



Exploring quality management processes in freight wagon manufacturing in South Africa:

A case study of a railway company

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A dissertation submitted in partial fulfilment of the requirements for the degree

of

Master of Commerce

School of Management, IT & Governance

College of Law and Management Studies

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2026

DECLARATION

I Mfaniseni William Tenza..... declare that

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- (ii) This dissertation/thesis has not been submitted for any degree or examination at any other institution.
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Signed:

ACKNOWLEDGEMENTS

First and foremost, I am extremely grateful to supervisors, Dr Mathew Kimanzi and Dr Vangeli Gamede for their invaluable advice, continuous support, and patience during my study. Their immense knowledge and plentiful experience have encouraged me in all the time of my academic research study. Finally, I would like to express my gratitude to my family at large, my wife, Buyisile Faith Tenza, and children. Without their tremendous understanding and encouragement in the past few years, it would have been impossible for me to complete my study.

DEDICATION

I dedicate this dissertation to my beloved late parents, Ms N.E. Mguzulwa and Mr M.R. Tenza. Your boundless love, endless encouragement, and profound wisdom have been the bedrock of all my achievements. Though you are no longer here in person, your presence and influence are ever strong in my heart and in every step of this journey. Mom and Dad, your strength and resilience have been my unwavering compass, illuminating my path even in the darkest times. This work stands as a tribute to your enduring legacy and the countless sacrifices you made to nurture my dreams. I am forever grateful and profoundly honoured to be your child.

LIST OF ACRONYMS

AAR - Association for the American railroad

AI - Artificial intelligence

CAD - Computer-aided design

CCC - Customer Complaints Chart

CNC - Computer numerical control

CI - Continuous improvement

CQI - Continuous quality improvement

DFM - Design for manufacturability

DFSS - Design for Six Sigma

DMAIC - D – Define, M – Measure, A – Analyse, I – Improve, C – Control

DMADV - D – Define, M – Measure, A – Analyse, D – Design, V – Validate

ED – Engineering Division

IoT - Internet of Things

ISO - International Organisation for Standardisation

JIT - Just-in-time

KPIs - Key performance indicators

MDS - Market Demand Strategies

NCR - Non-conformance reporting

NDT - Non-destructive testing

PDCA - Plan-Do-Check-Act

QA - Quality assurance

QC - Quality control

QM - Quality management

QMPs - Quality Management Processes

QMS - Quality Management System

QLF - Quality loss function

QP - Quality planning

RCA - Root cause analysis

RFID - Radio Frequency Identification

SOPs - Standard Operating Procedures

TD – Transnet Designing

TFR - Transnet Freight Rail

TQA - Total Quality Assurance

TQM - Total Quality Management

ABSTRACT

This study investigates the critical role of quality management processes within the wagon manufacturing sector, focusing on a major South African railway company's Engineering Division. This division, known for its responsibility over various aspects of rolling stock, was selected due to its history of crashes and mishaps, which have significantly impacted the company's reputation. In a competitive market marked by evolving demands and stringent regulations, ensuring high product quality is essential for sustained business growth and customer satisfaction.

Using a comprehensive case study approach, this research delves into the company's quality management strategies, challenges, and outcomes. The study involved in-depth interviews with 15 staff members, observations, and document analysis to explore how quality concerns, defects, and non-conformities are identified and addressed in the manufacturing process. The qualitative data, analysed through thematic analysis, revealed five key themes: inspection procedures; testing protocols; employee involvement; continuous improvement initiatives; and root cause analysis. These findings underscore the importance of lean manufacturing and Kaizen events in maintaining high-quality standards and highlight the structured approach to root cause analysis and corrective actions for preventing quality issues.

Furthermore, the study emphasises the integration of quality into all business processes, from design to production, ensuring adherence to industry standards like ISO 9001 and AAR M-1003. The research concludes with recommendations to leverage advanced manufacturing technologies and foster supplier collaboration to further enhance quality and operational efficiency.

Keywords: Quality management practices, continuous improvement, employee involvement, management commitment, quality control checks

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CHAPTER 1: INTRODUCTION, BACKGROUND AND SIGNIFICANCE OF THE STUDY

1.1 Introduction

Quality management (QM) refers to following the necessary stages to make sure the project progresses according to the predetermined specifications and determinations before it begins to fulfil the client's requirements as well as those of the partners involved (Goetsch and Davis, 2021). According to Smith (2018), effective quality management is crucial for organisational success. To ensure organisational success with total quality management, active involvement of senior management and a deep understanding of customer-centric principles are essential (Goetsch and Davis, 2021).

While TQM principles such as continuous improvement and customer focus are universally relevant (Zairi, 2018; Tatikonda and Tatikonda, 2016), their application may vary significantly in different industries. In the South African rail manufacturing sector, for instance, challenges such as aging infrastructure, inconsistent quality standards, and limited workforce skills can hinder the successful implementation of TQM (TIPS, 2022; Transnet, 2023). Linking these sector-specific issues to the general TQM framework helps clarify the relevance of the study and demonstrates how tailored quality management strategies are needed to improve performance within this context (Tague, 2016; Terziovski and Samson, 2015).

ISO 9001 is an international standard that specifies requirements for a quality management system (QMS) and is used by organisations to ensure they consistently meet customer and regulatory requirements (ISO, 2015). It focuses on principles such as customer satisfaction, continual improvement, and process-based approaches to enhance overall organisational performance (Hoyle, 2017). Implementing ISO 9001 in engineering firms is very difficult because of limited management support, poor communication among employees, and a tendency to confine quality management efforts to the construction phase alone (Pyzdek and Keller, 2020).

Transnet is a state-owned organisation in the South African railway industry, which has many divisions (Transnet, 2023). One of the newly established divisions is responsible for train building (Transnet, 2023).

While undertaking fabrication projects, several incidents of crashes and mishaps have been reported, as indicated in Transnet's 2014-2015 financial year report (Transnet 2022). Transnet employees regularly encounter high-risk environments, making a study focused on quality management in their projects a crucial step for sustaining quality (Griffith and Watson, 2021).

1.2 Background

The Engineering Division is an integral part of the South African railway industry, comprising several business units engaged in the manufacturing, upgrading, conversion, repair, and maintenance of rolling stock and associated transport equipment (Transnet Engineering, 2024). This division has historically been central to rail operations, yet its performance reflects the broader challenges of state-owned enterprises undertaking large-scale projects. For instance, government committed R300 billion to Transnet Freight Rail (TFR) to modernise rail foundations, pipelines, and capacity (Transnet, 2015; TIPS, 2022). While such investments demonstrate the strategic importance of the sector, international evidence shows that large-scale infrastructure projects frequently face delays, escalating costs, and underperformance (Flyvbjerg, 2017; Demirkesen and Ozorhon, 2017).

Although Transnet has long repaired rolling stock, the company's move into train manufacturing illustrates these challenges. The Transnet Design unit, for example, failed to deliver its target of 100 locomotives of classes 34-600 and 34-800 in 2008; only five were built before the project was abandoned due to prohibitive costs (Kaziboni, 2017; Railways Africa, 2008). Such outcomes mirror global findings that project management success depends heavily on effective cost, quality, and schedule control (Brown and Green, 2021; Zidane and Andersen, 2018). Poorly managed projects often encounter increased costs, delays, and customer dissatisfaction, reinforcing the need for robust project governance (Smith, 2022).

Maintaining quality standards in complex engineering projects is equally critical. Organisations like Transnet Engineering are expected to comply with international benchmarks to ensure safety, reliability, and efficiency. The ISO 9001:2015 framework provides a globally recognised structure for quality management systems (ISO, 2015). Academic research highlights the benefits of adopting ISO standards, particularly in driving consistency and stakeholder confidence (Heras-Saizarbitoria and Boiral, 2013).

Moreover, the integration of Total Quality Management (TQM) practices such as continuous improvement, employee involvement, and customer focus remains central to improving project outcomes (Shah and Ward, 2007; Liu, Love and Sing, 2016).

Continuous Quality Improvement (CQI) processes are therefore vital in strengthening competitiveness and minimising incidents, including accidents and operational failures (SixSigma, 2024). However, studies show that the implementation of TQM in construction and engineering is often constrained by factors such as poor documentation systems, inadequate subcontractor commitment, and difficulties in measuring outcomes (Taylor, 2021; Liu, Love and Sing, 2016). Leadership commitment plays a decisive role: senior management must not only mandate but also actively participate in quality initiatives to embed organisational excellence (Johnson and Lee, 2019; Williams and Turner, 2019). Research further suggests that leadership's alignment with client expectations and consistent reinforcement of quality values are critical for sustained improvement (Turner, Ledwith and Kelly, 2012).

Against this backdrop, the current study will evaluate how core TQM principles can be adapted to overcome sector-specific constraints within Transnet Engineering. By grounding the analysis in both international scholarship and the South African case, this research contributes to addressing gaps in the literature on quality management in state-owned rail enterprises. It also aims to provide practical recommendations for improving operational performance in the country's rail manufacturing environment (Tague, 2016; TIPS, 2022).

1.3 Problem Statement

The local production of wagons by Transnet has been recognised as a positive step toward bolstering South Africa's economy through job creation and income generation for its citizens (Transnet, 2023).

However, delays in the release of new wagons for the rail industry have led to significant setbacks for Transnet, primarily due to incidents involving sub-standard trains and wagons (Railway Safety Regulator, 2023). To mitigate these risks, it is imperative to evaluate the quality management system (QMS) processes and enhance the interaction between quality assessments to improve assembly process guidelines (Transnet, 2024).

Despite the presence of global quality standards such as ISO 9001, inconsistencies in the application of quality management practices continue to affect the performance and reliability of wagon production projects within Transnet's Engineering Division. This has raised concerns regarding the effectiveness of quality control, assurance, and confirmation mechanisms. The lack of alignment with ISO-compliant systems may lead to operational inefficiencies, safety risks, and reputational damage. Therefore, there is a need to investigate how quality is managed, controlled, and confirmed across various projects and whether these processes align with established ISO standards.

Challenges such as aging infrastructure, inconsistent quality standards, and a shortage of skilled labour continue to undermine TQM implementation in this context (Transnet, 2023; TIPS, 2022). Despite the sector's strategic importance to the country's industrial development and logistics capacity (DTIC, 2021), existing studies often overlook the need for tailored quality strategies that align with the unique structural and operational conditions of this industry (Tague, 2016).

This research therefore seeks to fill the gap by evaluating the applicability and effectiveness of TQM practices in this underexplored, yet critical, manufacturing domain.

Such improvements are expected to contribute to economic stability and growth by ensuring the timely release of high-quality wagons, thereby sustaining employment and income for South African citizens (Steyn, 2023).

1.4 Research Questions

1.4.1 Main Research Question

- How are quality management practices of wagon manufacturing undertaken at a South African railway company?

1.4.2 Secondary Research Question

- What are the Total Quality Assurance (TQA) measures taken in the production process of wagons?
- What quality standards are adhered to by the company in the production process?
- What strategies can be used to improve the quality of the manufactured wagons?

1.5 Research Objectives

1.5.1 Primary Objective

To analyse the quality management practices of wagon manufacturing at a South African railway company.

1.5.2 Secondary Objectives

The secondary objectives developed in support of this primary objective are:

- To identify Total Quality Assurance (TQA) measures taken in the production process of wagons.
- To identify the quality standards adhered to by the company in the production process.
- To find out the strategies that can be used to improve the quality of the manufactured wagons.

1.6 Significance of the Study

The findings from this study hold significant implications for the South African railway industry (TIPS, 2022). By elucidating the quality management cycle employed to measure wagon manufacturing quality, the study provides a detailed framework that can be adopted or adapted by other divisions and companies within the sector (Mhleka, 2019).

This enhanced understanding will aid in identifying gaps and strengths in current practices, thereby enabling targeted improvements (Railway Safety Regulator, 2024).

Moreover, the study's insights into quality management and quality measures will facilitate the development of more robust, standardised protocols that can elevate overall manufacturing quality (Mpontshane et al., 2024). This, in turn, will help reduce the frequency of crashes and mishaps, thereby safeguarding the reputation of railway companies and ensuring higher levels of safety and reliability for end-users (Railway Safety Regulator, 2024).

Additionally, the study's recommendations on collaborative product development with suppliers can lead to the adoption of innovative technologies and practices across the industry (ResearchGate, 2024). By leveraging suppliers' technical expertise and specialised knowledge, railway companies can enhance their product designs, improve performance, and gain a competitive edge (Kearney, 2024).

This collaborative approach not only boosts the industry's technological advancement but also fosters a culture of continuous improvement and innovation (Steyn, 2023).

Ultimately, the study contributes to the sustainable growth of the South African railway industry by promoting practices that enhance product quality, customer satisfaction, and operational efficiency (SA-TIED, 2023).

1.7 Overview of Research Methodology

This study adopted a qualitative research approach to explore quality management practices in wagon production projects within Transnet Engineering. Data was collected through semi structured interviews and surveys involving selected suppliers and industry experts. Thematic analysis was used to categorise and interpret the data under three main quality dimensions: quality management, quality control, and quality confirmation.

1.8 Conclusion

This study not only highlights the significant role of quality management in the wagon manufacturing sector but also provides actionable recommendations for improving quality management practices.

These insights are invaluable for the South African railway industry as they strive to enhance product quality, ensure safety, and maintain a strong reputation in a competitive and regulated market.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter considers the theoretical basis for the research and what previous scholars have done in the subject area. Identification and definition of key terms related to quality, quality management practices, Total Quality Assurance (TQA) measures and quality standards are all considered in turn. Finally, the chapter considers strategies that are utilised for the purposes of improving the quality in wagon manufacturing.

2.2 Definition of Key Terms

2.2.1 Quality

The International Organisation for Standardisation (2015) defines quality as “the degree to which a set of inherent characteristics fulfil requirements”.

- Quality involves products, defects, processes, customers and systems.
- Quality is the ability of a set of inherent characteristics of a product, system, or process to fulfil the requirements of customers and other interested parties.
- Quality is a fourth among equals in relation to the project triple constraints of time, cost and scope.

According to Smith (2019), quality has two meanings that are critical to its management. The quality is defined as "product features that meet customers' needs and thus provide customer satisfaction" (Smith 2019), the quality enhancement also implies "deficiency-freedom".

