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Root Cause Analysis – Technical Report

Engineering Applications & Study Skills (ACMA 4039)

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1 Task 1 – Personal Development Plan (PDP)

Name – Todd Marshall

Degree – BSc Hons Engineering Management

Previous Qualifications – BSc Hons Applied Sports Science, Level 7 CMI Project Management, BTEC National Diploma in Engineering Manufacturing

Previous Experience – 6 Years Royal Engineers, 10 Years Automotive Electronics and Mechatronics, 3 Years Metal Powder Manufacturing.

Long Term Goals (5 to 10 years)				
Progress into plant manager role within LSN Diffusion Ltd. Continue to up-skill in areas that are relevant to my career progression. Obtain an MSc in Project / Engineering Management.				
Short Term Goals (0 to 5 years)				
Obtain BSc Hons in Engineering Management from UWTSD. Up-Skill in aspects of my work that I do not fully understand.				
Goal	Objective	Resources Required	Measurement	Target Date
Understand Engineering Management in greater detail and be able to apply lessons learned to role within LSN.	Obtain BSc Hons in Engineering Management from UWTSD	Lectures, Assignments to check progression, Lecturers to answer queries and provide guidance in areas of little knowledge, Classmates to work on projects and understand their thoughts when it comes to subject matter.	Overall performance on the degree course, feedback from colleagues at LSN when implementing or discussing lessons learnt from degrees to the workplace.	Degree is due to completion in 2029 although continual learning from learnings will be ongoing.
Understand in greater detail the requirements for top level project management.	Obtaining MSc in Project Management	Access to MSc program, information from lecturers such as course materials, case studies etc. Feedback from project management within my workplace.	Completion of success of MSc program, performance of key projects within LSN Diffusion.	2031-degree completion.
Work better cross functionally with other departments within LSN Diffusion	Spend more time with other departments understanding roles and responsibilities and aspects of other job roles	Time with other departments, understanding of documented procedures, and working practices.	Progressions within LSN and feedback from other stakeholders within the company.	Quarter 4 - 2026

	within LSN to allow progression into more advanced roles.			
Expand quality team within LSN and take onboard more responsibility in progressing the younger team to be onboarded.	Bring onboard three quality apprentices.	Learning agreements to be created for job specifications within LSN and onboarding processes defined for successful fulfillment of the roles.	Successful recruitment and retention of inexperienced staff members.	Mid to end of 2026.
Improve skill set in technical report writing.	Become proficient in the use of Texstudio for report writing.	Support from two x doctorates within LSN who are well versed in using the software. Access to the software for trialing report writing.	Submit reports for peer review and accuracy checks.	Mid to end of 2026.

Table 1: Personal Development Plan

2 Task 2.a – Root Cause Analysis (RCA)

Figure 1 highlights a small section of a manufacturing PFMEA document which highlights potential risks and failures modes within a production environment and the control measures identified to mitigate or reduce the risk either occurring or not being detected leading to non-conforming product. Figure 2 shows in a graph the reduction in RPN score when corrective actions are added to reduce the occurrence of operational failure.

Root Cause Analysis (RCA)																
Item: Oxygen Control		Responsibility: Production / Technical / QA		RCA number: 1												
Model: Low Oxygen Alloys		Prepared by: Todd Marshall		Page: 1												
Core Team: Todd Marshall / Sally Park / Dan Butcher / Mitchell Watson / Andrew Smedley				FMEA Date (Orig): 15.10.25		Rev: 1										
Process / Function	Identified Issue	Potential Effect(s) of Failure	Severity	Cause(s)	Potential Cause(s)/ Mechanism(s) of Failure	Occurrence	Current Controls	Detection	RPN	Recommended Action(s)	Responsibility and Target Completion Date	Action Results				
												Actions Taken	Severity	Occurrence	Detection	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	
Removal of Powder from POD	Early removal of Atomised Metal Powder	Scrap Powder	8	SC	Human interaction and release of powder which is too hot	3	Physical Timer	6	144	PLC Control powder release valve linked to probe thermostat	01.07.2025 - Engineering / Technical Departments	Siemens PLC now linked to powder collection POD with thermostat controlled valve	8	2	16	
Removal of Powder from POD	Overdose powder in final product increasing oxygen levels	Rework of Powder	5	SC	No system in place to prevent overdose powder being mixed with product	3	Sieve on top of hopper lid	6	90	Incorporate mesh hopper lid into decant process to remove the chance of overdose entering hopper	01.07.2025 - Engineering / Technical Departments	New hopper lids fabricated with built in mesh filter for powder processing	5	2	20	
Removal of Powder from POD	Superfine powder entering product increasing oxygen levels	Rework of Powder	5	SC	No extraction in place to remove the sub 5um particles entering product	3	N/A	10	150	Incorporate kemper extraction system with fixed hood to decant station to remove fines.	15.07.2025	Kemper extraction unit fitted to POD with extraction hood in place	5	2	20	

