

University of Wales Trinity Saint David
School of Engineering

Failure Mode & Effect Analysis
- Technical Report
Engineering Applications & Study Skills
ACMA4007

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1 Introduction

1.1 Aims

This report will discuss the importance of risk management to the manufacturing sector, including a review of the appropriate legal considerations governing sound engineering practice. Risk management is a crucial part of all engineering practices and processes, each process will undergo a thorough risk assessment to identify and mitigate all possible failures and their causes.

1.2 Objectives

To satisfy the aim of this task, several actions will be taken. Through consulting with professionals in the engineering field, accompanied with extensive research into failure modes & effects analysis, an in-depth report will be created to summarise how risk is identified and managed. Firstly, a literature review will be carried out conveying knowledge of failure modes within the manufacturing sector, highlighting the importance of assessing possible failures within the manufacturing process. H&S legislations and the IMechE Code for professional engineers are vital to total compliance with risk management, so will be explained thoroughly in the literature review.

An FMEA will be presented highlighting various risks, affects, and causes of failure which can lead to the cessation of a procedure. The evaluation and management of the risk will also be included in the FMEA to show the compliance and awareness of MME to potential human resource, technological, economic, political, environmental and legislation risks.

2 Literature Review

5	6	Process / Function	Potential Failure Mode	Potential Effect(s) of Failure	S e v e r i t y	C a u s e s	Potential Cause(s)/ Mechanism(s) of Failure	O c c u r r e n c e	Current Controls	D e t e c t	R P N	Recommended Action(s)	Responsibility and Target Completion Date	Action Results			
														Actions Taken	S e v e r i t y	O c c u r r e n c e	R P N
7		Design	Gate Caught by wind forces when not deployed	Injury/Damage	5		No hold back mechanisms or handles designed and fitted	3	Hold back mechanism designed and handles to be added to the gate	1	15		MME Engineers during Production drawing stage+ installers during installation	SHE Box added on production drawings	3	1	3
8		Design	Mechanism Corrosion	Short Life Span	3		Incorrect build material used for system use	2	Mechanism is made from stainless steel to prevent corrosion	1	6		MME Engineers when creating Production Drawings		3	1	3
9		Design	Bird nesting in shrouds/covers	Due to environmental constraints with birds nesting, the opening or closing of gates will not be allowed. Flooding could then occur with gates left open	4		Locking shroud gaps are made accessible for birds to nest	4	Locking shroud gaps to be reduced to minimise access to these components for birds. Brush strips to be used to close up any remaining gaps and detailed in design	1	16		MME Engineers + EA to check Production/ As-Built drawings		1	2	2
10				Damage to					All exposed fixings are security rated								

Figure 1: Results from Experiment

“Manufacturing companies seek to reduce the incidence of occupational risk while they strive to increase efficiency and productivity.’ (C.F Oduoza, 2020, pp. 1291). The implementation of risk management is essential to the safety of all manufacturing processes, the detection and control of failure within manufacturing is critical for all systems, and legislations must be adhered to when carrying out risk assessments. The importance and of risk management can be explained simply, *“If you cannot manage the risk, you cannot control it. If it is not possible to control, you cannot manage it.”*(Korenko M, Bujna M, Foldesiova D, Dostal P, Kyselica P, 2015, pp. 1493).

FMEAs are conducted to identify risk in manufacturing processes, the main three categories of Failure Modes and Effects Analysis are, system FMEAs, design FMEAs and process FMEAs (CRSP, S.B. 2021). To carry out FMEAS there must be inherent risk, which must be identified and ranked on its severity and likelihood. A higher RPN (Risk Priority Number) indicates a greater risk to the process, thus requiring the most attention and action. Each risk must be mitigated to an acceptable level for the process to be carried out safely and legally. A new RPN score is then given after the risk has been managed, the score must land in the green part of the FMEA RPN table (Figure 2) for the process to be carried out safely and legally.

Risk Priority Number Table (RPN = S * O)								
		Severity of Impact (S)						
		1	2	3	4	5	6	7
Rating of Failure Mode's Occurrence (O)	7	7	14	21	28	35	42	49
	6	6	12	18	24	30	36	42
	5	5	10	15	20	25	30	35
	4	4	8	12	16	20	24	28
	3	2	6	9	12	15	18	21
	2	2	4	6	8	10	12	14
	1	1	2	3	4	5	6	7

Figure 2: FMEA RPN table (Witcher, M.F, 2021)

Following laws and legislations is crucial in manufacturing, failure to do so can lead to penalties and legal complications. The Health and Safety at Work act of 1974 must be abided by with the highest due diligence, employers/employees must practice H&S laws to ensure the minimisation of injury or death. H&S sets out its duties out simply, employers have a duty of care to employees and members of the public, and employees are equally responsible to ensuring both themselves and others are protected from possible harm. (hse.gov, 1974).