According to Johnson and Clark (2018), quality is determined by how well inherent characteristics align with specified requirements, leading to either high or low quality depending on the alignment.

According to Smith and Adams (2017), quality is a subjective term that varies between individuals and sectors, and in technical contexts, it can have multiple meanings, including:

- The characteristics of a product or service that bear on its ability to satisfy stated or implied needs.
- A product or service free of deficiencies.

Ultimately, quality is an outcome, a feature of a product or service provided to a customer, and the mark of a company that has satisfied all its stakeholders (ASQ, 2023). Customer requirements are the fundamental ideal underlying all quality definitions (ISO, 2015).

2.2.2 Quality Management

Managing quality refers to following the necessary stages to make sure the project progresses according to the predetermined specifications and determinations before it begins to fulfil the client's requirements as well as those of the partners involved (Ahmed, 2023).

Quality management is described as a part of the general management process, focusing on how quality approaches are resolved and executed by senior management (Brown, 2018).

Aside from this, Brown (2018) argues that while management is characterised by a quality framework, all management activities such as quality planning, quality assurance, quality control, and quality improvement are also managed via quality management cycles (Doe and Smith, 2022).

The Project Management Institute (2021) defines Quality Management Systems (QMS) as “all activities of the overall management function that determine the quality policy, objectives and responsibilities, and implement them by means such as quality planning, quality control (QC), quality assurance (QA) and quality improvement within the quality system”. QMS has many applications in the construction industry and such systems are implemented either at the company level or at the project level (Anitech Group, 2023). Quality in the construction industry is linked with client satisfaction, and the implementation of a quality management system is a key tool in consistently and reliably managing the goal of client satisfaction (ISO 9001, 2015).

De Feo and Barnard (2023) contend that QMS could be implemented either at the organisation level or at the project level itself.

For the implementation of quality management in construction projects, the concepts of quality planning (identification of quality standards), quality assurance (evaluation of overall project performance) and quality control (monitoring of specific project results) in the quality management processes were defined by the (Project Management Institute 2021).

Several tools and techniques were identified as part of the implementation process, like cost benefit analysis, benchmarking, flow-charting, design of experiments, cost of quality, quality audits, inspection, control charts, Pareto diagrams, statistical sampling, flow-charting and trend analysis (ASQ, 2025). The subsequent section discusses the quality management measures necessary to accomplish a project's objectives.

Establishing clear quality standards, goals, and metrics that align with project objectives is critical for measuring and analysing quality performance (SixSigma.us, 2024). Bendell et al. (2015) assert that quality management is the act of supervising all activities and tasks that must be completed to maintain a desired level of excellence.

This includes establishing a quality policy, developing and implementing quality planning and assurance, and ensuring quality control and improvement (ASQ, 2025). According to Pham and Oztemel (2016), quality management is the act of supervising various activities and tasks within an organisation to ensure that the products and services provided, as well as how they are delivered, are consistent. It aids in the achievement and maintenance of the desired level of quality within the organisation (Flowdit, 2024).

2.2.3 Quality Planning

Senaratne and Jayarathna (2023) describe quality planning as a systematic process aimed at ensuring the successful execution of a coordinated set of activities. This approach is designed to help organisations meet deadlines, minimise costs, and fulfil specific customer requirements (Senaratne and Jayarathna, 2023).

Senaratne and Jayarathna (2023), quality planning (QP) is crucial in quality processes like quality control, assurance, and improvement. Moreover, Dahlgaard et al. (2018). Furthermore, the first step in implementing a quality management system is commitment from top management. The top management of an organisation should be determined and committed to implement a quality management system (ISO, 2015). No quality initiative within an organisation can succeed without commitment from top management (ISO, 2015).

Top management can demonstrate to their clients that the organisation is committed to quality through the certification and registration of the ISO 9000 standard (Tuzunkan, 2023). Top management should thus come to the realisation that overall business efficiency would be improved by means of a quality management system. Dahlgaard et al. (2018) indicate that the other steps include establishing an implementation team, conducting ISO 9000 awareness programmes, providing training, conducting an initial status survey, creating a documented implementation plan, carrying out implementation, conducting an internal quality audit, ensuring certification and registration, and finally, working toward continual improvement (ISO, 2015).

In the long term, quality planning is fundamental to total quality management (TQM) and the global standardisation of organisations (ISO).

Many companies that employ quality management strategies often fail because they rely on approaches that are not integrated with their core planning (Goetsch and Davis, 2018).

Transnet's goal is to advance the South African rail industry, which includes improving the efficiency of its operations while reducing business costs. Besides transporting goods to and from its ports, Transnet moves thousands of tons of goods daily across South Africa (Transnet, 2022).

Transnet's market demand strategies include reducing logistics costs by shifting more traffic to railways to support rural development, beneficiation, and manufacturing goals; advancing Africa's connectivity; enhancing rail and port logistics to make South Africa more competitive in global markets; creating jobs, developing skills, localising production, and empowering communities; and positioning South Africa's railways among the top five globally (Transnet, 2012).

Some projects aimed at achieving these strategies are currently being executed. However, several derailments and accidents have occurred, as noted in Transnet's business performance report for the 2014/2015 financial year (Transnet, 2022).

Construction projects can be considered successful in several ways. A project is deemed successful when its objectives are achieved (Gido et al., 2017). Gido et al. (2017) state that the success of a project is influenced by cost, time, and quality management within the context of current project performance management. The quality management of a construction project is directly affected by its budget and schedule. Larson and Gray (2018) argue that poorly managed construction projects can lead to time extensions, cost overruns, and alterations in client requirements.

They suggest that there is significant potential to enhance project performance by identifying the causes and costs associated with rework (Larson and Gray, 2018).

For an organisation to succeed with total quality management, the involvement of senior management and a strong focus on customer-centricity are essential. A key aspect of construction quality management is the commitment of top management. The success of ISO 9000 implementation in the construction industry also largely depends on this commitment. According to Zeng, Tian and Tam (2015), high levels of management commitment during the implementation of total quality management on construction sites can help prevent problems from arising.

Management actions are crucial for continuous quality improvement at every project phase.

The quality management process should be fully supported and understood by top management, rather than being delegated to lower levels. Zeng, Tian and Tam (2015) recommend that top management not delegate the implementation process altogether.

According to the literature, the most common reason for the failure of TQM implementation is a lack of management commitment. Management needs to be dedicated to the goal, offering support and motivation to employees to successfully implement TQM. The TQM approach should be outlined within a clear framework, and management must regularly communicate to clarify the stages of this framework to achieve the desired outcomes (Kumar and Sharma, 2017). If the framework's stages are unclear, management must provide necessary support. Additionally, management should frequently highlight the benefits and advantages of TQM implementation at every possible opportunity (Anholon et al., 2018).

The most challenging and time-consuming aspect of TQM implementation is changing the organisational culture. This difficulty arises from employees' fear of and resistance to change (Whatfix, 2022). Employees accustomed to the existing culture find it harder to adapt their daily routines compared to those with a quality-oriented mindset (AIHR, 2023). As a result, during this phase, management must work to shift the current culture toward a quality-focused one to ensure a smooth TQM implementation (Dale and Shaw, 2016).

Empirical evidence supports the need for context-specific adaptation of TQM. For instance, Naidoo and Wu (2018) found that South African manufacturing firms struggle with TQM implementation due to inadequate training and poor infrastructure.

Similarly, Sifiso and Mokgadi (2020) reported that despite the introduction of tools like Six Sigma, the rail manufacturing sector faces persistent quality issues due to skills shortages and inconsistent standards. These studies highlight the importance of tailoring TQM strategies to address sectorspecific challenges.

There are instances when quality tools and techniques are not applied correctly. Incorrect use of quality tools and techniques can result in the collection of invalid data, making it impossible to achieve improvements without accurate information (Anomalo, 2023). Management should possess fundamental knowledge of quality tools and techniques for their effective application; it seems it would be very important for management to know these things (Prajogo and Sohal, 2018).

The TQM approach is a long-term and gradual process. Employees need time to adopt and adjust to the fundamental principles of TQM. Sufficient time is essential for the successful implementation of TQM (Shill, 2022). Chakravarty et al. (2022) emphasise that “TQM is not a panacea or an Aladdin’s lamp.” It must be understood, integrated, and cultivated before any benefits can be realised (SixSigma.us, 2024). Therefore, TQM is not suitable for quick fixes, and ample time is crucial for its successful implementation (Tatikonda and Tatikonda, 2016).

Total Quality Management (TQM) has received significant attention in recent academic debates due to its ability to provide quality through effective management practices (Zairi, 2023).

This focus was necessitated by the overarching need to improve the quality of products delivered in the architecture, engineering, and construction (AEC) industry (Aghimien et al., 2019). Aghimien et al. (2019) conducted a study in Gauteng, South Africa, to assess TQM practices in construction project delivery. The study used a quantitative approach with a questionnaire survey to gather information from construction participants involved in the delivery of civil engineering projects in the study area (Aghimien et al., 2019).

According to the study's findings, the most used TQM practices are customer focus, supplier quality management, strategic planning, and employee relations.

Measures such as ensuring customer involvement, top management involvement and commitment, education and training of engineers on TQM practices, effective customer-supplier relationship, effective communication (internal and external), and primary customer focus are important in improving TQM practice adoption (Aghimien et al, 2019).

Cerenio (2015) focused on the development of the TQM philosophy and the creation of a TQM model to be used as a reference in the design of a TQM process in the manufacturing environment. Cerenio’s (2015) study also endeavoured to formulate an implementation process that can be used as guideline for implementing TQM in an organisation.

The study concludes that South African organisations can address the issues prohibiting real economic growth by continuously improving every product and service produced, through the involvement of an empowered workforce, and by operating in teams with the objective of achieving optimum customer satisfaction in the long term (Cerenio, 2015).

2.2.4 Total Quality Management

According to Aghimien et al. (2019), Total Quality Management (TQM) is the continual process of detecting and reducing or eliminating errors in manufacturing, streamlining supply chain management, improving the customer experience, and ensuring that employees are up to speed with training. Total Quality Management (TQM) emphasises that all parties involved in the production process are accountable for the final product or service quality (Tari, 2018).

It represents a systematic approach to organisational management (Tari, 2018). The focus of the process is to improve the quality of an organisation's outputs, including goods and services, through the continual improvement of internal practices (Feigenbaum, 2019).

The standards set as part of the Total Quality Management (TQM) approach can reflect both internal priorities and industry standards (Feigenbaum, 2019).

Freund (2016) contends that TQM is a management framework based on the belief that an organisation can build long-term success by having all its members, from low-level workers to its highest ranking executives, focus on improving quality and thus deliver customer satisfaction. It can be described as a management approach to long-term success through customer satisfaction (Freund 2016).

It requires organisations to focus on continuous improvement, or Kaizen. It focuses on process improvements over the long term, rather than simply emphasising short-term financial gains (Freund 2016).

2.2.5 Quality Assurance

Adam (2019) defines quality assurance (QA) as a systematic process for determining whether a product or service meets specified requirements and emphasises its role in creating and maintaining standards for reliable products. A quality assurance system is intended to boost customer confidence and a company's credibility while also improving work processes and efficiency; and it allows a company to compete more effectively (Arumugam et al., 2015). The International Organisation for Standardisation (ISO) is a driving force behind QA practices and the mapping of QA processes.

Quality assurance, as defined by the International Organisation for Standardisation (ISO), refers to the systematic efforts in both manufacturing and service industries to ensure that the products meet the customer's expectations for performance, design, reliability, and maintainability that are established and agreed upon (ISO, 2022). The main objective of quality assurance is to prevent errors and defects during the development and production of manufactured goods, such as automobiles and shoes, as well as in delivered services like car repair and athletic shoe design (Adam, 2017).

2.2.6 Quality Standards

Quality standards, according to Douglas and Judge (2017), are sets of good management practices, methods, systems, requirements, and/or specifications established by industry advisory groups to assist manufacturers in achieving and demonstrating consistent production and product quality. Some quality standards apply to a wide range of manufacturing and service organisations, whereas others are industry specific.

The American Society of Quality (2022) defines quality standards as documents that contain requirements, specifications, guidelines, or characteristics that can be applied consistently to ensure that materials, products, processes, and services are fit for purpose.

2.3 ISO 9001:2015 and Quality Management Systems (QMS)

The International Organisation for Standardisation (ISO) developed the ISO 9001 standard to guide organisations in establishing effective quality management systems.

ISO 9001:2015 outlines seven principles including customer focus, leadership, engagement of people, and continuous improvement (ISO, 2023).

These principles are particularly relevant to engineering-based production environments such as wagon manufacturing within Transnet, where consistent quality and compliance are essential. This study uses ISO 9001 as a theoretical lens to assess how quality is managed, controlled, and confirmed across various projects.

2.4 Quality Management Practices

Increased competition in business and the market has opened the door to better production of products and services than before.

The need for a quality management approach has provided a means for organisations to develop and upgrade their quality measures. In today's business world, the focus on quality has increased and is being used as a competitive tool. In organisations, management secures vitality through fulfilling client needs and organisational survival, which is the fundamental logic of quality management (Nayepour and Koehn, 2016).

The quality practices of an organisation, which occur within a quality culture or context, are defined as the actions and procedures undertaken by a company to ensure the delivery of a highquality service or product (Antony et al., 2021). Sousa and Voss (2015) mention that “practices are the observable facet of QM, and it is through them that managers work to realise organisational improvements. Quality management practices have been investigated extensively (Fredriksson, 2016; Park-Dahlgaard, 2016; Rategan, 2018; Nilsson et al., 2016). Despite the numerous practices that have been outlined, commonalities among them can be identified.

Sousa and Voss (2015) assert that there are ten distinct generic practices: top management commitment and support; organisation for quality; employee training; employee participation; supplier quality management; customer focus continuous support; improvement of quality system; information and analysis; and statistical quality techniques use.