Figure 1 – PFMEA – Root Cause Analysis LSN Diffusion

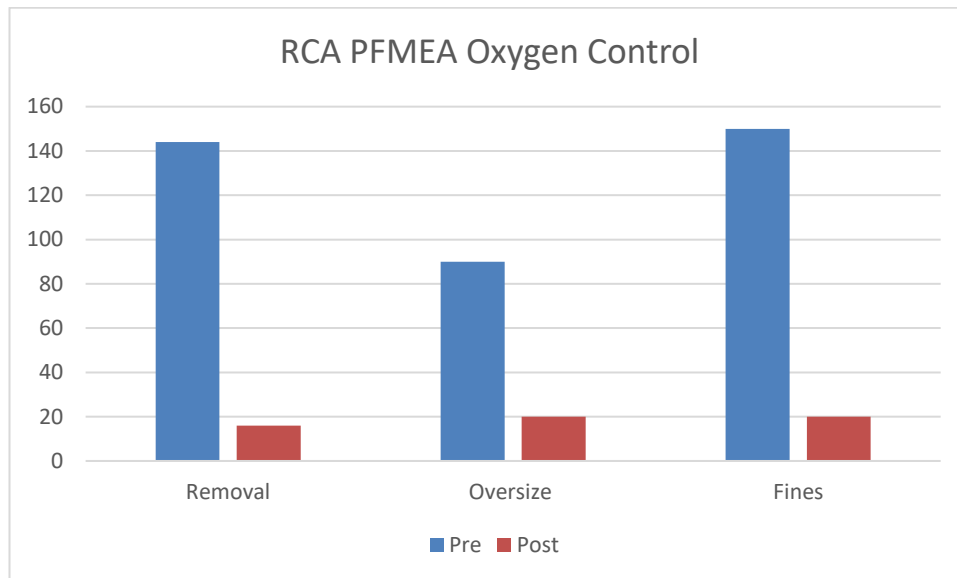


Figure 2 RPN Figures

3 Task 2.b – Technical Report

3.1 Introduction

This report investigates the role of risk management within the manufacturing sector, focusing on legal obligations and engineering best practices. It also examines the application of Root Cause Analysis (RCA) as a key tool for identifying and mitigating potential risks. The manufacturing industry is widely considered high risk due to its reliance on complex machinery, hazardous substances, and human interactions within challenging work environments. Engineers must understand and apply risk management methodologies to ensure safety, regulatory compliance, and operational effectiveness. The aim of this report is to highlight the significance of risk management in engineering, emphasising its role in maintaining legal, ethical, and regulatory standards while safeguarding public trust. Root Cause Analysis, adaptable across various sectors including engineering, is utilised to identify the underlying causes of both current and potential failure modes (Pietsch et al., 2024). The objective of this review is to examine how risk management frameworks and methodologies, including RCA, support compliance with legal and regulatory requirements, enhance safety standards, and promote operational efficiency within the manufacturing sector.

3.2 Literature Review

Overview of risk management in manufacturing:

Manufacturing globally faces a range of risks which significantly impact operational output and overall success. These risks include, but are not limited to, operational failures such as equipment breakdowns, financial instability, supply chain disruptions, and competitive pressures (Hosseini Shekarabi, Kiani Mavi, & Macau, 2025). To effectively manage these challenges, organisations must adopt cross-functional risk assessment methodologies to ensure all factors influencing operational performance are identified and mitigated where possible. Research indicates that companies failing to analyse such risks are more susceptible to business failure, financial penalties, and regulatory sanctions (Benedek & Bognár, 2024).

Risk management is defined as a systematic process of identifying, assessing, and mitigating risks to reduce their likelihood or impact (Becker, 2004). This process involves implementing detection and prevention strategies to safeguard operations and maintain continuity.

