

University of Wales Trinity Saint David

Wales Institute of Science & Art



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***Risk Analysis of working in an Explosive
Atmosphere***

Study Skills (Module Code)

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Introduction

Risk management is at the core of modern engineering practice, providing the basis for identifying, assessing, and mitigating uncertainties that may impact the performance, safety, or sustainability of manufacturing processes. Within this investigation, there will be an exploration of how risk management principles are deployed throughout the disciplines of engineering with the main areas of focus being the methods, frameworks and decision-making processes. Engineers rely on these disciplines for continuous quality, reliability and integrity of designs. The scope includes an examination of formal standards such as ISO 31000, established methodologies for risk assessment, and the influence of organisational and human factors on risk-related decisions; whilst considering real-world cases to illustrate both effective and inadequate applications of risk management in engineering contexts.

The understanding of risk management is essential for engineers because their decisions often have extensive technical, economic, and societal consequences as these projects typically involve the integration of complex technologies and interconnected systems. However, this increases the probability of risk and uncertainties within the system. Therefore, the knowledge and practice of risk-management principles enables engineers to predict potential failures, have a systematic way to evaluate hazards and the best potential mitigation strategies (Aven, 2015). Additionally, regulatory bodies and professional institutions emphasise risk awareness as a key area of ethical and responsible engineering; this reinforces the importance of risk-management to public safety and environmental governance (Royal Academy of Engineering, 2014).

Literature Review

What is Risk Management?

Risk management is the process of identifying a risk, analysing it and then putting measures in place in order combat that risk. Risk analysis can be defined as the identification, analysis, and economic control of those risks which can threaten the assets or earning capacity of an enterprise. (Dickson, 1995). According to Dickson's definition the idea of risk management is to use techniques in order to find and deal with risks in a cost effective manner. This means analysing the potential cost of a risk in order to obtain a budget for managing that risk. According to T,Aven the potential cost of a risk is not just how much one instance of risk will cost but the amount the risk is expected to cost over its lifetime. This can be the lifetime of a building or the length of a production run. Considering this the cost of a risk can be considered as $\text{Cost} \times \text{Probability} \times \text{Lifetime}$. However, Aven states that it is important to consider the error of these values when analysing risk (Aven, 2025). Once the risk has been analysed, measures can then be put in place in accordance with the budget acquired within the analysis stage.

Methods of Risk Management

There are many techniques for management of risk but one of the main methodologies that persists throughout a majority of techniques is root cause analysis. Root cause analysis (RCA) as suggested by the name is a method for finding the root cause of an issue that is causing the risk. This allows for an effective fix to be made instead of patching over an underlying issue.

Ishikawa Diagram

RCA has many forms such as the Ishikawa diagram which also goes by the name of the 'Fishbone Diagram' due to how it looks. The Ishikawa diagram starts by writing down the issue that has been caused, then one must draw a line out with branches labeled with all the Material, Manpower, Machine, Method and Environment. Branches should then be made from these with possible causes in these classes. Then smaller branches should be made from there with the causes of the previous causes and so on and so forth until it isn't possible to break down the problem any further. Once this point has been reached the 'root causes' can then be analysed in order to determine how easy they are to fix as well as how much of a difference they will make, giving a cost effectiveness or priority scale in which order to tackle them in. (Mirel Glevitzky et al., 2025). Figure 1 shows a diagram of this.