Table 1. Presents, for each generic practice, a list of similar practices proposed by other authors

	Generic Practice	Related Practice
1	Top Management commitment and support	Top management commitment (Ahire et al., 1996; Powell, 1995). Top management team involvement (Douglas and Judge, 2001). Leadership (Anderson and Sohal, 1999).
2	Quality management organisation	Quality management framework (Ahire et al., 1996). Open organisational structure (Powell, 1995). Collaborative cross-functional teams (LaHay and Noble, 1998).
3	Staff development	Employee training (Saraph et al., 1989). Training and/or educational initiatives (Ahire et al., 1996; Powell, 1995).
4	Employee participation	Involvement (Zhang et al., 2000). Delegation of authority (Ahire et al., 1996). Employee development (Ahire et al., 1996).
5	Supplier quality control	Supplier quality control (Ahire et al., 1996; Saraph et al., 1989; Zhang et al., 2000).
6	Customer orientation	Customer-centric approach (Ahire et al., 1996; Zhang, 2000). Strong customer relationships (Powell, 1998). Customer-driven strategy (Douglas and Judge, 2001).
7	Ongoing support	Ongoing improvement (Douglas and Judge, 2001). Recognition and incentives (Zhang et al., 2000).
8	Enhancement of the quality system	Enhancement of the quality system (Zhang et al., 2000).
9	Information and Analysis	Information and analysis processes (Anderson and Sohal, 1999; Choi and Eboch, 1998). Information management (Sun, 2000), quality data (Saraph, 1989).
10	Application of statistical quality methods	Application of statistical techniques (Ahire et al., 1996). Comprehensive quality methodologies (Douglas and Judge, 2001).

Source: Sousaa and Voss (2015)

Various authors, such as Antony et al. (2021), Sharma et al. (2020), and Zhang and Liu (2022), point out that the terminology of quality management practices has been criticised for lack of standardisation. Researchers should also strive for a standardisation of definitional terms. There have been several other criticisms of the terminology used in quality management practices over the years. One of the criticisms is regarding the jargon and technical language used. Brown et al. (2015) argue that quality management practices can be filled with jargon and technical language that is difficult for laypeople to understand. This can create barriers to communication and limit the effectiveness of quality management practices. Another criticism relates to lack of clarity and consistency: Carlsson and Carlsson (2019) contend that some of the terminology used in quality management practices can be vague or unclear, which can lead to confusion and misunderstandings. Additionally, different organisations and industries may use different terms for the same concepts, which can further complicate matters.

Zhihong (2015) further argues that some of the terminology used in quality management practices can reinforce a focus on compliance and meeting standards, rather than on continuous improvement and innovation. Tague (2016) claims that the terminology used in quality management practices can be too focused on processes and systems, and not enough on meeting the needs and expectations of customers.

A quality management system (QMS) is utilised by companies aiming to meet or surpass established quality standards effectively. It is designed to prevent loss and enhance compliance by providing a framework for measuring and monitoring products, services, processes, procedures, production, and employees to ensure they meet expectations. The Total Quality Management (TQM) programme is one of the most used practices for QMS compliance (Gao et al., 2023).

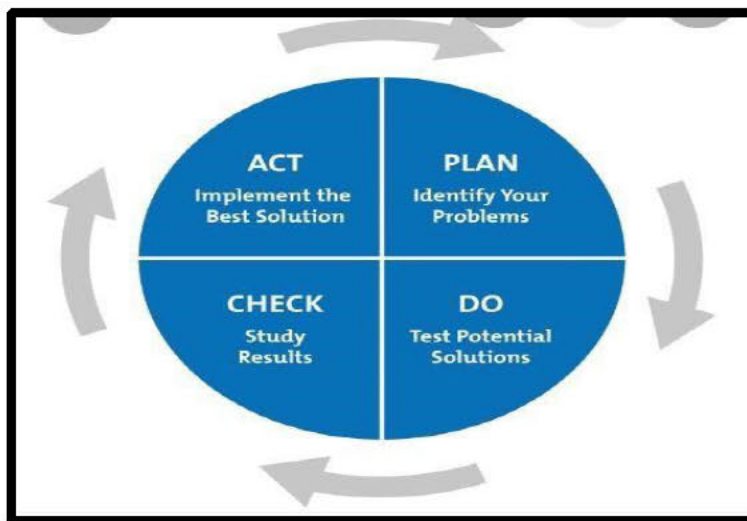
Heizer and Render (2015) contend that TQM refers to a quality emphasis that encompasses the entire organisation from supplier to customer. TQM stresses commitment by management to have a continuing companywide drive toward excellence in all aspects of products and services that are important to the customer.

Further, Heizer and Render (2015) hold the view that TQM is effectively implemented through seven concepts:

□ Continuous improvement

TQM requires a never-ending process of continuous improvement that covers people, equipment, suppliers, materials, and procedures. The basis of the philosophy is that every aspect of an operation can be improved. The end goal is perfection, which is never achieved but always sought. Plan-Do-Check-Act (PDCA) is a type of continuous improvement model developed (Smith, 2023). The PDCA cycle is an iterative process for continually improving products, people, and services. It became an integral part of what is known today as Lean Management. The Plan-Do-Check-Act model includes solutions testing, analysing results, and improving the process. Figure 1 below illustrates the PDCA cycle (Heizer and Render, 2015).

Figure 1. Plan-Do-Check Act cycle



Source: Heizer and Render (2015)

The Japanese use the word Kaizen to describe this ongoing process of unending improvement, the setting and achieving of ever-higher goals (Bennett, 2023). Kaizen is the practice of continuously monitoring, identifying, and executing improvements (Bennett, 2023). This is a particularly useful practice for the manufacturing sector (Kareska, 2024).

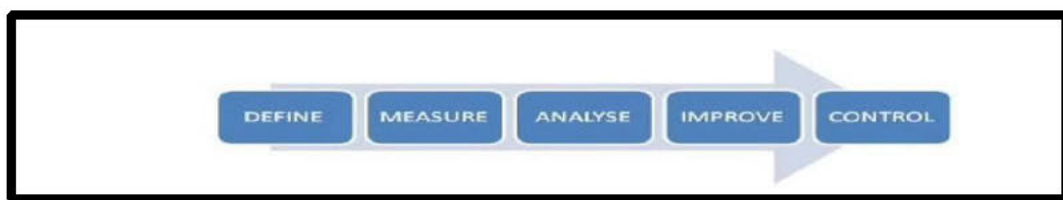
Collective and ongoing improvements ensure a reduction in waste, as well as immediate change whenever the smallest inefficiency is observed (Giflow, 2016).

□ Six Sigma

According to Pande et al. (2017), the term Six Sigma has two meanings in TQM. In a statistical sense, it describes a process, product, or service with an extremely high capability (99.9997% accuracy). The second TQM definition of Six Sigma is a programme designed to reduce defects to help lower costs, save time, and improve customer satisfaction. Six Sigma is a comprehensive system, a strategy, a discipline, and a set of tools for achieving and sustaining business success. Successful Six Sigma projects are clearly related to the strategic direction of a company. It is a management-directed, teambased, and expert-led approach (Six Sigma Council, 2018).

The two main Six Sigma methodologies are DMAIC and DMADV. Each has its own set of recommended procedures to be implemented for business transformation. DMAIC is a data-driven method used to improve existing products or services for better customer satisfaction. It is the acronym for the five phases: D – Define, M – Measure, A – Analyse, I – Improve, and C – Control. DMAIC is applied in the manufacturing of a product or delivery of a service (George et al., 2016). Figure 2 below illustrates the DMAIC methodology.

Figure 2. DMAIC methodology



Source: George et al. (2016)

DMADV is a part of the Design for Six Sigma (DFSS) process used to design or re-design different processes of product manufacturing or service delivery. The five phases of DMADV are: D – Define, M – Measure, A – Analyse, D – Design, and V – Validate. DMADV is employed when existing processes do not meet customer conditions, even after optimisation, or when it is required to develop new methods (George et al., 2016).

□ **Employee empowerment**

Employee empowerment means involving employees in every step of the production process. Consistently, business literature suggests that some 85% of quality problems have to do with materials and processes, not with employee performance (Choi and Eboch, 2016). Therefore, the task is to design equipment and processes that produce the desired quality. This is done with a high degree of involvement by those who understand the shortcomings of the system. Techniques for building employee involvement include building communication networks that include employees; developing open, supportive supervisors; moving responsibility from both managers and staff to production employees; building high morale organisations; and creating such formal organisational structures as teams and quality circles (Thomas, 2015).

□ **Benchmarking**

Benchmarking is another ingredient in an organisation's TQM programme. Beer (2017) asserts that benchmarking involves selecting a demonstrated standard of products, services, costs, or practices that represent the very best performance for processes or activities very similar to the company's own. The idea is to develop a target at which to shoot and then develop a standard or benchmark against which to compare the company's performance. Typical performance measures used in benchmarking include percentage of defects, cost per unit or per order, processing time per unit, service response time, return on investment, customer satisfaction rates, and customer retention rates (Singh et al., 2022).

□ **Just-in-Time (JIT)**

Goetsch and Davis (2015) postulate that the philosophy behind just-in-time (JIT) is one of continuous improvement and proactive problem-solving. These are key aspects of JIT systems, which are designed to produce or deliver goods precisely when needed. JIT is connected to quality in three significant ways:

- ✓ **Cost Reduction:** JIT lowers the cost of quality by minimising scrap, rework, inventory investment, and damage costs, all of which are associated with holding inventory. With less inventory, costs decrease, and issues with quality are immediately identified rather than being masked by excess stock.

- ✓ **Quality Enhancement:** By reducing lead times, JIT keeps evidence of errors current and limits potential sources of error. It effectively acts as an early warning system for quality issues within the company and with suppliers.
- ✓ **Inventory and Quality:** Improved quality leads to reduced inventory needs and facilitates a more effective JIT system. Inventory is often used to mitigate poor production performance caused by inconsistent quality. With reliable quality, JIT enables firms to lower inventory-related costs.

□ Taguchi Concepts

Many quality issues stem from inadequate product and process design. Taguchi et al. (2022) introduce three concepts to enhance both product and process quality: quality robustness; quality loss function; and target-oriented quality.

Quality products are products that can be produced uniformly and consistently in adverse manufacturing and environmental conditions. Taguchi et al.'s (2022) idea is to remove the effects of adverse conditions instead of removing the causes. Taguchi et al. (2022) suggest that removing effects is often cheaper than removing the causes and more effective in producing a robust product. In this way, small variations in materials and processes do not destroy product quality (Heizer and Render, 2015). Heizer and Render (2015) further assert that a quality loss function (QLF) identifies all costs connected with poor quality and shows how these costs increase as the product moves away from being exactly what the customer wants. These costs include not only customer dissatisfaction but also warranty and service costs; internal inspection, repair, and scrap costs; and costs that can best be described as costs to society (Juran and Godfrey, 2023). Taguchi et al. (2022) observed that traditional conformance-oriented specifications (that is, the product is good if it falls within the tolerance limits) are too simplistic. Target-oriented quality, on the other hand, strives to keep the product on the desired specification, producing more (and better) units near the target. It is a philosophy of continuous improvement to bring the product exactly on target (Oakland, 2024).

TQM, which can deliver quality through efficient management practices, has recently received a great deal of attention in most of the academic discourse.

The overarching need to improve the quality of products delivered within the architecture, engineering, and construction industry (AEC) necessitated this attention (Aghimien et al., 2019).

According to the study's findings, customer focus, supplier quality management, strategic planning, and employee relations are the TQM practices that are most widely used. The study found that measures like ensuring customer involvement, top management commitment, education and training of engineers on TQM practices, effective customer-supplier relationships, effective communication (internal and external), and a primary customer focus are crucial for enhancing the adoption of TQM practices (Aghimien et al., 2019).

Anholon et al. (2018) found in their study on TQM that the main reason for TQM implementation failure is insufficient management commitment. Management needs to be dedicated to the goal and should provide support and motivation to employees.

For successful TQM implementation, the approach must be outlined with a specific framework, and management must regularly communicate and clarify the stages of this framework to achieve the desired outcomes. When the stages of the framework are unclear, management support is crucial. Management must frequently discuss the advantages and benefits of implementing TQM on every occasion or circumstance (Anholon et al., 2018).

Another study by Dale and Shaw (2016) found that cultural change is the most challenging and time-consuming aspect of TQM implementation. This difficulty is attributed to employees' fear and resistance to change. Employees accustomed to the existing culture find it harder to adapt their daily routines compared to those with a quality-focused mindset. Hence, during this phase, management must facilitate a shift from the current culture to a quality-oriented culture to ensure a smooth implementation of TQM.

Various aspects of TQM that are required for its successful implementation have come under criticism. Culture change is one such aspect. To fulfil the satisfaction of the customer, the organisation is required to change the culture of the organisation. Organisational culture influences the way operations are conducted within a company. However, not all organisations are able to alter their culture (Antony et al., 2015). Another contentious aspect is the time taken to implement TQM.

Critics point out that implementing TQM is a time-consuming process as it involves proper evaluation of the process of manufacturing a product or service. Evaluation is a prerequisite when implementing TQM before the quality of a product can be improved (Ahire et al., 2015).

TQM has been criticised as being expensive to implement. Arumugam et al. (2015) point out that maintaining the quality of a product comes at high cost. It requires the cost of training the employees, improving the infrastructure of the organisation, and, in most cases, consultancy fees will need to be paid to consultants that will be hired to guide the process of implementing TQM. Black and Porter (2016) claim that TQM has been criticised as stifling creativity and innovation. The staff of the organisation focuses on the satisfaction of the customer. If the product satisfies the needs of the customer, then staff may not be creative or innovative by producing new products as these might not satisfy the customer. Thus, the management cannot use creative ideas as it may result in losing the customer.

Bettina (2017) describes the central concepts of Quality Management (QM), such as process orientation, controllability, and zero defects, as modern myths. She alleges that zero-error processes and the associated illusion of controllability involve the epistemological problem of selfreferentiality. The emphasis on the processes in QM also ignores the artificiality and thus arbitrariness of the difference between structure and process. Above all, the complexity of management cannot be reduced to standardised (mathematical) procedures. According to Bettina (2017), the risks and negative side effects of QM are usually greater than the benefits.

Recent studies continue to explore the relevance and impact of TQM. For instance, a study carried out in 2023 by Mohsin et al. (2024) found that while TQM practices positively influence environmental and economic sustainability, their effect on social sustainability is less clear. This study also highlighted the important role of knowledge management in enhancing the outcomes of TQM (Mohsin et al., 2024).