In the manufacturing sector, risk management must be approached holistically, considering legal and compliance requirements as a critical component. Key legislation includes the Health and Safety at Work Act 1974, as well as regulations such as PUWER (Provision and Use of Work Equipment Regulations) and LOLER (Lifting Operations and Lifting Equipment Regulations), which govern the safe use of machinery and lifting equipment (HSE, 2024). Additionally, manufacturers may be subject to industry-specific regulations, such as those governing nuclear waste or hazardous chemicals, alongside customer-specific requirements. These factors introduce further risks, including increased costs resulting from manufacturing failures or non-compliance.

Tools for risk management:

Business can utilise several options for identifying risks within an organisation, Failure Modes and Effects Analysis (FMEA), Fault Tree Analysis (FTA), Risk Matrix and Root Cause Analysis (RCA) are just some of the tools utilised to aid in the

identification and treatment of risk. The higher the risk the greater chance of more in-depth risk management tools will be utilised (Shafiee, Enjema and Kolios, 2019)

An important aspect of risk management is stakeholder engagement. Having the right stakeholders assessing and identifying risk is critical in ensuring from an engineering perspective that all avenues for risk are assessed and that the identification of the risks is agreed cross-functionally by applying sound engineering practices to any given scenario (Eyieyien et al., 2024). If the correct stakeholders are not involved in risk identification, then the organisation runs the risk of issues not being identified and addressed.

Root Cause Analysis is a system or process for defining the underlying cause of failures or potential failures. By identification of root cause failure modes, engineers can implement corrective actions to ensure the issue does not repeat itself for future manufacturing runs, likewise if utilised in pre-production engineering design changes can be implemented to remove any potential failure before it even occurs.

Several options are available for RCA such as but not limited to 5 Why Investigation, Ishikawa Diagrams, Is-Is Not Studies and ABA Swap Test.

The 5-Why problem-solving technique is linked to Taiichi Ohno of the Toyota Motor Corporation and is used to explore cause and effect relationships which cause an underlying problem (Ohno, 1988). The primary goal of the technique is to determine the root cause of a problem by asking “Why” five times, each time directing the current “why” to the previous “why” – if followed correctly the final “why” in principle should determine the root cause of the problem. Figure 2 below shows the Toyota example of a coolant leak on a machine and the method for asking why until the root cause of the failure mode is defined.



Figure 3 – Example 5 Why Investigation

The Ishikawa fault finding method is used heavily within industry to answer queries which a 5-Why may not be able to define and begins with the problem statement being defined (Pacana and Siwiec, 2020) the individual or team then list possible causes which may cause the problem in six distinct categories, Manpower, Method, Machine, Material, Measurement, Environment. Once all the possible causes are listed, the likelihood of these being the root cause is then scored. The highest scoring factors identified are then investigated in greater detail to try and determine root cause of the failure. Figure 3 below shows an example of a car engine which will not start, the team have identified possible root causes of the failure mode which can be investigated until the root cause of the failure mode is defined.