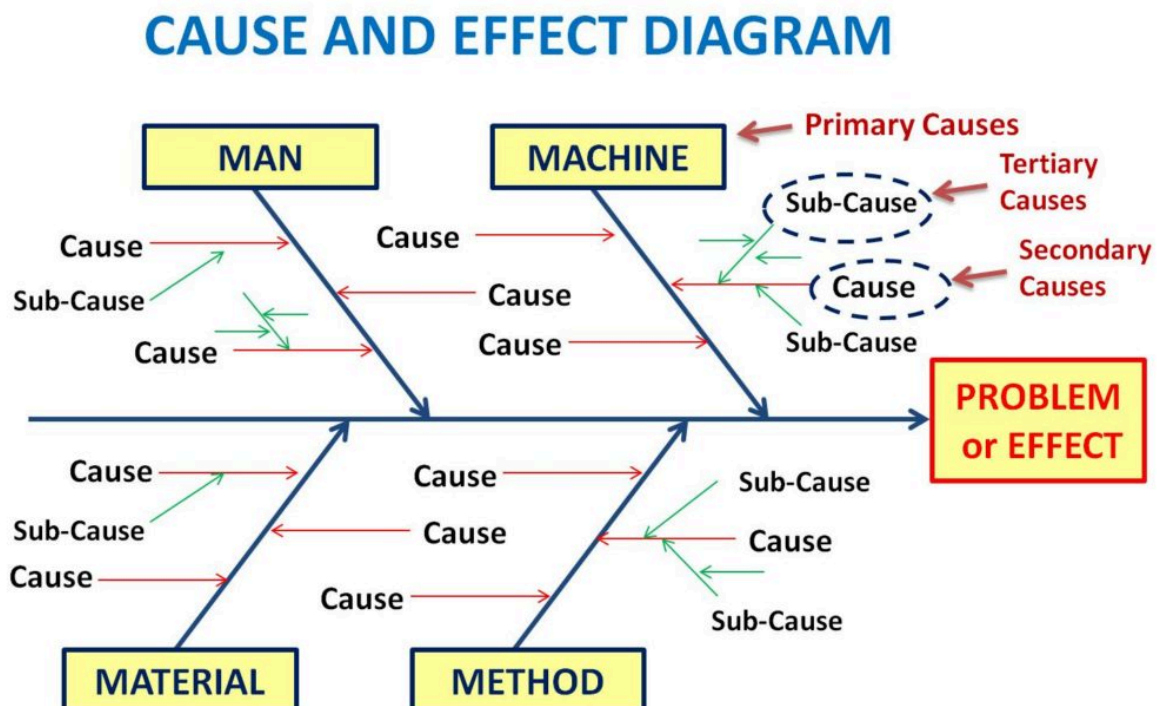


Figure 1 - Isikawa Diagram (TQP, 2020)

5 Whys Method

The 5 whys technique is a method for identifying root causes by repeatedly asking why. Though this one can identify the root causes of problems and effectively correct them instead of patching symptoms of these problems. The method of asking why also allows for the gain of a deeper understanding of the issue as well as guiding a critical thinking mindset. It is important to note that while named the 5 whys method, the number of whys required may be larger or smaller than five. Furthermore, it's important to accept all answers to the questions even if they are unexpected. (WOLNIAK and Wies GREBSKI, 2023)

Standards and Legislation

When performing risk management it's important to consider any standards or legislation that may be in place to govern how risk is managed such as the Management of Health and Safety at Work Regulations 1999. This governs how employers must identify health and safety risks and either remove or mitigate them. Whether they should be removed or mitigated must be determined by risk cause analysis (Health and Safety Executive, 2022). ISO 45001 is a standard that gives a guideline on assessing the risk to health and safety at work (International Organization for Standardization, 2018).

A business may also be required to conform to a code of conduct such as the IMechE code of conduct. The IMechE code of conduct governs areas such as maintaining competency and up to date knowledge and skills, where members must maintain up to date knowledge as well as a record of them. Furthermore, members must disclose any limitations on their competency as well as perform risk assessments based on it (Institution of Mechanical Engineers, 2023).

RCA

During the RCA any event that caused the death, severe injury or minor injury of a low quantity of workers was classed as a severity 7. Any event that caused the death, severe injury or minor injury of a large quantity of workers was classed as a severity 9. Any event that caused the death, severe injury or minor injury of a large quantity of workers and surrounding environment was classed as a severity 10. As all of these hazards involve the ignition or detonation of the atmosphere their detectability will always be 10.

When considering an ignition of the atmosphere due to a spark caused from colliding metals the severity was given a 7 (as per predefined), the likelihood was also given a 7 as it would be reasonably common for this to occur. In order to solve this non sparking metals should be used for tools making production of a spark almost impossible and reducing the chance of occurrence score to a 1. This resulted in a 86% reduction of risk score.