Other criticism comes from Park Dahlgaard (2015), who, citing other authors, identified two main ways that TQM has been criticised negatively. One group concerns TQM implementation and how it has fallen short of expectations. Whether the failing organisations implemented TQM or something else is up for debate.

The second type of criticism focuses on TQM's status as a general management theory. It is argued that there is lack of agreement on definitions and that TQM is not connected to other management theories even though its primary characteristics are not unique.

Kroslid (2019) argues that it is difficult to give one definition of what TQM really is and what it is not, which is problematic if one is to examine the positive or negative outcome of its implementation. Several definitions of Total Quality Management (TQM) often appear more like vague descriptions. For instance, TQM is considered a set of improvement tools useful within an organisation (Zairi, 2018). Total Quality Management (TQM) is often described as a management philosophy emphasising the importance of customer satisfaction, continuous improvement, and employee involvement across all levels of an organisation. It seeks to integrate quality discipline into the culture and processes of an organisation (ASQ, 2023).

TQM is not just a set of tools but a holistic approach involving all employees from top management to front-line workers, aiming to improve quality and meet or exceed customer expectations (Six Sigma, 2023). It is also described as a programme for changes based upon organisational culture (Luthans and Doh, 2015).

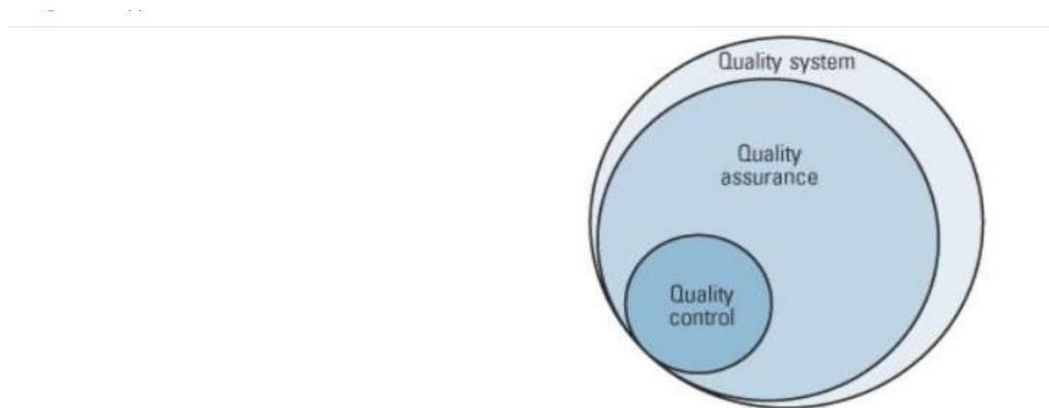
2.5 Total Quality Assurance Measures

The terms "quality assurance" and "quality control" are frequently used interchangeably when discussing methods for ensuring the quality of a service or product. According to Prahalad and Krishnan (2019), quality assurance comprises administrative and procedural activities implemented in a quality system so that requirements and goals for a product, service or activity will be accomplished. It is the systematic measurement, comparison with a standard, and monitoring of processes in an associated feedback loop that confers error prevention (ComplianceQuest, 2023). This can be contrasted with quality control, which is focused on process output (ASQ, 2025).

Quality assurance (QA) and quality control (QC) are both components of quality management (ISO, 2015). Although there is some overlap between QA and QC activities, they are defined differently (Juran and De Feo, 2017).

Generally, QA encompasses a broad range of activities and responsibilities related to the quality system, while QC is a specific subset within QA (Hoyle, 2017). Additionally, certain aspects of the quality system may not be directly addressed by QA/QC activities but can still involve both QA and QC (ISO 9000, 2015).

Figure 3. Relationships between quality system, quality assurance and quality control



Source: ISO 9000 (2015)

According to ISO 9000 (2015), quality assurance includes two principles: "fit for purpose" (the product should be suitable for the intended purpose); and "right first time" (mistakes should be eliminated).

QA includes management of the quality of raw materials, assemblies, products and components, services related to production, and management, production and inspection processes. The two principles also manifest before the background of developing (engineering) a novel technical product: The task of engineering is to make it work once, while the task of quality assurance is to make it work all the time.

Several approaches to quality assurance are applied in practice. These approaches include the following:

□ Failure Testing

Conducting failure or stress tests on a complete consumer product is valuable.

This involves operating the product until it fails, often under increasing levels of stress such as vibration, temperature, and humidity. This process can reveal unforeseen weaknesses, and the resulting data is used to enhance engineering and manufacturing processes.

Simple modifications, like using mold-resistant paint or updating assembly training with lock-washer placement, can significantly improve product performance (Brown, 2015).

□ Statistical Control

Statistical control involves analysing both objective and subjective data. Many organisations utilise statistical process control as a tool in quality improvement efforts to monitor quality data. Product quality data is charted statistically to identify common cause variation versus special cause variation (Montgomery, 2023). During production, data from sampled parts are analysed for statistical variances, which are then charted. Control measures can be applied either to the individual parts, such as rework or scrapping, or to the production process to address defects before more faulty parts are produced (Heizer and Render, 2015).

□ Total Quality Management

The overall quality of products relies on the quality of their individual components, some of which are sustainable and well-regulated, while others may not be. Quality assurance processes are integral to total quality management. The assurance of product quality depends on whether the specifications accurately reflect the required quality standards.

For instance, the specifications for a pressure vessel should include considerations for material, dimensions, operation, environment, safety, reliability, and maintainability requirements (Douglas and Judge, 2019).

□ Company Quality

According to Giflow (2020), the 1980s saw the rise of the "company quality" concept in the United States, which highlighted the critical roles of management and employees. It was believed that success could be achieved if all departments were receptive to quality initiatives, with management taking the lead in the process of enhancing quality.

This company-wide approach focuses on four key aspects, as outlined in standards like ISO 9001:

- ✓ **Aspects:** Controls, job management, effective processes, performance and integrity standards, and record identification.
- ✓ **Competence:** Involves knowledge, skills, experience, and qualifications.
- ✓ **Soft elements:** Includes personal integrity, confidence, organisational culture, motivation, teamwork, and quality relationships.
- ✓ **Infrastructure:** Can either enhance or constrain functionality.

Feigenbaum (2019) argues that quality assurance (QA) extends beyond manufacturing and is applicable to a variety of sectors, including sectors such as design, consulting, banking, insurance, software development, retail, investment, transportation, education, and translation. It involves a quality improvement process that is broadly applicable across these areas. It fosters a quality culture that supports achieving high standards, which is further bolstered by quality management practices. These practices can encompass various business systems tailored to the specific activities of the business unit.

In manufacturing and construction, these practices align with the quality assurance models outlined in the ISO 9000 series and the detailed specifications for quality systems. Within the Company Quality system, shop floor inspections failed to identify major quality issues, leading to the development of quality assurance or total quality control methods in recent times (Boulter and Dale, 2022).

Salvi and Kerkar (2020), in their study on quality assurance in the building industry, found that building costs could potentially be reduced significantly if the industry adopted the concept of quality assurance, which has been used with great success by many other sectors of the economy. Building owners must be forced to learn about quality assurance for them to start speaking out in favour of its adoption to protect their investments and lower construction costs.

Bhattacharjee (2018) found that quality control (QC) and quality assurance (QA) represent increasingly important concerns for project managers. Defects or failures in constructed facilities could result in very large costs.

Bhattacharjee's (2018) study found that even with minor defects, re-construction was required and facility operations impaired. Increased costs and delays were the result. Quality assurance and quality control were an important a part of any construction process to boost the standard and uniformity of the project. The requirement for QA and QC in construction projects has increased considerably in recent times because of significant changes, advancements in technology and high expectations of the users.

The QA and QC maintain uniformity in the construction process and ensure more economical utilisation of materials, leading to significant reduction in cost to the users. The extra cost involved in QA and QC is directly proportional to the advantages (Bhattacharjee, 2018).

A study by Manghani (2016) on quality assurance distinguishes between quality control and quality assurance. Fulfilling quality requirements is the main goal of quality control. It includes all operational methods and tasks carried out as a component of the quality assurance system to verify that the quality standards have been met. On the other hand, quality assurance aims to instil confidence that the requirements for quality are met.

Manghani (2016) further argues that the goal of a quality assurance department is to offer guidance to the operational units as well as a quality assurance system that is both effective and efficient. The department responsible for quality assurance needs to have enough committed employees who are well-versed in their respective fields and have strong interpersonal skills. The quality assurance staff will have the persuading, diplomatic, tactful, and resilient traits usually necessary for them, attributable to their well-developed interpersonal skills.

To ensure that operational units adhere to company quality standards, effective procedures, current good manufacturing practices, and legal, ethical, and regulatory requirements, the quality assurance department must frequently carry out quality review activities, such as self-inspection audits and internal audits, and operate independently from the operational units (Spath, 2023).

Zhihong (2015) stressed that the establishment and management of quality control and quality assurance systems, along with their comprehensive standard operating procedures and other quality documents, are crucial for achieving a company's business goals. These systems act as a key to success, helping the company attain high standards in processes, procedures, systems, and personnel, ultimately leading to superior products and services.

The benefits include:

- Increased customer satisfaction, leading to customer loyalty, repeat business, and referrals.
- Improved operational results, such as higher revenue, profitability, market share, and export opportunities.
- Better alignment of processes with the achievement of desired outcomes.
- Enhanced understanding and motivation of employees regarding the company's quality policy and business objectives, along with active participation in ongoing quality improvement efforts.
- Strengthened confidence of stakeholders in the company's effectiveness and efficiency, reflected in the financial and social benefits derived from its performance and reputation (Zhihong, 2015).

A criticism of effective quality assurance systems, according to Zbaracki (2018), is that they are challenging to implement. One explanation given is that different stakeholders have different interests and ideas about what constitutes quality. Another problem identified is the “implementation gap” and, finally, the external ownership of quality assurance systems which often leads to compliance instead of improvement.

Newton (2021) highlights the importance of the "implementation gap", referring to the difference between intended policy definitions or goals and the actual outcomes achieved during the implementation process. Newton (2021) makes the claim that there is a discrepancy between what was intended for and expected of the quality assurance system and what, at the production level, prevented this from being achieved, citing a case study of a university sector college. It is argued that the opinions of "front-line" employees who are involved in the actual production are especially significant because they are "makers" and "shapers" in the process of implementing policy, rather than merely recipients. Thus, how policy is received and decoded by production staff seems to be of particular importance. The effectiveness of a quality assurance system may rely less on its meticulous application or the thoroughness of its documentation, and more on how it is utilised and perceived by its users (Newton, 2021).

The fact that quality assurance systems are imposed on production staff is another criticism of them. However, when the system is developed apart from the production staff to whom, and by whom, it is applied, it is unlikely that ownership of the system, let alone its intended outcomes, will be achieved (Sroufe, 2023). There is a risk that quality assurance systems lead to a performance of compliance to the requirements of the system, instead of quality improvement. Additionally, as higher education and quality assurance systems develop, there is a risk that emphasis will shift from innovative processes to procedural aspects of quality.

In the same vein, continuous monitoring by a controlling agency requiring "overly bureaucratic procedures" will produce detailed paper trails but completely stifle development and innovation, leading to a continuous procedure's tendency and a lack of innovation (Brown and Clark, 2022).

There is considerable discussion regarding the best way to implement and design quality assurance systems in higher education. For example, it is unclear what the goal of quality assurance should be, whether the various techniques and tools used by quality assurance mechanisms are sufficient, or what the results of quality monitoring should mean (Fry, 2015). The challenges in measuring the efficacy of such systems make identifying the characteristics of effective quality assurance systems more challenging. It is also difficult to know how the quality of education would have changed without the implementation of quality assurance processes. Moreover, it is not easy to measure the outcomes of quality in higher education.

Nilsson et al. (2020) also critique quality assurance, arguing that it often requires substantial documentation to be effective. However, that functionality is threatened and compromised when documentation is overemphasised. Excessive documentation has been found to sometimes overwhelm staff members and even top management, leaving them frustrated with the procedure. These difficulties have the effect of making the quality assurance process ineffective. Documents within an organisation should be utilised for managing knowledge, facilitating communication, and providing evidence of results (Nilsson et al., 2020).

The practice of isolating the work of quality assurance to one single department is a part of the old business paradigm. It dictates that only the department of quality assurance is tasked with safeguarding the accurate manufacturing of the firm's products.

This practice has been criticised as outdated. Strategic thinking today holds that the organisation must have a more integrated approach. Each department should consider itself as part of a larger system, collectively accountable for producing a quality product. The outcomes on the shop floor reflect the functioning of the entire organisation (Samson and Terziovski, 2021).

2.6 Quality Standards

Every sector needs to focus on quality management. It is a keyway to establish strong trust with customers and to consistently grow revenue. The manufacturing sector is no exception. In fact, quality control or management must be emphasised first by all manufacturers because their products are complex, are made of various inputs or raw materials, and go through numerous processes. Therefore, they need the best quality management programme to ensure all their inputs and processes are up to the mark for producing quality finished products (Thomas, 2015).

Saraph et al. (2019) contend that quality standards provide organisations with the shared vision, understanding, procedures, and vocabulary required to meet their stakeholders' expectations. Standards provide an objective and authoritative basis for organisations and consumers all over the world to communicate and conduct business because they present precise descriptions and terminology. Quality standards are established to help companies meet the minimum requirements necessary to become an essential part of various industries, including food, automotive, and healthcare. Quality goes beyond financial performance or outpacing competitors; it involves ensuring safety, fulfilling commitments, and meeting basic customer expectations. By adhering to quality standards, companies often experience increased profits and reduced losses. Exceeding these standards can set companies apart from their competitors and enhance their potential for profit and customer loyalty. This is the key advantage of quality standards (Johnson, 2023).

Sousa and Voss (2015) note that quality can initially be a vague concept, as different people may have varying perceptions of what constitutes quality. This underscores the importance and purpose of quality standards. The International Organisation for Standardisation (ISO) is a global standards-setting body made up of representatives from the national standards organisations of its member countries. Established on 23 February 1947, ISO has since issued over 19,500 international standards that encompass various aspects of technology and business.

The organisation focuses on creating and disseminating standards across all technical and nontechnical areas, excluding electrical and electronic engineering.