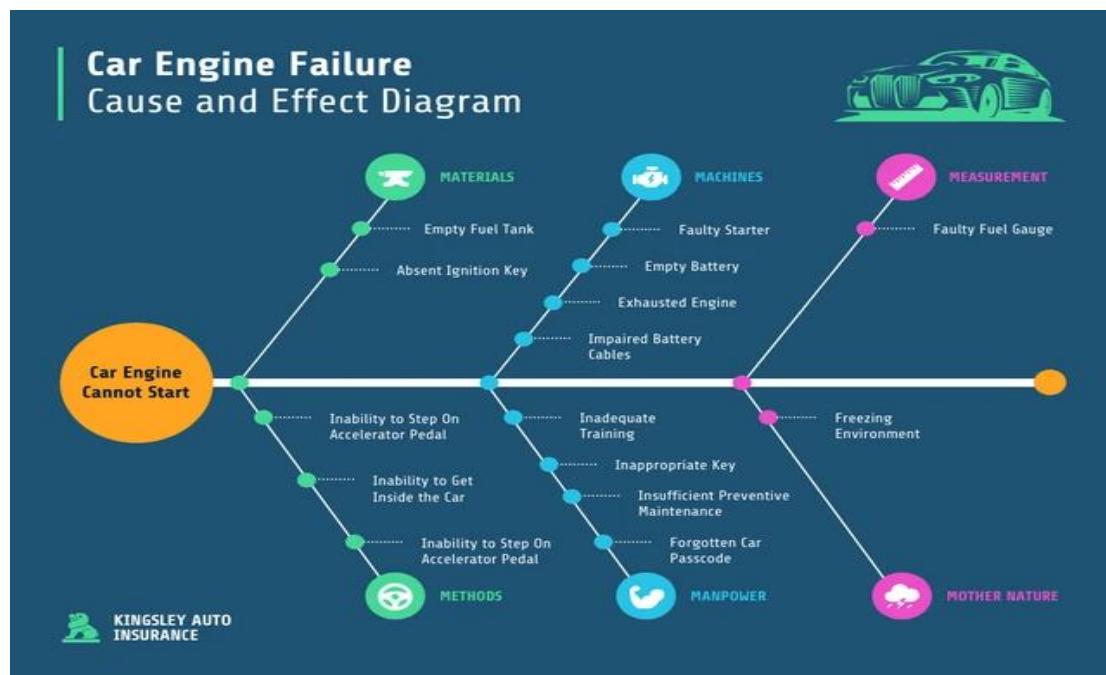


Figure 4 – Ishikawa / Fishbone Diagram RCA Tool

In the case of the LSN, RCA document the examples highlighted have been used as they are industry standard and understood by a cross functional team within the organisation, they are also industry proven as effective so there was no reason to migrate from current process.

Legal and Ethical Considerations:

When applying risk management within the manufacturing sector businesses must always be aware of the legal and ethical considerations which will impact their operation and must be followed to avoid fines or sanctions from governing bodies. By-Laws and national legislation must be adhered to ensure engineering Organisation's operation within (Blessing, 2024). Ethical considerations such as the IMechE code of conduct which is centered around the four main principles of: acting with care and competence, promoting sustainability, exercising leadership and maintaining integrity are good principles to follow if an engineering business is to remain viable to customers and the public (Institute of Mechanical Engineers, 2023). As LSN diffusion is a foundry and handles molten metal daily, using sound engineering practices and ensuring the HSE policies surround hot works etc. is of paramount importance to ensure compliance to legislation.

3.3 Root Cause Analysis

The root cause analysis listed above (Figure 1) is part of a PFMEA document which is utilised within LSN Diffusion Ltd. As LSN deals with automotive and aviation-based customers, this is a customer specific document which must be completed, then shared with the end user for assessment. FMEA analysis looks at potential failure modes within each manufacturing step and then has sections to identify the control measures which will be utilised to control the risk and keep the risk priority number (RPN) at a manageable level. It must be noted that (RPN) numbers and their acceptance dependent on scoring can be different from organisation to organisation, Figure 4 and 5 below are RPN tables set out in the same format but have different criteria in relation to next step actions required post scoring. In Figure 1 this is an agreement between LSN and the end user Rolls Royce Nuclear Power. Customers can identify critical and special characteristics to designs, sections etc. which must be considered as part of the FMEA process and scored internally with agreement from the end user as to the control methods.

