitoring of the air cleanliness.	6	252	More scheduled maintenance and inspections more often.
		Filters having holes in nearer to the entry point of the bagfilter system, releasing unfiltered dust	8	Diffuser having holes in due to lack of maintenance or the diffuser not being fit for purpose.	7	Scheduled maintenance of the system every 20 Weeks and monitoring of the air cleanliness.	6	252	More scheduled maintenance and inspections more often.
		Filters not being maintained unfiltered dust being released.	8	Potential for filters to rip upon being inserted into position.	7	Scheduled maintenance of the system every 20 Weeks and monitoring of the air cleanliness.	6	252	More scheduled maintenance and inspections more often.
		Filters becoming ineffective and releasing unfiltered dust	8	Filters not being placed in correctly.	7	Scheduled maintenance of the system every 20 Weeks and monitoring of the air cleanliness.	6	252	More scheduled maintenance and inspections more often.
		Filters becoming overfilled and past their life span and failing releasing unfiltered dust	8	Old filters yet to be changed.	7	Scheduled maintenance of the system every 20 Weeks and monitoring of the air cleanliness.	6	252	More scheduled maintenance and inspections more often.
Bagfilters not being the correct size and/or length	Filter is then not fit for purpose and is ineffective.	8	Wrong filters being displayed on the SAP system.	6	Update SAP system to notify they are wrong and to correct this problem.	6	216	Update SAP everytime a material has changed.	
	Bagfilters not being the correct filtration size	Potential for the filter to become ineffective and leave more dust to pass through than is intended.	8	Wrong filters being displayed on the SAP system.	6	Update SAP system to notify they are wrong and to correct this problem.	6	216	Update SAP everytime a material has changed.
Pulsing System	Pulsing System not pulsing air into the filters.	Filters overfilling with dust and breaking.	8	Potential to many factors such as a pulse bar loose, the system not working as intended, the system needing maintenance etc.	8	Visual inspections of the pulsing system conducted on a 13 weekly basis. Service lights being it when service is needed.	4	160	Conduct more inspection more often and into more detail.
	Pulsing System pulsing moisture into the bagfilters.	Filters becoming more and more getting trapped onto the rear and the pulsing system not being able to pulse dust off causing clumps to other bagfilter compartments as these are now	7	Dryer system not working effectively, leak in the system, maintenance not being conducted.	8	Visual inspections of the pulsing system conducted on a 13 weekly basis. Service lights being it when service is needed.	4	224	Conduct more inspection more often and into more detail.
	Pulse bars becoming dislodged and out of position	Filters not being pulsed effectively and dust not being loosened from the filter causing premature failure.	5	Pulse bars not being held in place correctly, not fit for purpose, not tightened down appropriately or not maintained properly.	5	26 Weekly inspection conducted both mechanical and electrical.	3	75	Conduct more inspection more often and into more detail.
Bagfilter cages	Cages not being sealed properly.	Air being drawn through the gaps making the system less effective.	5	Upon insertion of the cages they are not being sealed correctly.	2	26 Weekly inspection conducted both mechanical and electrical.	3	18	Jobs to be done correctly and to specification.
	Broken cages being fitted	Possibility of ripping new filters.	8	Cages not inspected properly or cages being stored incorrectly before use leading to premature failure of new bags.	5	26 Weekly inspection conducted both mechanical and electrical.	4	120	Cages to be inspected after removal and something done on basis of inspection.
	Incorrect sized cages being fitted.	Filters becoming less effective, putting more stress on the system drawing air through.	4	Wrong sized filter cages being displayed on the SAP system.	5	26 Weekly inspection conducted both mechanical and electrical.	4	80	Update SAP everytime a material has changed.
Compartment Top Covers	Not being sealed down correctly.	Drawing in clean air into the system making the system pull less dirty air making it less effective.	8	Top Compartment Covers not being sealed down correctly, not being tightened down correctly, or seals being broken on the cover and not inspected correctly.	2	26 Weekly inspection conducted both mechanical and electrical.	5	50	Conduct more inspection more often and into more detail.
Poppet Valves	Working incorrectly	More stress on other compartments, making that compartment ineffective as there is no air being drawn through the filters.	4	Inadequate maintenance or inspection of the valves.	3	26 Weekly inspection conducted both mechanical and electrical.	5	36	Can only be done once asset is on stop. More detailed inspections and better maintenance from inspections need to be conducted.
Air Dilution Damper	Not working correctly.	Build up of pressure throughout the system if a blockage were to occur.	7	Inadequate maintenance, pneumatics not working correctly, electronics to the system functioning correctly.	6	26 Weekly inspection conducted both mechanical and electrical.	5	126	Update of electrical system to ensure all procedures and warnings are working and conduct more detailed inspection
Dampers	Working incorrectly.	Air flow within the system to build up momentum and cause damage within the system.	7	Inadequate maintenance, or inspections of the dampers when asset on stop.	5	26 Weekly inspection conducted both mechanical and electrical.	5	105	Update of electrical system to ensure all procedures and warnings are working and conduct more detailed inspection
	False position reading	Allow air flow to build up momentum and cause damage within the system.	7	Inadequate maintenance, or inspections of the dampers when asset on stop.	6	26 Weekly inspection conducted both mechanical and electrical.	5	126	Update of electrical system to ensure all procedures and warnings are working and conduct more detailed inspection
Hoppers	Low level sensor probe.	Hoppers filling with dust and causing a blockage stopping the dust from flowing through the bags.	4	Electronics systems not working appropriately. Inadequate maintenance or inspections.	3	13 Weekly inspections conducted both mechanical and electrical.	5	60	Update of electrical system to ensure all procedures and warnings are working and conduct more detailed inspection
Chain Conveyors	Conveyors not working.	Dust built within the hopper and not being removed due to conveyor not working.	4	Inadequate maintenance or inspections.	3	13 Weekly inspections conducted both mechanical and electrical.	6	60	More detailed inspection needed and or specialists to come in or train a team onsite and inspect.
	Conveyors working when not intended.	Dust built within the hopper and not being removed due to conveyor not working.	7	Electrical system fail, mechanical fault, inadequate maintenance or inspections.	3	13 Weekly inspections conducted both mechanical and electrical.	7	147	More detailed inspection needed and or specialists to come in or train a team onsite and inspect.
Implosion hatches	Not operating correctly.	Build up of pressure within the system and no release, potential for system to implode.	8	Inadequate maintenance or inspections, electrical fail or reading.	6	13 Weekly inspections conducted both mechanical and electrical.	6	432	Update of electrical system to ensure all procedures and warnings are working and conduct more detailed inspection
	Stuck Open/Closed	Build up of pressure within the system and no release, potential for system to implode.	8	Inadequate maintenance or inspections, electrical fail or reading.	9	13 Weekly inspections conducted both mechanical and electrical.	6	432	Update of electrical system to ensure all procedures and warnings are working and conduct more detailed inspection