The quality management standards are details of requirements, specifications, guidelines and characteristics that products, services and processes should consistently meet to ensure:

- Their quality matches expectations.
- They are fit for purpose.
- They meet the needs of their users.

Standards are an essential element of quality management systems. Businesses committed to following quality management standards are often more able to increase their profits, reduce losses or costs across the business, improve their competitiveness, gain market access across the world, and increase consumer loyalty. The ISO standards that relate to quality management are as follows (ISO, 2015):

□ **ISO 9000:2015**

This standard outlines the fundamental concepts, principles, and terminology essential for quality management systems (QMS) and serves as the basis for other QMS standards.

It is designed to assist users in comprehending the core ideas and principles of quality management, facilitating the effective and efficient implementation of a QMS, and maximising the benefits from other QMS standards.

The standard's principles and concepts are broadly applicable to the following:

- ✓ Organisations aiming for sustained success through QMS implementation.
- ✓ Customers seeking assurance in an organisation's consistent ability to meet product and service requirements.
- ✓ Organisations looking for confidence in their supply chain's ability to fulfil product and service expectations.
- ✓ Organisations and stakeholders aiming to enhance communication through a shared understanding of quality management terminology.
- ✓ Organisations conducting conformity assessments based on ISO 9001 requirements.
- ✓ Providers offering training, assessment, or consultancy in quality management.
- ✓ Developers of related standards.

The standard defines the terms and concepts applicable to all quality management and QMS standards developed by ISO.

□ **ISO 9001:2015**

ISO 9001:2015 specifies requirements for a quality management system when an organisation:

- ✓ Needs to demonstrate its ability to consistently provide products and services that meet customer and applicable statutory and regulatory requirements, and
- ✓ Aims to enhance customer satisfaction through the effective application of the system, including processes for improvement of the system and the assurance of conformity to customer and applicable statutory and regulatory requirements.

All the requirements of ISO 9001:2015 are generic and are intended to be applicable to any organisation, regardless of its type or size, or the products and services it provides. ISO 9001 sets out the criteria for a quality management system and is the only standard in the family that can be certified to (although this is not a requirement).

It can be used by any organisation, large or small, regardless of its field of activity. In fact, there are over one million companies and organisations in over 170 countries certified to ISO 9001.

This standard is based on several quality management principles including a strong customer focus, the motivation and implication of top management, the process approach and continual improvement. These principles are explained in more detail in ISO's quality management principles. Using ISO 9001 helps ensure that customers get consistent, good quality products and services, which in turn brings many business benefits.

□ **ISO 9004:2018**

ISO 9004:2018 gives guidelines for enhancing an organisation's ability to achieve sustained success. This guidance is consistent with the quality management principles given in ISO 9000:2015. ISO 9004:2018 provides a self-assessment tool to review the extent to which the organisation has adopted the concepts in this document. ISO 9004:2018 is applicable to any organisation, regardless of its size, type and activity.

2.6.1 Quality Management Principles

ISO 9000, 9001 and related ISO quality management standards are based on these seven Quality Management Principles (QMP). One of the definitions of a “principle” is that it is a basic belief, theory or rule that has a major influence on the way in which something is done (American Society of Quality, 2022). “Quality management principles” are a set of fundamental beliefs, norms, rules and values that are accepted as true and can be used as a basis for quality management. The QMPs can be used as a foundation to guide an organisation's performance improvement (Aghimien et al., 2019).

The seven quality management principles are:

□ **Customer Focus**

According to Smith (2023), the primary focus of quality management is to meet customer requirements and strive to exceed customer expectations. Sustained success is achieved when an organisation attracts and retains the confidence of customers and other interested parties.

Every aspect of customer interaction provides an opportunity to create more value for the customer. Understanding current and future needs of customers and other interested parties contributes to the sustained success of the organisation.

To implement this principle, the following actions will need to be taken (ISO, 2015):

- ✓ Identify both direct and indirect customers who gain value from the organisation.
- ✓ Understand and anticipate the current and future needs and expectations of customers.
- ✓ Align the organisation's goals with the needs and expectations of customers and ensure these are communicated across the organisation.
- ✓ Plan, design, develop, produce, deliver, and support products and services that fulfil customer needs and expectations.
- ✓ Regularly measure and monitor customer satisfaction and take necessary actions based on the results.
- ✓ Identify and address the needs and expectations of stakeholders that may impact customer satisfaction.
- ✓ Proactively manage customer relationships to ensure long-term success.

□ Leadership

Leaders across all tiers foster a shared sense of purpose and direction, thereby cultivating an environment where individuals are actively involved in meeting the organisation's quality goals. By establishing this unity and engagement, organisations can effectively align their strategies, policies, processes, and resources to fulfil their objectives. To put this principle into practice, the following steps should be taken (ISO, 2015):

- ✓ Disseminate the organisation's mission, vision, strategy, policies, and processes throughout the entire organisation.
- ✓ Develop and maintain shared values, fairness, and ethical behaviour models at every level.
- ✓ Build a culture rooted in trust and integrity.
- ✓ Promote a commitment to quality across the organisation.

- ✓ Ensure that leaders at all levels serve as positive role models for others. Equip individuals with the necessary resources, training, and authority to act responsibly.
- ✓ Motivate, support, and acknowledge the contributions of individuals.

□ **Involvement of individuals**

Brown et al. (2015) assert that competent, empowered and engaged people at all levels throughout the organisation are essential to enhance its capability to create and deliver value. To manage an organisation effectively and efficiently, it is important to involve all people at all levels and to respect them as individuals. Recognition, empowerment and enhancement of competence facilitate the engagement of people in achieving the organisation's quality objectives. To implement this principle, the following actions will need to be taken (ISO, 2015):

- ✓ Engage with individuals to enhance their understanding of the significance of their personal contributions.
- ✓ Foster collaboration across the organisation.
- ✓ Encourage open dialogue and the exchange of knowledge and experiences.
- ✓ Empower individuals to identify performance barriers and take initiatives without hesitation.
- ✓ Recognise and appreciate the contributions, learning, and growth of individuals.
- ✓ Allow for self-assessment of performance in relation to personal goals.
- ✓ Implement surveys to gauge employee satisfaction, share the findings, and take necessary actions.

□ **Process approach**

Achieving consistent and predictable outcomes is more effective and efficient when activities are recognised and managed as interconnected processes that operate as a unified system. The quality management system comprises these interrelated processes. By comprehending how results are generated within this system, an organisation can enhance both the system and its overall performance.

To implement this principle, the following actions will need to be taken (ISO, 2015):

- ✓ Identify the system's objectives and the processes needed to achieve them.
- ✓ Assign authority, responsibility, and accountability for process management.
- ✓ Assess the organisation's capabilities and recognise resource limitations before acting.
- ✓ Examine the interconnections between processes and evaluate the impact of changes on the overall system.
- ✓ Manage processes and their interactions as a cohesive system to meet the organisation's quality goals effectively and efficiently.
- ✓ Ensure that the necessary information is accessible to operate, enhance processes, and monitor, analyse, and evaluate the system's overall performance.
- ✓ Address risks that may influence process outcomes and the overall performance of the quality management system.

□ Improvement

Thriving organisations consistently emphasise continuous improvement. This focus is crucial for sustaining current performance levels, adapting to internal and external changes, and seizing new opportunities. To implement this principle, the following actions will need to be taken (ISO, 2015):

- ✓ Encourage the setting of improvement goals across all levels of the organisation.
- ✓ Provide education and training for all staff on using fundamental tools and methods to meet improvement goals.
- ✓ Ensure individuals are skilled in effectively leading and completing improvement initiatives.
- ✓ Create and implement processes to carry out improvement projects throughout the organisation.
- ✓ Monitor, review, and assess the planning, execution, completion, and outcomes of improvement projects.
- ✓ Incorporate improvement aspects into the design of new or revised products, services, and processes.

- ✓ Recognise and reward improvement efforts.

□ **Decision-making Based on Evidence**

Decisions that rely on analysing and evaluating data and information are more likely to yield the desired outcomes. The decision-making process can be complex and inherently uncertain, often requiring various inputs and their interpretation, which can be subjective. Understanding cause-and-effect relationships and potential unintended consequences is crucial. Utilising facts, evidence, and data analysis enhances objectivity and confidence in decision-making (Johnson, 2023).

To implement this principle, the following actions will need to be taken (ISO, 2015):

- ✓ Determine, measure and monitor key indicators to demonstrate the organisation's performance.
- ✓ Make all data needed available to the relevant people.
- ✓ Ensure that data and information are sufficiently accurate, reliable and secure.
- ✓ Analyse and evaluate data and information using suitable methods.
- ✓ Ensure people are competent to analyse and evaluate data as needed.
- ✓ Make decisions and take actions based on evidence, balanced with experience and intuition.

□ **Relationship management**

For sustained success, an organisation manages its relationships with interested parties, such as suppliers. Interested parties influence the performance of an organisation. Sustained success is more likely to be achieved when the organisation manages relationships with all its interested parties to optimise their impact on its performance. Relationship management with its supplier and partner networks is of important.

To implement this principle, the following actions will need to be taken (ISO, 2015):

- ✓ Determine relevant interested parties (such as suppliers, partners, customers, investors, employees, and society as a whole) and their relationship with the organisation.
- ✓ Determine and prioritise interested party relationships that need to be managed.
- ✓ Establish relationships that balance short-term gains with long-term considerations.
 - ✓ Pool and share information, expertise and resources with relevant interested parties.
- ✓ Measure performance and provide performance feedback to interested parties, as appropriate, to enhance improvement initiatives.
- ✓ Establish collaborative development and improvement activities with suppliers, partners and other interested parties.
- ✓ Encourage and recognise improvements and achievements by suppliers and partners.

Together, these principles can serve as a foundation for enhancing performance and achieving organisational excellence. There are various methods for applying these quality management principles, and how they are implemented will depend on the organisation's nature and the specific challenges it encounters. For many organisations, establishing a quality management system rooted in these principles can be advantageous (Smith, 2022).

A positive correlation between the application of quality standards and business performance has been confirmed by numerous academics. Savino and Shaffiq (2015), who concluded that quality control allows for high quality product standards thus reducing wastage and rework, confirmed this relationship between quality control and business performance. Johnson and Lee (2020) support this opinion even more. Bjorg et al. (2020) discovered that enhancing both local and global competitiveness for businesses was directly linked to the development and implementation of quality standards. Zhao et al. (2018) assessed the extent to which small and medium sized enterprises disclosed quality compliance in their organisational strategies and found that they had several quality disclosure strategies to improve organisational performance and optimise competition in the marketplace.

Rategan (2018) similarly examined the adoption of quality practices and environmental practices in small service companies, and he found that ‘high quality companies’ have greater chances of obtaining high profits than ‘low-quality companies’ even though customers are aware of the actual quality of a company. A study by Savino and Batbaatar (2015) found that quality standards are some of the critical factors for success in the global market for all kinds of businesses. TQM is a tool in operational management that is used by a company for better work and its aim is customer satisfaction. Customer satisfaction occasioned by good product quality and quality practices enhances the competitive position of a manufacturer (Madikiwe, 2016).

In South Africa, the South African Bureau of Standards (SABS) is a statutory body initially established under the Standards Act of 1945 (Act No. 24 of 1945), and continues to function under the latest Standards Act of 2008 (Act No. 29 of 2008). It serves as the national entity responsible for promoting and upholding standardisation and quality in relation to goods and service delivery. As the national standardisation authority, the SABS is responsible for maintaining South Africa's database of more than 6,500 national standards, as well as developing new standards and revising, amending or withdrawing existing standards as required (SABS, 2022).

The length of time required to properly implement quality standards accounts for a sizable portion of the criticism levelled at them. Many people think that this time could be used more productively to expand or support the business, but businesses will find that they are spending it on compliance and administrative tasks. Achieving this level of work requires either reallocating employees from their usual tasks or investing in new hires or external personnel (Samson and Terziovski, 2021).

Another significant issue is the widespread perception that in the workplace, emphasis is placed more on the nature of the work than on its actual results. There is a suggestion that there is a level of management that would prefer to manage by analysing data and figures as opposed to comprehending the work that is being done in the office or on the shop floor. Even though data and statistics are crucial, they rarely provide the full picture, and this is where businesses can overlook many things. Statistics do not always predict impending issues or declines in employee morale, but a good manager who works closely with their staff will be able to gauge the atmosphere and productivity in a company (Brown, 2021).

This underscores the importance of integrating both quantitative and qualitative management approaches to ensure comprehensive oversight and employee satisfaction (Smith, 2022). Because of this, it is critical that companies use managers who interact with employees and "manage their staff" in addition to statistics and data to manage their businesses effectively (Kleinhans, 2015).

2.7 Conclusion

This chapter examined the theoretical underpinnings of the study as well as the work of earlier researchers in the field. Total Quality Assurance (TQA) measures, quality standards, and the identification and definition of key terms related to quality were all taken into consideration in turn. The next chapter presents the research methodology used to collect data for this research.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methodological framework employed in the study. It details the research philosophy, design, strategy, sampling procedures, data collection techniques, analytical approach, and measures undertaken to ensure trustworthiness. The purpose is to demonstrate that the selected methods are logically consistent, suitable for addressing the research questions, and firmly grounded within the interpretivist paradigm.

3.2 Research Design

The research design serves as the overarching framework that guided this investigation. In line with the study's aim of examining how Total Quality Management (TQM) practices are applied within Transnet Engineering's wagon manufacturing context, a qualitative research design was employed.

Qualitative inquiry is particularly appropriate for research that seeks to understand experiences, perceptions, and interpretations rather than quantify variables statistically (Creswell, 2018; Denzin and Lincoln, 2018). This approach allows for a deeper exploration of organisational practices by engaging directly with participants and interpreting their viewpoints (Merriam and Tisdell, 2016).

Adopting a qualitative design was therefore well-suited to the purpose of this study, as the focus was on generating insights into the lived experiences of both employees and managers rather than on hypothesis testing or producing broadly generalisable numerical findings (Bryman, 2016).

3.3 Research Philosophy

The philosophical stance underpinning this research is interpretivism. Interpretivism holds that reality is socially constructed and is best understood by examining how individuals make sense of their experiences (Saunders, Lewis and Thornhill, 2019; Creswell, 2018).