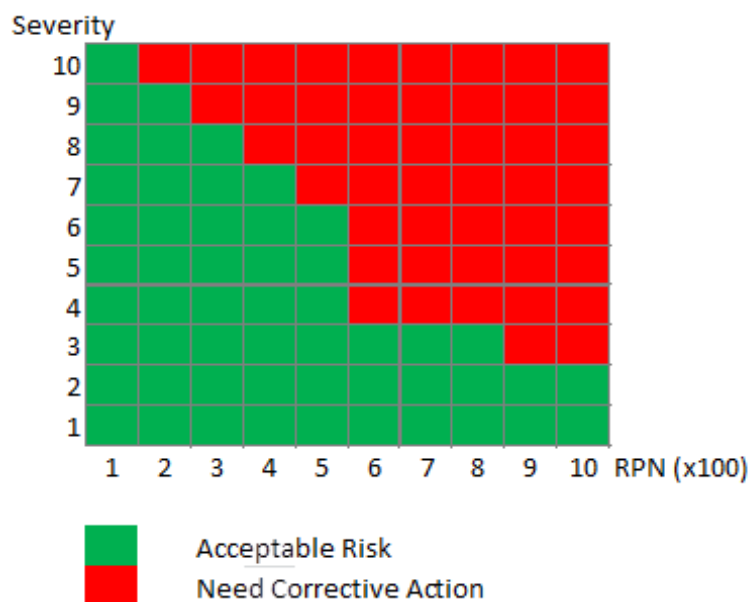


Figure 5 – RPN Example Calculator

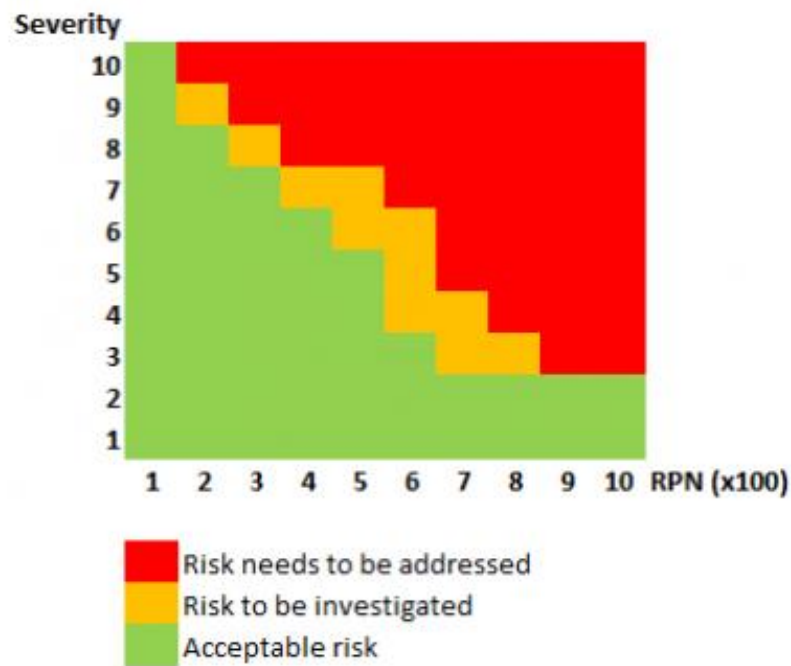


Figure 6 – RPN Example Calculator Variation

As listed under the POD section the oxygen content of the alloy is of critical importance to the end user so the focus of the FMEA has been centered on the ability to keep oxygen levels as low as possible. As the processes within the control of oxygen are manual the systems must be physically checked by quality and technical team members to ensure that correct processes are being followed.

The full scope of the FMEA covers many aspects of the manufacturing process which must be accepted due to the nature of the operation, working with molten metal with temperatures more than 1700 degrees Celsius will always carry risk which can only be managed with the tools available to the industry.

In relation to risks identified within the manufacturing of this product a cross functional team is identified at project initiation, and a RACI matrix is defined to ensure all relevant stakeholders are involved in any key decisions surrounding the manufacturing of the product.

The Pod referenced in Figure 1 is the final collection vessel for atomised metal powder, it is a crucial aspect in oxygen control of the alloy, molten metal is intersected by nitrogen gas at temperatures of circa 1700 degrees, as the material is atomised and process into the collection pod the material is still held at

a temperature of circa 300 degrees. If the material is allowed into an oxygen rich environment at this temperature it will absorb oxygen leading to failed powder batches. Risks were identified surround the release of powder above 30 degrees Celsius which could cause oxidization, likewise oversized or foreign debris of unknown nature could cause additional oxygen spikes. To combat this a PLC controlled temperature probe was inserted into the POD which will not allow the pneumatic valve to open until it reaches the set temperature. To reduce the risk of oversized powder or foreign particles entering the product, extraction and a sieve lid was introduced with the contents then discarded and any super fines again oxygen rich extracted from the final product. Figure 7,8,9 highlights the improvements which will be covered in video presentation.

Where applicable, knowledge and experience are used as guidelines to aid the team in scoring each manufacturing process to as accurate a number as possible. As the FMEA is a living document, any updates which are required during processing after lessons learnt are input into the document. Figure 10 highlights the oxygen control point in relation to manufacturing. During the Atomisation stage the material is more susceptible to oxygen intake due to the molten stage of material production.