The FMEA above has been conducted by identifying the possible failure, which could occur within the process of the Bag Filter Plant. A rating scale of 1-10 for each possible failure & failure effect has been given this has been done in 3 sections, Severity, Occurrence & Detection.

Severity – A rating that shows the severity of the failure/failure effect. 1: no effect on the process at all. 10: Hazardous/Catastrophic failure.

Occurrence – The likelihood of the failure/failure effect occurring or the occurrence of the failure due to general wear & tear. 1: Unlikely failure. 10: Imminent failure.

Detection – A rating that shows the likelihood of the failure being detected externally or by the system. 1: Easily detectable. 10: unlikely/impossible to detect without possible testing/inspection.

Once I allocated the correct ratings for each category on each failure/failure effect, I got an RPN value for each failure/failure effect. This was done using the equation above which was: Severity x Occurrence x Detection. The RPN is used to decide which potential failure is the higher priority and higher risk.

I then gave recommended actions based on the failures and reason of failure to try to mitigate the failures shown. Throughout the system there are a lot of possible failure/failures occurring, so acting on the recommended actions wouldn't be viable due to the amount of time it would take including and the people needed, also the systems within Tata Steel are very large so doing this would take a great amount of time and would not be possible for this report. Although I wasn't able to take action on the recommended actions, I do believe that the actions stated in the above table would greatly decrease the amount of failures ongoing in the system, such as simple tasks like updating the SAP system of a change of material/size of the bag filters when needed, this would lower the amount spent on the

system and resources, time and money of work needed, including lowering the failure rate of these bag filters ripping, not fitting etc.

4 Conclusion

To conclude, my report and actions shows how effective FMEA can be when used appropriately and is a great analysis tool to use for any engineer no matter how big or small the analysis is. It's a simple process and an extremely easy tool to utilize for any circumstance allowing any engineer to use it with little knowledge of it. This report shows how FMEA can be applied and how it can mitigate any failure or possible failure within an asset, system or process but can also show the amount of possible problems that can occur within in a system even ones which haven't happened, but again this gives a great advantage to catch the failures before they happen, which it extremely helpful.

5 References

Liu, H.-C., Wang, L.-E., Li, Z., & Hu, Y.-P. (2019). Improving Risk Evaluation in FMEA With Cloud Model and Hierarchical TOPSIS Method. *IEEE Transactions on Fuzzy Systems*, 27(1), 84–95.