Within this perspective, knowledge is generated through interaction with participants and through the researcher's interpretation of meanings embedded in their accounts (Merriam and Tisdell, 2016). This philosophy contrasts with positivism, which is rooted in objectivity and measurement, and is therefore not suitable for the current qualitative investigation (Bryman, 2016).

By adopting an interpretivist philosophy, this study emphasises context, meaning, and subjectivity, aligning with its focus on understanding how TQM practices are perceived and enacted in the real world context of Transnet Engineering (Denzin and Lincoln, 2018).

3.4 Research Strategies

The research strategy outlines the approach adopted to carry out the study. For this investigation, a phenomenological case study strategy was employed.

- **Phenomenology** seeks to explore and interpret lived experiences, focusing on how individuals make sense of phenomena within their environment (van Manen, 2016). This was particularly relevant to the present study, as it enabled the researcher to understand the personal and professional experiences of employees and managers in relation to the implementation of TQM practices.
- **Case study** research, on the other hand, allows for an in-depth examination of a phenomenon within its real-life organisational context (Yin, 2018). Transnet Engineering served as the bounded case, offering a defined organisational setting within which to investigate the practices, challenges, and perceptions of TQM in wagon manufacturing.

The combination of phenomenology and case study thus provided both depth (through lived experiences) and context (through the organisational setting), enabling the generation of rich insights into how TQM is enacted and understood within Transnet Engineering.

3.5 Population and Sampling

The target population for this study consisted of employees and managers directly involved in wagon manufacturing at Transnet Engineering. This choice aligned with the study's purpose of exploring how Total Quality Management (TQM) practices are applied within a specific organisational setting. Focusing on individuals engaged in production and quality processes ensured that participants were best placed to provide practical and insightful perspectives.

Guided by the study's interpretivist stance, a non-probability purposive sampling strategy was employed. This method is widely recommended in qualitative research for selecting participants with direct experience and knowledge of the phenomenon under study (Etikan, Musa & Alkassim, 2016; Saunders, Lewis and Thornhill, 2019). By targeting individuals with substantial exposure to TQM practices in wagon manufacturing, the study enhanced the relevance and richness of the data collected.

Participants were chosen based on their direct involvement in TQM-related activities across different organisational levels, including management, supervisory, and frontline roles. This approach enabled the study to capture diverse viewpoints and offered a more comprehensive understanding of how quality practices are experienced and interpreted within Transnet Engineering. Such role-based variation is considered essential in organisational case study research to develop well-rounded insights (Creswell and Poth, 2018).

The final sample comprised 15 participants, including managers, supervisors, and frontline employees. Although relatively small, this number was adequate for qualitative research, where the aim is depth of exploration rather than broad generalisation. Scholars argue that smaller, carefully selected samples can yield valuable insights when participants are information-rich (Patton, 2015; Guest, Namey and Chen, 2020). The sample size was further supported by the principle of data saturation, achieved when additional data no longer produced new themes or insights. Reaching saturation is widely recognised as a key marker of adequacy in qualitative sampling (Nyimbili and Nyimbili, 2024; Bouncken, Czakon and Schmitt, 2025).

Overall, the population and sampling strategy was well aligned with the research objectives and methodology.

Selecting participants with relevant knowledge and ensuring data saturation strengthened the credibility and validity of the findings, providing a reliable basis for examining TQM practices within Transnet Engineering's wagon manufacturing operations.

3.6 Data Collection Methods

Data for this study were gathered using two complementary qualitative methods, intentionally chosen to enhance depth and validity.

- **Semi-Structured Interviews**

Semi-structured interviews combine predefined topics with the flexibility to follow up on unexpected insights, making them ideal for exploring participants' perspectives in detail (Scribbr, 2022). Their adaptability enables researchers to follow conversational flow while remaining focused, ensuring rich, and nuanced understanding of how TQM practices are perceived and enacted.

- **Document Analysis**

To contextualise interview data and strengthen credibility, internal materials—such as quality assurance reports, training manuals, and policy documents—were systematically reviewed. Document analysis serves as a trusted method to corroborate interview findings and provide organizational context (Bowen, 2017).

By triangulating semi-structured interviews with document analysis, the study benefits from both qualitative depth and contextual validation, thereby enhancing the trustworthiness of the findings (Meydan & Akkaş, 2024).

3.7 Research Instrument

The primary research instrument employed in this study was an interview guide designed by the researcher. The guide consisted of open-ended questions that were directly aligned with the study's objectives, focusing on participants' experiences, challenges, and perceptions regarding TQM practices. Unlike structured questionnaires, the use of open-ended questions enabled participants to articulate their views freely, resulting in richer and more meaningful data (Kallio et al., 2016). To enhance clarity and ensure relevance, the guide was piloted with two participants prior to its finalisation.

3.8 Data Analysis

The interview data were analysed using thematic analysis, recognised as one of the most widely applied methods for interpreting qualitative data (Braun and Clarke, 2022; Hole, 2023). This approach was selected because of its rigour, adaptability, and suitability for exploring participants' perceptions of TQM practices in depth. Thematic analysis involves systematically identifying, organising, and interpreting patterns, or themes, within the dataset.

The process followed six stages:

- **Familiarisation** through transcription and repeated reading of transcripts,
- **Coding** by assigning labels to meaningful excerpts,
- **Theme development** by clustering related codes,
- **Reviewing themes** to ensure accuracy in reflecting the data,
- **and naming themes** to capture their **Defining** essence, and
- **Reporting** findings supported by illustrative participant quotations.

Additionally, findings from document analysis were used to triangulate and support the interview results, thereby enhancing the credibility and depth of the overall analysis (Bowen, 2017).

3.9 Trustworthiness of the Study

To strengthen the quality and rigour of this study, the four trustworthiness criteria were applied (Connelly, 2016; Nowell et al., 2017).

- **Credibility** was supported through prolonged engagement with participants, triangulation of data sources, and member checking, whereby participants verified the accuracy of interpretations.
- **Transferability** was facilitated by providing thick, detailed descriptions of the research context, enabling readers to assess the relevance of findings to other settings.
- **Dependability** was ensured by maintaining a clear audit trail of methodological decisions and data analysis procedures, making the research process transparent and traceable. Finally,

- **Confirmability** was enhanced by practising reflexivity and minimising researcher bias through systematic documentation of data collection and analysis. Researchers conduct a test run, known as a pilot study, to prepare for the main research study.

3.10 Ethical Considerations

Ethical clearance for the study was granted by the appropriate institutional ethics committee. Participation was entirely voluntary, with informed consent obtained from all participants prior to data collection. To safeguard confidentiality, responses were anonymised and sensitive organisational information was carefully protected. Participants were also made aware of their right to withdraw from the study at any stage without any negative consequences. In line with established ethical research practices, all data were securely stored and made accessible only to the researcher (Creswell and Creswell, 2018; Saunders, Lewis and Thornhill, 2019).

3.11 Conclusion

In summary, this chapter has set out the methodological framework that guided the study, providing justification for the research design and methods employed. The qualitative design, grounded in an interpretivist philosophy, enabled an in-depth exploration of participants lived experiences within the chosen phenomenological case study context. Purposive sampling ensured the selection of participants who could provide rich, relevant insights, while semi-structured interviews and document analysis served as the primary instruments for generating comprehensive data. Ethical considerations, including informed consent, confidentiality, and voluntary participation, were also addressed to uphold research integrity. Finally, strategies to ensure trustworthiness, such as credibility, transferability, dependability, and confirmability, were incorporated to strengthen the rigour of the study. The subsequent chapter presents the analysis of the data collected, highlighting the key themes that emerged and illustrating how they respond to the research objectives.

CHAPTER 4: RESULTS, DISCUSSION AND INTERPRETATION OF FINDINGS

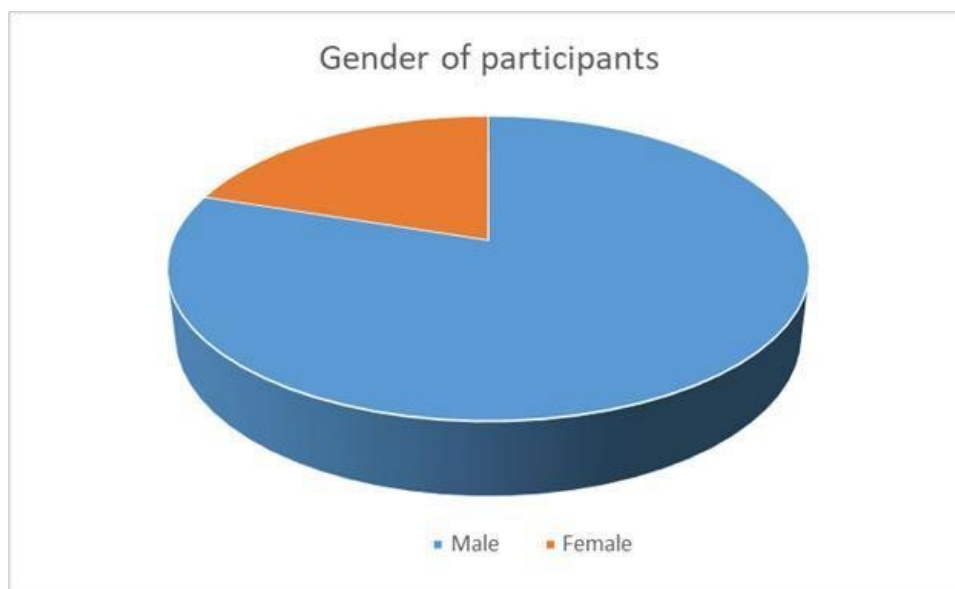
4.1 Introduction

This chapter showcases, analyses, and interprets the findings of the study, along with the biographical information of the participants and the themes that were found. Four major themes were found overall in the research instrument, which was successfully completed by all 15 participants. Themes include quality management practices, total quality assurance measures, quality standards and strategies to improve quality.

4.2 Sample Characteristics/Demographics

4.2.1 Gender of Participants

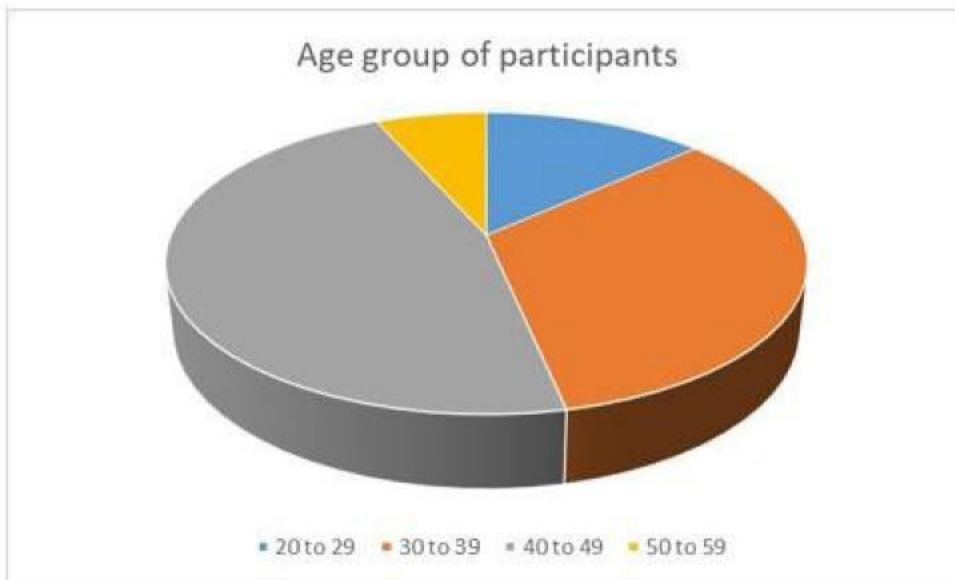
Figure 4. Gender of participants



There were 12 male and 3 female participants in this study.

4.2.2 Age Group of Participants

Figure 5. Age group of participants



There were 2 participants aged between 20 to 29 years, 5 participants aged between 30 to 39 years, 7 participants aged between 40 to 49 years and 1 participant aged between 50 to 59 years.

4.2.3 Number of Years in the Mandate/Official Position

Table 2. Number of years in the mandate/official position

	Number of years	Number of participants	
	1 to 5	2	
	6 to 10	6	
	11 to 15	4	
	16 to 20	3	

Two of the participants had worked for Transnet Cargo Rail for 1 to 5 years, while 6 other participants had 6 to 10 years of cumulative work experience with Transnet Cargo Rail. Four participants worked there for 11 to 15 years while 3 others had 16 to 20 years.

It is crucial to remember that to protect their identities, specifics about the positions or mandates they held have been left out.

4.3 Thematic Analysis of Qualitative Data

This research study used thematic analysis to methodically examine its data. Several themes were identified under each research objective as follows:

4.3.1 Quality Management Practices of Wagon Manufacturing at a South African Freight Rail Company

One of the aims of the study was to find out which quality management practices were currently used in wagon manufacturing from the participants. The purpose of this investigation was to fulfil the primary objective goal of the study. Under the objective, the following themes were identified:

4.3.1.1 Theme 1: Quality Control Processes

This theme focused on the methods and procedures implemented to ensure that wagons meet specified quality standards and requirements. At Transnet Rail Cargo, the components of quality control processes were:

a) Inspection procedures

Inspection procedures involved visually examining and assessing components, subassemblies, and finished wagons for defects, deviations, or non-conformities. Inspections occurred at various stages of the manufacturing process, including incoming inspection of raw materials, in-process inspection during assembly, and final inspection before shipment.

The participants stressed the importance of inspection procedures in wagon manufacturing as evidenced in the response below.

“Inspection happens at all stages beginning with materials to be used, fabrication, assembly and welding and joining”. Participant 12

b) Testing protocols

Testing protocols involved subjecting finished wagons to various tests and measurements to verify their performance, durability, and safety.

Common tests included structural integrity tests, load testing, fatigue testing, and environmental testing (corrosion resistance).

c) Quality checkpoints

Quality checkpoints were designated stages or checkpoints within the manufacturing process where specific quality criteria were evaluated and verified. Quality checkpoints ensured that quality standards are maintained and that any deviations from specifications were identified and addressed promptly.

Participants emphasised the importance of quality checkpoints as denoted by the below response.