FMEAS are created with H&S legislations in mind, once a risk is identified it must be mitigated to an acceptable level. Consumers today demand 100% safe and reliable products; however, this is almost impossible to achieve which is why FMEAS are a tool to get as close to that goal as possible. (CRSP, S.B. 2021).

IMechE has four Code of Conduct principles, the first is to practice and maintain up-to-date knowledge and skills which is ever so important in risk management. When fulfilling an FMEA, members should regularly practice their skills of risk detection and mitigation to maintain the safety of all engineering applications. Secondly, members must act with integrity and respect for others both at work and in a personal setting, respect and confidentiality are vital to achieving. Members of IMechE are expected to engage responsibly with the environment through understanding the "importance of socioeconomic and environmental factors in the work they carry out" (ImechE). Following this principle will guarantee safe and eco-friendly work, and considerations must be met when conducting FMEAS. The fourth principle states one must exercise engineering leadership (ImechE), members of ImechE must take control of situations when conducting work in their sector. This carries over in to FMEAS, as an individual must show ever present leadership when assessing risk and carrying out effective preventative measures.

3 Methodology

During the research phase of this task, an FMEA was carried out with the intention of identifying inherent risks to MME workers, the environment, and public. The research was produced during the design process of flood gates, the intention of the FMEA was to limit the possibility of risks which could have either contributed to the cessation of the project or endanger MME operatives/public. The FMEA was ranked on its severity and likelihood with figures ranging from 1-5 (1 being lowest risk, 5 being highest risk).

Design	Vandalism to gates or gates being accessed by unauthorised users	Damage to components effecting life cycle of product/ Gates left open during flood event, causing flood damage to nearby residents	4	Gate components damaged/vandalised causing mechanism failure. Gate left open by unauthorised person(s) during event of a flood	4	All exposed fixings are security rated and vandal resistant. Lock shrouds are used to cover access to mechanism. Padlock Lugs are used to secure gates.	1	16	MME Engineers + EA to check Production/ As-Built drawings		2	2	1	4
Design	Lifting of new refurbished gates and components	Injury/Death, suspended lifted load could fall & fast. Can also damage product and environment	5	Lifting operation missing critical health & safety factors	5	Lift area will be cordoned off, with only the lifting equipment operator, slinger signaller and MME Engineer in the work area during the lifting operations. Lifting points will be inspected, with SWL determined. All lifting equipment will be tested and only used within its safe rated load limits	1	25	MME Engineers when providing an in depth lift plan		2	2	1	4
Design	Mechanism becoming hard to operate / binding	Overextension leading to injury and potential leakage	3	Lack of parts aiding free movement of the mechanism	3	Oilite brass bushes used to produce a free moving mechanism	1	9	As built drawings, production drawings and O&M manual checked and reviewed by MME Engineers		3	1	1	3

Figure 3: Results from Experiment

Figures 1 and 3 display the results obtained from the FMEA carried out by MME.

4 Discussion

Row 2 (Figure 3) states the potential failure of lifting refurbished gates and components on site at Clacton. Failure of the lifting operation can result in catastrophic consequences, most notably injury/death in addition to complete failure of the product and damage to existing surrounding infrastructure. The components landing on humans is a very possible and highly severe failure if H&S legislations are ignored and a clear lifting plan is not implemented, the consequences of this can be very severe legally and financially. The destruction of the product and surrounding infrastructure/environment can also have highly severe implications for companies and engineers.

Due to the extreme nature of this failure in both its severity and likelihood, it has received a high RPN score of 25 due to scores of 5 in both sections and 1 in the detection column. The 1 for detection is due to the experience and awareness of H&S legislations and IMechE Code of Conduct from MME Engineers.

The current control measures in place by MME Engineers are “Lift area will be cordoned off, with only the lifting equipment operator, slinger signaller and MME Engineer in the work area during the lifting operations. Lifting points will be inspected, with SWL determined. All lifting equipment will be tested and only used within its safe rated load limits” (Figure 3). These factors are closely observed and practiced guaranteeing the maximum level of safety.

The way the risk is curtailed during the design phase is through the MME Designers compiling a lifting operation plan which will be clear for the MME operatives. The lifting operation plan will reduce the severity of the failure to 2 and the likelihood of failure to 2 whilst maintaining a score of 1 for detection, these scores will combine to give an acceptable RPN score of 4. Despite the RPN score being far lower, there is still risk to the operation as human nature and potential working conditions can alter the safety of the lifting operation.

Another risk featured on the FMEA is the corrosion of the mechanism (Figure 1), this failure may cause the mechanisms life span to be cut short resulting in a replacement part. The effects of this are that of a financial nature as replacement parts cost money to manufacture and install, however, a corroded part can cause far worse consequences such as potential leakage. The severity of this risk is ranked at 3 and the likelihood at 2, whilst the detection is ranked as 1, leaving an RPN number of 6.