When considering an ignition of atmosphere due to a spark caused from electrical failure the severity was given a 7 (as per predefined), the likelihood was given a 4 as it is unlikely for

this to occur. In order to solve this ATEX rated equipment should be used that is able to keep the spark contained so that any electrical failure cannot result in ignition. This brings the occurrence score to 1, resulting in a 75% reduction in risk score.

When considering ignition of atmosphere due to a spark caused from electrostatic discharge (ESD) the severity was given a 7 (as per predefined), the likelihood of occurrence was given an 8 as static build up is really common in a factory. In order to solve this equipment and personnel must be grounded with regular checks occurring (in the form of HPTM tests for employees). Furthermore employees must wear ESD safe PPE and humidity must be controlled above a certain level. This brings the likelihood of occurrence down to a 1 which is a 86% decrease of risk score.

When considering ignition of atmosphere due to impact of heavy objects the severity was given a 7 (as per predefined), the likelihood was given a 4 as it's unlikely for material to initiate from compression. The likelihood is reduced by securing heavy objects, limiting the speed of heavy objects and reducing hard surfaces as well as keeping surfaces clean. This reduces likelihood of occurrence to a 1 which is a 75% decrease in risk score.

When considering ignition of atmosphere due to a naked flame caused by smoking burners the severity was given a 7 (as per predefined), and the chance of it is an 8 as it has a high chance of ignition. In order to reduce the chance of ignition smoking and smoking material should be banned from the hazard area. This reduces the chance of occurrence down to a 1 which is an 88% reduction in risk score.

When considering ignition of atmosphere due to a naked flame caused by use of gas burners the severity was given a 7 (as per predefined), and the chance of ignition is an 8 due to its high likelihood of ignition. In order to reduce the chance of ignition alternative heating methods should be used such as steam heating. This removes the risk.

When considering detonation of the atmosphere once burning the severity was given a 10 (as per predefined), and the likelihood would be an 8 as current buildings hold in pressure. In order to reduce likelihood buildings should be designed to release pressure by falling apart in a controlled manner to stop a deflagration to detonation transfer. This lowers the likelihood to a 1 which is a 91% reduction to risk score.

When considering the burning/ignition of surrounding buildings the severity was given a 10 (as per predefined), the chance of occurrence is a 7 as surrounding buildings have not been placed specifically, had contents checked for flammables/explosives or had barriers erected to catch fragments. To mitigate this risk buildings should be spaced out, had surrounding buildings checked for flammables/explosives and barriers erected to catch fragments. After these changes the chance of occurrence is reduced to 1 which results in a 86% reduction in risk score.

When considering the possibility of any injury or death caused by further accidental ignitions, the severity was given a 10 (as per predefined), the chance of occurrence was given a 7 as buildings are not designed to direct explosion away from operators and the workers were too close to the high risk processes. In order to reduce the severity, the number of workers in the building which reduced the severity score to a 7. In order to reduce the chance of

occurrence, remote processes should be undertaken where possible and buildings should be designed to protect the occupants by redirecting the explosion which reduces the chance of occurrence score to 2. This reduces the risk score by 80%

The complete RCA is included in the appendices.

Conclusion

To conclude, risk management is essential to the manufacturing sector not only to reduce costs of producing a product but also for managing health risks in a working environment and keeping employees safe. Therefore, understanding of risk management and the tools within it are critical to all businesses in the manufacturing sector.

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Appendices

PDP

Name - Milo Montague

Degree – Mechanical Engineering

Previous Qualifications – A-Levels

Previous Experience - Thales Underwater Systems Internship

Long Term Goals (5 to 10 years)				
Attain Chartership				
Short Term Goals (0 to 5 years)				
Increase report/essay writing skills, Increase time management skills				
Goal	Objective	Resources Required	Measurement	Target Date
Attain Chartership	Attain chartership certification	Masters degree Undergrad degree Experience	Progress through the requirements list	10 years
Increase report/essay writing skills	Get better at writing reports/essays	Guidance from lecturers Assignments to use for practice	Marks of assignments increasing	2 years
Increase time management skills	Get better at managing my time	Learning resources	Reduced number of times caught by a deadline	1 year