Risk Identified	Initial RPN Score	Justification	Final RPN Score	Justification
Early release of atomised metal powder too high in temperature which would attract oxygen intake	144	$8 \times 3 \times 6 = 144$ – Severity of 8 is based on scrap cost to LSN and additional material purchase required, Occurrence of 3 and detection of 6 would be based on skilled operators understanding oxygen	16	$8 \times 2 \times 1$ – The severity remains high; the chance of occurrence and detection are both reduced ed heavily by the system being PLC controlled with digital monitoring equipment

		control as a best-case scenario.		which cannot be overwritten.
Mixing of oversize atomised metal powder with product leading to higher oxygen levels.	90	$5 \times 3 \times 6 = 90$ – Severity for oversize inclusion is mid-range in the event it occurs the material is not scrap but would require rework to remove at a cost to the business. Justification for occurrence and detection again based on best case scenario with a skilled operator carrying out the task.	20	$5 \times 2 \times 2 =$ By standardizing the sieving collection process to a single unit design the risk of oversize entering the product reduces heavily. The production team have a single piece of equipment to utilise to reduce the oversized particles entering product.
Mixing fine particles into final product	150	$5 \times 3 \times 10 = 150$ – Sub 5um particles are unable to be detected by traditional testing methods so run the risk of increasing oxygen levels and would not be defined as root cause due to diameter.	20	$5 \times 2 \times 2 =$ The score was justified by analysing the highest apparent density metal powder LSN produces and calculating the vacuum pressure required to extract this at a set distance, this was then manufactured into the extraction system which is fixed in a set position to remove fines during product decant.

Figure 7 - RPN Scoring Justification



Figure 8 – PLC controlled thermostat not allowing powder release until set temperature is met.



Figure 9 – Powder collection POD used to hold atomised metal powder and cooled with the aid of cooled water jackets.



Figure 10 – POD Decant station with oversize grill and extraction unit fitted.

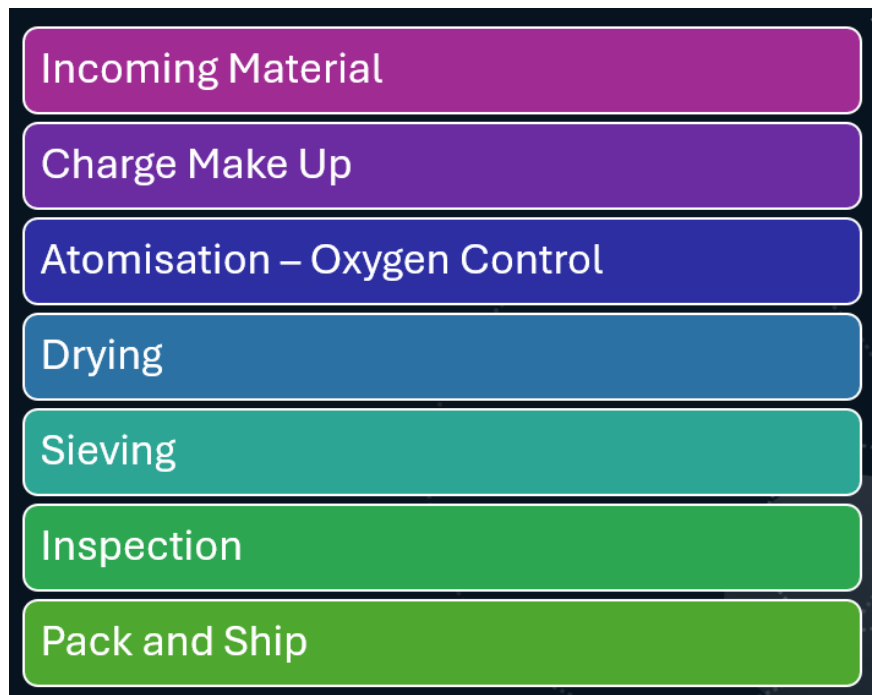


Figure 11 - Process Flow LSN Manufacturing

3.4 Conclusion

Effective risk management, when applied systematically, is a cornerstone of operational excellence in high-risk manufacturing environments. Tools such as Root Cause Analysis (RCA) and Process Failure Mode and Effects Analysis (PFMEA) provide structured methodologies to identify potential failure modes, assess their impact, and implement robust corrective actions. However, their success depends on accurate problem definition, cross-functional collaboration, and alignment with customer-specific requirements.

In this case, the RCA process—supported by experienced stakeholders and validated against Rolls Royce Nuclear Power standards—enabled LSN Diffusion Ltd to significantly reduce risk priority numbers (RPN) through targeted improvements such as PLC-controlled temperature monitoring, standardized sieving systems, and fine particle extraction. These measures not only mitigate oxygen-related risks but also enhance product integrity and customer confidence. Ultimately, RCA and PFMEA should be treated as living documents, continuously updated with lessons learned and technological advancements. By embedding these practices into the culture of quality and innovation, organisations can proactively manage risks, reduce costs, and maintain compliance with stringent aerospace and automotive standards.

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