This failure is caused by incorrect material selection, so it is neutralised in the design stage through selecting parts made of stainless steel for our flood gates as they will be in contact with sea water. These factors leave scores of 3 for severity and 1 for detection, however occurrence is lowered to 1 as this is always amended in the design phase.

5 Conclusion

This technical report laid out the basic knowledge needed for understanding risk management and how it ties in with industry guidelines. The information outlined in the introduction and literature review was applied to the FMEA, the knowledge gained through research was vital to conclusively explaining the results in the FMEA.

ImechE code of conduct and H&S legislations gave the reader an understanding of what guidelines had to be met in the FMEA, this created a greater depth of understanding of the risks that were identified, their RPN score and their solution. The FMEA conducted was a comprehensive look at what risks come with installing/replacing flood gates in areas open to the public, the RPN scores provided an insight into the severity and likelihood of the initial risks along with the new RPN score after corrective measures.

The FMEA was a useful tool to identify risks involved with the installation of flood gates, it highlighted several risks involved in the process by listing potential failures and consequences that may arise. A detailed overview of what can happen during the process was emphasised in-which a thorough and well-practiced solution was put in place to mitigate the effects arisen. Each solution followed laws and legislations as shown by figures 1 and 2.

To summarise, FMEAs are a critical factor in risk management, they lay the foundations of spotting and mitigating risks to maximise safety and compliance. The use of FMEAS are vital for all manufacturing process due to their simplicity along with their thorough detail when done properly.

6 References

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7 Appendices

7.1 Personal Development Plan

Name – Samuel Roberts

Degree – Mechanical Engineering

Previous Qualifications – Level 3

Previous Experience – Aerospace Engineering Degree (Partly)

Goal	Objective	Resources Required	Measurement	Target Date
Carry out FMEA at my Workplace	Evaluate possible failure modes in my workplace to create an FMEA review	Understanding of processes in the workplace and how they can go wrong	The likelihood and severity of the failure mode	12/02/2024
Create a technical report about risk management	Assess data from FMEA and incorporate third party information	FMEA table and websites/journals	Write a report on all data collected and sufficient third party information within 1600 words	12/02/2024
Improve ways of collecting data	Research different methods of extracting data from various sources	Websites and journals	Numerous forms of information and data in the technical report	12/02/2024
Understand H&S Legislations and ImechE Code of Conduct	Research and gather information on each legislation	Websites	High volume of quality information about each legislation in the report	12/02/2024

Failure Modes & Effects Analysis

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Risk Management

Failure Modes and Effects Analysis is vital to maintaining a safe workspace for employees, employers and the public.

The introduction of risk management ensures inherent risks are mitigated and compromised to keep companies compliant with governed laws and legislations.

FMEA tables are a key tool to identifying and compromising potential risks to a process, all risks must be monitored and dealt with to an acceptable level to ensure complete compliance with H&S legislations and ImechE Code of Conduct.

Figure 1: Results from FMEA Experiment carried out by MME

Figure 5: FMEA RPN table (Wolcott, M.F., 2011)

Risk Priority Number Table (Wolcott, M.F., 2011)		Severity of Impact (S)						
		1	2	3	4	5	6	7
Ranking of Failure Modes Occurrence (O)	7	7	14	21	28	35	42	49
	6	6	12	18	24	30	36	42
	5	5	10	15	20	25	30	35
	4	4	8	12	16	20	24	28
	3	3	6	9	12	15	18	21
	2	2	4	6	8	10	12	14
	1	1	2	3	4	5	6	7



Figure 2: MME Double Flood Door (MME Engineering, N.D.)



Figure 3: MME Flood gate (MME Engineering, N.D.)

What is an FMEA?

An FMEA table is a form of research in-which potential risks are identified. They are ranked from 1-5 or 1-10 based on severity, likelihood and detection.

A combined score is tallied to create an RPN number, the higher the RPN the higher the risk.

A new RPN score is then given after a solution to the risk has been carried out, the score must be reduced to an acceptable level.

ImechE four principles

- Practice competently and maintain up-to-date knowledge and skills (ImechE, N.D)
- Act with integrity and respect for others (ImechE, N.D)
- Promote Sustainability (ImechE, N.D)
- Exercise Engineering Leadership (ImechE, N.D)



Figure 4: Table of Risk Management Activities (Avasthine, N.D.)

Summary of Key Findings

Risk management is a key factor for all companies to carry out processes safely and effectively. The introduction of risk management is vital to all businesses in the manufacturing industry.

Many tools such as FMEAs provide companies with effective solutions to carry out their risk assessments and adhere to laws and legislations.

Effective risk management promises financial gain and credibility within the industry, which makes it one of the fundamental blocks in running a successful company.

When conducting risk management, companies should always keep in mind the quote, "If you cannot manage the risk, you cannot control it. If it is not possible to control, you cannot manage it." (Korenko M, Bujna M, Foldesiova D, Dostal P, Kyselica P, 2015, pp. 1493).

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