<https://doi.org/10.1109/TFUZZ.2018.2861719>

[*The Quality Toolbox*](#), ASQ Quality Press (N/A)

[What is FMEA? Failure Mode & Effects Analysis | ASQ](#)

Health and Safety Executive (2023)

[Managing risks and risk assessment at work – Overview -HSE](#)

ISO Organization (2009)

[ISO - ISO 31000 — Risk management](#)

Adam Hayes (2024)

[ISO 9000 Standard: Benefits and How to Achieve \(investopedia.com\)](#)

6 Appendices

6.1 Personal Development Plan

Name – Shay Quinn

Degree – BEng (Hons) Mechanical Engineering

Previous Qualifications –

Previous Experience –

Goal	Objective	Resources Required	Measurement	Target Date
Complete Engineering Application & Study Skills Module	Acquire at least a pass mark.	Attend the Module lectures.	Pass mark in the module	12/02/24
Finish my degree.	Complete my 4 years at UWTSD	Attend University lectures as much as possible.	Complete all lectures and gain my degree.	2027
Complete Apprenticeship with Tata Steel	Complete 4 years at Tata Steel	Continue working		2027
Attend as many courses within Tata Steel as possible in my time there	Complete learning courses within Tata Steel	Sign up and complete learning courses.	Amount of courses attended and completed by 2027	2027

6.2 Technical Poster



Failure Modes & Effect Analysis of an FEP Bag Filter Plant

Shay Quinn

School of Engineering
BEng (Hons) Mechanical Engineering

Introduction

What is an FEP Bag Filter Plant?

This is a Fume Extraction System used within Tata Steel to draw dust and gas away from the steel making processes in places such as the BOS Plant & Blast Furnaces. Without proper extraction the steel making areas would become inadequate work areas due to health and safety reasons.

The reason I chose this process and why I decided to conduct an FMEA on it, is because this asset is what I work with closely within Tata Steel Port Talbot and these process I regularly inspect.

Project Aims

My aims throughout this project was to:

- Produce an accurate FMEA on an FEP Bag Filter Plant
- Fairly rate each category of failure and in turn get an accurate RPN value for each failure.
- Give accurate recommended actions for each failure.

Findings

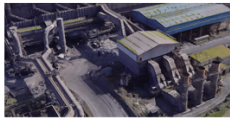
I was not able to get any findings during my FMEA due to the number of failures, the amount of time it would take, and the people needed to do this. However, I did still give recommended actions on failures from experience of working with the FEP systems.

My recommended actions are appropriate actions for what I thought was needed to mitigate the failures, again this was based on experience of the FEP systems and witnessing the failures from inspections.

General arrangement of FEP System



FEP & Bag Filter Plant in Tata Steel



Summary of FMEA conducted.

Upon conducting my FMEA I found several instances of failures/possible failures. There is a lot to improve within the systems as found by the number of failures on my FMEA. Although I couldn't do anything on my recommended actions, I believe that the recommendations should be considered and could aid in mitigating the failures the system experiences.

Failure Modes & Effect Analysis conducted

Highest & Lowest RPN Value

The highest RPN value from my FMEA was both possible problems with the implosion hatches. This means they were the highest priority to ensure they don't fail, if these were to fail there would be a catastrophic problem, meaning the whole system from the blockage to the fans would implode, causing a great amount of damage, possible injuries if people were to be in the area and a great expense for the company. The rating was 432 RPN value, which was the highest out of all the possible failures but for good reason.

The lowest RPN value from my FMEA was the Bag Filter cages not being seated properly, this failure wasn't a huge problem for the system, it could potentially lead to a rip/tear in the bag filter however, these problems are a low rate so don't happen often which is the reason it was scored as the lowest at an RPN value of 18. the failure of this wouldn't really be a problem and the system and readings wouldn't notice much.

References

- Li, H.-C., Wang, L.-L., Z.-A. Hu, Y.-P. (2018). Improving Risk Evaluation in FMEA with Cloud model and Interval TOPSIS Method. IEEE Transactions on Fuzzy Systems, 27(1), 84-97. <https://doi.org/10.1109/TFUZZ.2018.2851719>.
- The Quality Toolbox. ASQ Quality Press (NA).
- What is FMEA? Failure Mode & Effects Analysis (ASQ Health and Safety Executive (2023)).
- Managing risks and risk assessment at work - Overview - HSE.
- ISO Organization (2009).
- ISO - ISO 31000 - Risk management.
- Adam Hayes (2024).
- ISO 9000 Standard: Benefits and How to Achieve (Investopedia.com).

TATA STEEL

School of Engineering