RCA

Root Cause Analysis (RCA)

Item: Working In Explosive Atmosphere
 Model: _____
 Core Team: Production

Responsibility: Manufacturing Engineering Dept.
 Prepared by: Milo Montague

RCA number: _____
 Page : _____
 FMEA Date (Orig): _____ Rev: _____

Process / Function	Identified Issue	Potential Effect(s) of Failure	Severity	Cases	Potential Cause(s)/ Mechanism(s) of Failure	Occurrence	Current Controls	Detection	RNP	Recommended Action(s)	Responsibility and Target Completion Date	Action Results					%reduction
												Actions Taken	Sev	Occ	Det	RPN	
Process / Function	Describe the issue		Rate the severity from 1-10	Ex: Operational Failure	List potential causes of the issue	Rate the occurrence likelihood from 1-10	List current controls in place to detect/prevent the issue	Rate the detection capability from 1-10	Multiply severity, occurrence, and detection	Actions recommended to mitigate the issue	Person responsible and target date for action completion	Results after implementing actions				0	
ignition of atmosphere	spark	(death, severe injury, minor injury) of a low quantity of workers	7		metals colliding	7	none	10	490	use of non sparking metals/equipment,		Reduced risk of ignition	7	1	10	70	85.71%
ignition of atmosphere	spark	(death, severe injury, minor injury) of a low quantity of workers	7		Electrical failure	4		10	280	ATEX rated electrical equipment		Reduced risk of ignition	7	1	10	70	75.00%
ignition of atmosphere	spark	(death, severe injury, minor injury) of a low quantity of workers	7		Electrostatic Discharge (ESD)	8		10	560	ESD safe clothing, grounding shoes for employees and HPTM (grounding) tests, Grounding of equipment, humidity control		Reduced risk of ignition	7	1	10	70	87.50%
ignition of atmosphere	spark	(death, severe injury, minor injury) of a low quantity of workers	7		Lightning	2		10	140	lightning rods on building, weather monitoring		Reduced risk of ignition	7	1	10	70	50.00%

ignition of atmosph ear	impact	(death, sevear injury, minor injury) of a low quantity of workers	7		Heavy objects being dropped, objects hitting surfaces	4	none	10	280	securing heavy objects, limiting hard surfaces, limiting rate of motion of objects, keeping surfaces clean		Reduced risk of ignition	7	1	10	70	75.00%
ignition of atmosph ear	naked flame	(death, sevear injury, minor injury) of a low quantity of workers	7		smoking	8	none	10	560	not allowing smoking		reduced risk of ingintion	7	1	10	70	87.50%
ignition of atmosph ear	naked flame	(death, sevear injury, minor injury) of a low quantity of workers	7		gas burners	8		10	560	using alternate methods of heating		risk removed	0	0	0	0	100.00%
Detitinati on of ignited atmosph ear	Burning atmosph ear detonate s	(death, sevear injury, minor injury) of a very large quantity of workers and damage to surroundi ng environm ent	10		confinment of burning atmosphear	8	none	10	800	Designing building to fall apart/ release presure		Reduced risk of detonation	7	1	10	70	91.25%

Burning/ ignition of surrounding buildings	buring/de tonation spreads to nearby buildings ignitiong them	(death, sevear injury, minor injury) of a very large quantity of workers and damage to surroundi ng environm ent	10		nearby buildings contain flammable material or explosive atmosphear,no baricades to catch fragments, building too close together	7	none	10	700	not storing flammable material in surrounding buildings/placing building away from such buildings, placing building far away from others,building baracades to provent propagation of ignition by blocking fragments		reduced risk of proagation	10	1	10	100
Death due to Accedent	People are killed due to atmophe ar ignitioin/d etination	(death, sevear injury, minor injury) of a large quantity of workers	9		Too many people in building, Workers too close to high risk process, Building not designed to direct detination away from workers	7		10	630	Ruduce number of people taking part in process, Remote processes, Buildings designed to direct detination away from workers		Reduced number of deaths and Reduced risk of death	7	2	9	126

85.71%

80.00%