“The quality control will check each and every wagon that leaves the workshop that it meets the requirements as per check sheet, which is the guiding tool that verifies different aspects of your functionality and quality”. Participant 3

d) Defects and control

Quality control processes included mechanisms for detecting and controlling defects or non-conformities identified during inspection or testing. Defective wagons were repaired, reworked, or rejected, depending on the severity of the defect and its impact on wagon quality.

At Transnet Rail Cargo, the implementation of quality control processes was undertaken as follows:

a) Standard Operating Procedures (SOPs)

SOPs defined the step-by-step procedures for conducting inspections, tests, and quality checks, ensuring consistency and standardisation in QC activities. SOPs also outlined criteria for accepting or rejecting wagons based on predefined quality standards.

b) Quality control equipment and tools

Transnet Rail Cargo utilised a range of equipment and tools to facilitate QC processes, including measuring instruments, gauges, testing machines, and non-destructive testing (NDT) equipment. Calibration and maintenance of QC equipment was essential in ensuring accurate and reliable results.

c) Training and skill development

Training programmes were provided to employees involved in QC activities to ensure they possessed the necessary skills and competencies to perform inspections, tests, and quality checks effectively. Training covered topics such as visual inspection techniques, measurement methods, defect recognition, and equipment operation.

d) Documentation and record-keeping

Comprehensive documentation was maintained for all QC activities, including inspection reports, test results, and records of non-conformities and corrective actions. Documentation served as a basis for traceability, auditability, and continuous improvement in quality management practices.

The participants underscored the prominence of quality control and assurance as revealed by the following response.

“These processes are the tools which Transnet as an organisation uses to gauge quality. The quality management process in the wagon business is structured into four main segments, which is quality planning, quality assurance, quality control and continuous improvement of the final product as per customer’s expectations. The goal for the whole process is clear to all employees of the wagon business so that there is no misalignment in terms of the vision of the company”. Participant 9

4.3.1.2 Theme 2: Employee Involvement and Training

Employee involvement and training were critical components of quality management processes in wagon manufacturing. Engaged and well-trained employees played a vital role in maintaining product quality, identifying defects, and implementing corrective actions. This theme emphasised the importance of empowering employees to contribute to quality improvement efforts and ensuring they possessed the necessary skills to perform their roles effectively.

Employee involvement at Transnet Rail Cargo encompassed the following:

a) Participation in quality improvement initiatives

Employees were encouraged to actively participate in quality improvement initiatives, such as quality improvement teams, suggestion programmes, or continuous improvement projects. Their involvement allowed them to contribute insights, ideas, and feedback for enhancing quality control processes and addressing quality issues.

The participants highlighted the importance of quality improvement initiatives. This is evidenced in the response below.

“I belong to a quality improvement team which is tasked with identifying areas where improvements can be made. We also develop strategies to implement these improvements and monitoring the outcomes to ensure that the changes lead to improvements”. Participant

1

b) Ownership of quality

Employees were empowered to take ownership of quality by instilling a sense of responsibility and accountability for the quality of their work. They were encouraged to identify and address quality concerns proactively, fostering a culture of quality consciousness throughout the organisation.

c) Feedback mechanisms

Employees were provided with channels for providing feedback on quality-related issues, process inefficiencies, or opportunities for improvement. Their feedback was valued and considered in decision-making processes, promoting continuous learning and adaptation.

Employee training involved the following:

i. Quality control techniques

Employees received training on quality control techniques and methodologies relevant to wagon manufacturing, such as visual inspection, measurement techniques, and defect recognition. Training programmes aimed to enhance employees' ability to identify quality issues, make informed decisions, and implement quality control measures effectively.

Participants stressed the need for training in quality control techniques as evidenced by the responses below.

“Provide comprehensive training programmes to equip employees with the skills and knowledge necessary to maintain high-quality standards. Empower employees to take ownership of quality by fostering a culture of accountability and providing opportunities for skill enhancement.”

Participant 6

“The wagon business management and employees must work together in striving for perfection. The employees must be trained to keep with maintaining and improve product quality by so doing standards will be uniform”. Participant 7 ii. Quality management principles

Employees were educated on fundamental quality management principles, such as Total Quality Management (TQM), lean manufacturing, Six Sigma, or ISO standards. Training helped employees understand the importance of quality, their role in maintaining it, and the impact of their actions on overall product quality.

The participants showed knowledge of quality management principles, as evidenced by the response below.

“Wagons use a total quality management system (TQM) which is defined as a management system for a customer-focused organisation that includes all employees in continual improvement”. Participant 4 iii. Equipment operation and maintenance

Employees received training on the operation, calibration, and maintenance of quality control equipment and tools used in wagon manufacturing. Training ensured employees can use equipment effectively to perform inspections, tests, and quality checks accurately.

4.3.1.3 Theme 3: Continuous Improvement Initiatives

Continuous improvement initiatives involved ongoing efforts to identify, analyse, and implement enhancements to quality management processes, practices, and systems.

These initiatives were rooted in the principles of Total Quality Management (TQM), lean manufacturing, Six Sigma, and other quality improvement methodologies.

In the context of wagon manufacturing, continuous improvement aimed to optimise production processes, minimise defects, and enhance overall product quality. At Transnet Rail Cargo, key components of continuous improvement initiatives were:

a) Quality improvement teams

Transnet Rail Cargo has formed cross-functional quality improvement teams comprising employees from different departments and levels of the organisation. These teams collaborated to identify process inefficiencies, brainstorm solutions, and implement improvement initiatives.

The participants highlighted the importance quality improvement initiatives. This is evidenced in the response below.

“I belong to a quality improvement team which is tasked with identifying areas where improvements can be made. We also develop strategies to implement these improvements and monitoring the outcomes to ensure that product improvements”. Participant 1

b) Kaizen events

Kaizen, a Japanese term for "continuous improvement," refers to focused, short-term improvement events aimed at addressing specific quality issues or process bottlenecks (Pycraft et al., 2018). Kaizen events at Transnet Rail Cargo brought together employees to analyse problems, streamline processes, and implement immediate improvements.

c) Process optimisation

Transnet Rail Cargo strived to optimise manufacturing processes to eliminate waste, reduce variation, and improve efficiency and quality. Lean manufacturing principles, such as value stream mapping, 5S methodology, and Just-in-Time (JIT) production, were applied to streamline workflows and improve productivity.

The participants stressed the need for process optimisation. The response below testifies to this.

“We have lean management but to my opinion it is not utilised to it full to what it stands for and workers must be well informed about its responsibility within the business framework, by so doing and all the processes will be fully functional, customer satisfaction will grow”. Participant 9

4.3.1.4 Theme 4: Root Cause Analysis and Corrective Action

At Transnet Rail Cargo, root cause analysis (RCA) was a structured methodology used to identify the fundamental reasons behind quality issues, defects, or non-conformities within wagon manufacturing processes. By uncovering the root causes of problems, Transnet Rail Cargo could implement targeted corrective actions to address underlying issues and prevent future occurrences. This theme emphasised the importance of RCA in driving continuous improvement and enhancing product quality. Key components of RCA and corrective action at Transnet Rail Cargo were:

a) Identification of quality issues

Quality issues, defects, or non-conformities were identified through various sources, including customer complaints, internal inspections, quality control checks, or process monitoring systems. Issues manifested as defects in finished products, deviations from specifications, or deviations from established quality standards.

The participants underlined the criticality of identifying quality issues as is evidenced in the response below.

“As a business we have two control charts, NCR and Customer Complaints Charts. On NCR, we measure/control the number of defective units. On the Customer Complaints Chart, we record all customer complaints”. Participant 7

b) RCA techniques

The technique of Fishbone diagrams (Ishikawa diagrams) was the root cause analysis technique employed to systematically investigate the underlying causes of quality issues. This technique helped teams explore the chain of events leading to the problem and identify the root cause or causes at the source.

Participants drew attention to the technique utilised to investigate defects. This is revealed in the below response.

“A team with diverse knowledge and perspectives is assembled to brainstorm potential causes of defects. Potential causes are then grouped into major categories like people, processes, equipment, materials, environment and management”. Participant 12

c) Cross-functional collaboration

RCA involved cross-functional collaboration, bringing together employees from different departments or disciplines to contribute their expertise and perspectives. Collaborative problemsolving enabled a comprehensive understanding of the problem and ensured that potential root causes were thoroughly examined.

d) Validation of root causes

Identified root causes were validated through data analysis and observation to confirm their accuracy and relevance. Multiple data sources and verification methods were used to corroborate findings and eliminate biases or assumptions.

e) Development of corrective actions

Based on the identified root causes, corrective actions were developed to address underlying issues and prevent recurrence of quality problems. Corrective actions involved process improvements, procedural changes, equipment modifications, training initiatives, or policy revisions.

4.3.1.5 Theme 5: Integration of Quality into Business Processes

The integration of quality into business processes at Transnet Rail Cargo involved incorporating quality considerations, standards, and practices into every stage of the manufacturing process, from product design and procurement to production, assembly, and distribution. This theme underscored the holistic approach to quality management, where quality became a shared responsibility across all levels and functions within the organisation.

At Transnet Cargo Rail, components of integration of quality into business processes were: a)

Quality in wagon design

Quality considerations were integrated into the product design phase to ensure that products are designed to meet customer requirements, industry standards, and regulatory specifications. Design for manufacturability and design for assembly principles were applied to optimise product manufacturability, reliability, and performance.

Participants stressed the integration of quality considerations into wagon design. The response below testifies to this.

“In the product development environment when the product comes to the workshop it has the work instructions which is drafted by the product owner, and it will be manufactured according to those instructions. The Quality Assurer and Controller will have the same

Work instruction for checking purposes that the product meet the client’s requirement”.

Participant 8

b) Quality in procurement and supply chain management

Quality criteria and specifications were communicated to suppliers to ensure the procurement of high-quality raw materials, components, and parts. Supplier audit was the supplier quality management practice that was implemented to maintain supply chain integrity.

Supplier audit was stressed by participants as evidenced in the response below.

“We regularly conduct audits of our suppliers to assess their quality management systems, production processes, and adherence to quality standards. This helps identify any potential issues and ensure continuous improvement”. Participant 5

c) Quality in production processes

Quality control measures were integrated into production processes to monitor, measure, and control product quality at every stage of manufacturing. Statistical process control, process capability analysis, and in-process inspections were utilised to detect and address deviations from quality standards in real-time.

Quality control processes are fundamental components of any manufacturing operation, including wagon manufacturing. Quality control (QC) processes encompass a series of systematic activities aimed at monitoring, inspecting, and testing raw materials, components, and finished products to ensure they meet predefined quality criteria. In wagon manufacturing, where safety and reliability are paramount, and effective QC processes are critical to delivering products that meet customer expectations and regulatory requirements.

The participants confirmed the use of quality management practices in wagon manufacturing at Transnet Cargo Rail. According to the participants, ISO 9001:2015, the Association for the American Railroad (AAR) standards, and Total Quality Management (TQM) are in use. This is consistent with what the study's review of the literature found.

According to Antony et al. (2017), the quality practices of an organisation (which take place within a quality culture or context) are defined as the actions and procedures undertaken by a company or organisation to ensure the delivery of a high-quality service or product. Sousa and Voss (2015) mention that “practices are the observable facet of quality management, and it is through them that managers work to realise organisational improvements”.

4.3.2 To Identify Total Quality Assurance (TQA) Measures Taken in the Production Process of Wagons

Another objective of this study was to identify Total Quality Assurance (TQA) measures taken in the production process of wagons. The purpose of this investigation was to fulfil one of the secondary goals of the study. Under the objective, the following themes were identified:

4.3.2.1 Theme 1: Quality Standards and Metrics

Quality standards and metrics were the foundational elements of effective quality management systems within Transnet Rail Cargo. These standards defined the criteria, specifications, and requirements that products and processes had to meet to ensure consistency, reliability, and compliance with industry best practices and customer expectations. Quality metrics provided quantifiable measures for monitoring and evaluating performance against these standards. At Transnet Rail Cargo, key components of quality standards and metrics were:

a) Industry-specific quality standards

Transnet Rail Cargo adheres to industry-specific quality standards established by regulatory bodies, industry associations and international organisations. Industry standards which the company adhered to were ISO 9001 (Quality Management Systems), AAR M-1003 (Quality Assurance Specification), and customer-specific quality requirements.

Participants stressed the adherence to industry-specific quality standards as revealed by the responses below.

“ISO 9001 – 2015 and the Association for the American Railroad (AAR) standard are the standards we follow”. Participant 2

b) Internal quality standards

In addition to external quality standards, Transnet Rail Cargo has developed internal quality standards tailored to its specific products, processes, and customer requirements.

Internal standards ensured consistency, traceability, and continuous improvement in quality management practices.

Participants emphasised the use of internal quality standards as evidenced by the response below.

“Complying using the correct works instruction check sheets, latest drawings, and calibrated gauges, implement ISO-9001 quality management systems”. Participant 3

c) Quality metrics and key performance indicators

At Transnet Rail Cargo, quality metrics were measurable parameters used to assess product quality, process performance, and organisational effectiveness. These quality metrics included defect rates, first-pass yield, on-time delivery, customer satisfaction scores, and adherence to quality specifications.

The use of quality metrics was underlined by participants. The response below testifies to this.

“We use the number of defects per unit of production, the percentage of wagons that pass all quality checks without requiring rework and the percentage of materials or components that are discarded as waste during the manufacturing process as quality metrics”.

Participant 8

d) Supplier quality requirements

Transnet Cargo Rail has established quality requirements and expectations for suppliers to ensure the delivery of high-quality materials, components, and parts. Supplier performance metrics, such as on-time delivery, defect rates, and adherence to specifications, were used to evaluate supplier quality.

e) Continuous improvement targets

Quality standards and metrics served as targets for continuous improvement initiatives, guiding efforts to enhance product quality, reduce defects, and improve operational efficiency.

Benchmarking against industry standards and best practices helped Transnet Cargo Rail identify areas for improvement and set achievable improvement targets.

4.3.2.2 Theme 2: Supplier Quality Management

Supplier quality management at Transnet Rail Cargo involved the systematic evaluation, selection, monitoring, and improvement of suppliers which ensured that they consistently delivered highquality products and services that meet the requirements and specifications of wagon manufacturing. Effective supplier quality management enhanced supply chain resilience, mitigated risks, and contributed to overall product quality and customer satisfaction. Key components of supplier quality management at Transnet Cargo Rail were:

a) Supplier evaluation and selection

Transnet Rail Cargo conducted thorough evaluations of potential suppliers based on criteria which included quality standards, production capabilities, technical expertise, financial stability, and past performance. Supplier selection decisions were informed by factors which included product quality, delivery reliability, pricing, and compatibility with organisational requirements.

Participants underlined the supplier evaluation process and criteria as evidence by the response below.

“Evaluation of suppliers starts with defining our requirements, pre-qualification, request for proposal and supplier visit and audit. Criteria for evaluation are quality, cost, delivery, capacity, technical capability and financial stability”. Participant 15

b) Quality assurance agreements

At Transnet Rail Cargo, quality assurance agreements (QAAs) or supplier quality agreements (SQAs) established the quality requirements, expectations, and responsibilities of both parties. QAAs outlined quality specifications, acceptance criteria, inspection requirements, and dispute resolution procedures that ensured alignment and accountability.

c) Supplier performance monitoring

Transnet Cargo Rail monitored supplier performance using key performance indicators (KPIs) and quality metrics which included on-time delivery, defect rates, product conformance, and responsiveness.

Performance data was collected, analysed, and used to assess supplier effectiveness, identify areas for improvement, and facilitate data-driven decision-making.

d) Supplier development programmes

The company collaborated with suppliers to implement supplier development programmes that were aimed at improving quality, capability, and performance. Programmes included training initiatives, process improvement projects, technology transfers, and collaborative problem solving efforts that enhanced supplier effectiveness.

4.3.2.3 Theme 3: Quality Communication and Reporting

Quality communication and reporting at Transnet Rail Cargo encompassed the dissemination, exchange, and documentation of quality-related information across various levels and functions within the organisation, as well as with external stakeholders which included customers, suppliers, and regulatory agencies. These processes ensured that relevant quality information was shared in a timely manner, enabling informed decision-making, problem-solving, and continuous improvement efforts.

The following components constituted quality communication and reporting:

a) Internal communication channels

The company established internal communication channels with meetings, newsletters, intranet portals, and digital collaboration tools that facilitated the exchange of quality related information among employees. Cross-functional teams, quality committees, and quality circles were also formed to promote collaboration, share best practices, and address quality issues collectively.

The participants alluded to internal communication channels on quality matters and other company business as is evidenced by the response below.

“Email is used as a primary communication too. There is also a dedicated website where employees can access company policies, news documents and other resources. Scheduled meetings for departments, quality teams, and cross-functional groups to discuss ongoing work, align on goals, and address issues”. Participant 9

b) Quality documentation and records

Comprehensive documentation of quality processes, procedures, specifications, and performance data at Transnet Cargo Rail ensured transparency, traceability, and compliance with regulatory requirements.

Quality records, including inspection reports, non-conformance reports, corrective action plans, and audit findings, provided a historical record of quality-related activities and decisions.

Participants emphasised the maintenance of quality records and documentation as evidenced by the response below.

“We keep a number of quality records and documentation such as inspection, test, calibration, non-conformance, supplier audits and regulatory compliance audits”.

Participant 14

c) Performance dashboards and scorecards

Performance dashboards and scorecards were used to visualise key quality metrics, trends, and performance indicators in a clear and concise manner. Dashboards provided real-time insights into quality performance, enabling stakeholders to monitor progress, identify areas for improvement, and make data-driven decisions.

d) Quality reporting and analysis

Regular quality reporting and analysis processes were established to assess performance against quality objectives, targets, and benchmarks. Quality reports included trend analyses and root cause analyses to identify patterns, opportunities, and areas for corrective action.

e) External communication and collaboration

The company communicated quality-related information externally to customers, suppliers, regulatory agencies, and other relevant stakeholders.

Customer portals, supplier portals, quality certifications, and regulatory filings ensured transparency, compliance, and alignment with external quality requirements.

Participants stressed external communication as indicated in the response below:

“Solicit feedback from customers regarding product quality and satisfaction levels and use customer feedback to identify areas for improvement and make necessary adjustments to products and processes”. Participant 5

The responses from participants confirmed that quality assurance measures are part of the total quality management process in the manufacturing of wagons by Transnet Rail Cargo.

According to participants, quality assurance measures utilised include having a quality assurer, check sheets, calibrated Jigs gauges, customer complaints chart, and Non-Conformable Report (NCR). These quality assurance measures are aligned to the literature reviewed. Prahalad and Krishnan (2019) assert that the terms "quality assurance" and "quality control" are often used interchangeably to refer to ways of ensuring the quality of a service or product. Quality assurance comprises administrative and procedural activities implemented in a quality system so that requirements and goals for a product, service or activity will be accomplished. It is the systematic measurement, comparison with a standard, and monitoring of processes in an associated feedback loop that confers error prevention. This can be contrasted with quality control, which is focused on process output (Prahalad and Krishnan, 2019).

4.3.3 To identify the quality standards adhered to by the Company in the Production Process

The research aimed at identifying, among the participants, the quality standards that are adhered to in the production process of wagons. This investigation was conducted to achieve the study's second secondary objective. Under this objective one theme was identified:

4.3.3.1 Theme 1: Regulatory Compliance and Industry Standards

At Transnet Rail Cargo, regulatory compliance involved the conformity with laws, regulations, and directives established by governmental authorities to ensure product safety, environmental protection, and public health. Industry standards, on the other hand, were voluntary guidelines and specifications developed by industry associations, professional bodies, standardisation and organisations that promoted best practices, interoperability, and quality consistency within specific sectors.

Compliance with both regulatory requirements and industry standards was essential for the company to operate legally, mitigate risks, and meet customer expectations. Regulatory compliance and industry standards were constituted by the following components:

a) Government regulations

Transnet Rail Cargo had to comply with a range of government regulations related to product safety, emissions, environmental protection, labour practices, and trade regulations. Regulations varied and included directives such as safety standards, environmental regulations (e.g., emissions limits), and import/export requirements.

Participants underlined compliance to government regulations as is evidenced by the response below:

“We keep a number of quality records and documentation such as inspection, test, calibration, non-conformance, supplier audits and regulatory compliance audits”.

Participant 14

b) Industry standards

Industry standards provided guidelines, specifications, and best practices for manufacturing processes, product design, materials, and quality management. Standards were developed by industry consortia, professional associations and the International Organisation for Standardisation (IOS).

Participants stressed the company’s compliance with industry standards as evidenced by the following responses:

“Like many reputable organisations, Transnet Rail normally conforms to industry recognised quality management standards. The company conforms to ISO 9001. ISO 9001 is an international standard for quality management systems. It sets out the criteria for a quality management system and is founded on ideas such as customer focus, leadership, and ongoing improvement”. Participant 11

ISO 9001-2015 and the Association for the American Railroad (AAR) standard are the standards we follow”. Participant 2

c) Certifications and conformity assessment

The company had to obtain certifications and undergo conformity assessment processes to demonstrate compliance with regulatory requirements and industry standards. Certifications may include ISO 9001 (Quality Management Systems), ISO 14001 (Environmental Management Systems), AAR M-1003 (Quality Assurance Specification), and specific product certifications.

d) Documentation and recordkeeping

Comprehensive documentation and recordkeeping were essential for demonstrating compliance with regulatory requirements and industry standards.

Documentation included quality manuals, procedures, test reports, certificates of compliance, and regulatory filings.

e) Continuous monitoring and updates

Regulatory requirements and industry standards were subject to change over time due to evolving technologies, market dynamics, and regulatory developments. Transnet Rail Cargo had to continuously monitor changes in regulations and standards and update their processes and practices accordingly to maintain compliance.

The participants confirmed the use of quality standards in wagon manufacturing at Transnet Cargo Rail. According to the participants, ISO 9001-2015, the Association for the American Railroad (AAR) standards and total quality management (TQM) were used. This is consistent with what the study's review of the literature found. According to ISO 9000 (2015), this standard provides the fundamental concepts, principles and vocabulary for quality management systems (QMS) and provides the foundation for other QMS standards.

This international standard is intended to help the user to understand the fundamental concepts, principles and vocabulary of quality management, to be able to effectively and efficiently implement a QMS and realise value from other QMS standards.

4.3.4 Strategies that can be used to improve the Quality of the Manufactured Wagons

The research aimed at identifying, among the participants, the strategies to improve quality in the production process of wagons.

This investigation was carried out to fulfil the study's third secondary objective. Under this objective, the following themes were identified:

4.3.4.1 Theme 1: Technology and Innovation

The theme of "technology and innovation" revolves around the utilisation of advanced technologies and innovative practices to enhance various aspects of wagon manufacturing processes.

Technology and innovation play a crucial role in improving efficiency, productivity, product quality, and competitiveness in the industry. Technology and innovation encompass a wide range of tools, techniques, and practices employed by wagon manufacturing companies to optimise their operations, develop new products, and meet evolving customer demands.

This theme highlights the importance of embracing technological advancements and fostering a culture of innovation to drive continuous improvement and maintain a competitive edge in the market. Components of technology and innovation are as follows:

a) Advanced manufacturing technologies

Transnet Rail Cargo should leverage advanced manufacturing technologies such as robotics, automation, additive manufacturing (3D printing), and computer numerical control (CNC) machining to streamline production processes and improve efficiency. Robotics and automation reduce manual labour, increase precision, and enhance throughput, leading to cost savings and faster time-to-market.

Participants emphasised the need to modernise wagon manufacturing, as evidenced by the response below:

"The wagon business management and employees must work together in striving for perfection. The employees must be trained to keep with maintaining and improve product quality by so doing standards will be uniform". Participant 7

"By leveraging digital technologies, the company can achieve significant improvements in all aspects of its operations, from design and production to supply chain management and customer service. This not only enhances its competitive edge but also positions it for long term success in an increasingly digital world". Participant 8

b) Digitalisation and smart manufacturing

Digitalisation initiatives for Transnet Rail Cargo will involve the integration of digital technologies such as Internet of Things (IoT), big data analytics, cloud computing, and artificial intelligence (AI) into manufacturing operations. Smart manufacturing concepts will enable realtime monitoring, data-driven decision-making, predictive maintenance, and remote diagnostics, optimising production efficiency and resource utilisation.

c) Product design and development

Innovative product design and development practices, such as computer-aided design (CAD), simulation software, virtual prototyping, and design for manufacturability (DFM), will enable Transnet Rail Cargo to create innovative, high-performance wagon designs. Rapid prototyping techniques and agile development methodologies will facilitate faster iteration cycles and accelerate time-to-market for new products.

d) Supply chain optimisation

Technology and innovation should be utilised to optimise supply chain operations, improve logistics, and enhance collaboration with suppliers and partners. Supply chain management software, predictive analytics, block chain technology, and Radio Frequency Identification (RFID) tracking systems will enable better visibility, traceability, and coordination across the supply chain.

e) Sustainability and environmental solutions

Transnet Rail Cargo should adopt sustainable technologies and practices to reduce environmental impact, minimise waste, and improve resource efficiency. Initiatives such as light-weighting, energy-efficient manufacturing processes, renewable energy adoption, and eco-friendly materials contribute to sustainability goals and meet regulatory requirements.

4.3.4.2 Theme 2: Supplier Collaboration and Development

The theme of "supplier collaboration and development" emphasises the importance of building strong partnerships with suppliers and fostering collaborative relationships aimed at mutual growth, innovation, and continuous improvement within the wagon manufacturing industry. Supplier collaboration and development involves engaging with suppliers to enhance communication, share knowledge, drive innovation, and optimise supply chain performance.

Supplier collaboration and development entails working closely with suppliers to achieve common goals, such as improving product quality, reducing costs, enhancing supply chain efficiency, and fostering innovation. By forging strategic partnerships and fostering collaborative relationships with suppliers, Transnet Cargo Rail can leverage external expertise, resources, and capabilities to enhance their competitiveness and create value for both parties. Components of supplier collaboration and development include the following:

a) Open communication and information sharing

Effective supplier collaboration will begin with open communication channels and transparent information sharing between manufacturers and suppliers. Regular meetings, joint planning sessions, and shared platforms will facilitate the exchange of information, requirements, and feedback to align goals and expectations.

The participants emphasised the need for open communication. This is evidenced in the response below.

“Develop strong relationships with suppliers and ensure they meet quality standards by implementing rigorous supplier evaluation and monitoring processes. Conduct regular audits and inspections of supplier facilities to ensure compliance with quality requirements”. Participant 11

b) Supplier relationship management (SRM)

Supplier relationship management practices will focus on cultivating long-term, mutually beneficial partnerships with key suppliers. SRM will involve segmenting suppliers based on strategic importance, performance, and relationship dynamics, and implementing tailored strategies to optimise collaboration and value creation.

c) Joint product development and innovation

Collaborative product development initiatives will involve working closely with suppliers to cocreate innovative solutions, improve product designs, and enhance performance. Suppliers may contribute technical expertise, specialised knowledge, and access to new technologies, enabling manufacturers to develop differentiated products and gain a competitive edge.

d) Supplier training and capability building

Supplier development programmes will aim to enhance the capabilities, skills, and processes of key suppliers to meet quality, performance, and delivery requirements. Training initiatives, process improvement projects, and knowledge-sharing sessions will strengthen supplier capabilities and drive continuous improvement in supply chain performance.

e) Risk sharing and mitigation

Collaborative risk management will involve identifying, assessing, and mitigating risks jointly with suppliers to minimise disruptions and enhance supply chain resilience. Strategies such as dual-sourcing, inventory pooling, and contingency planning will help mitigate risks associated with supply chain disruptions, quality issues, and market fluctuations.

The participants suggested several strategies to improve the quality of wagons manufactured by Transnet Rail Cargo. The strategies included lean management, employee training, building strong supplier relationships, developing a culture of accountability and getting customer feedback.

This is consistent with what the study's review of the literature found. Johnson (2019) emphasises that the main goal of quality management is to meet customer needs and aim to exceed their expectations. Sustained success is achieved when an organisation attracts and retains the confidence of customers and other interested parties.

Brown et al. (2015) argue that having competent, empowered, and engaged individuals at every level of the organisation is crucial for enhancing its ability to create and deliver value. Effective and efficient management of an organisation requires involving and respecting all individuals at every level. Similarly, Dale and Shaw (2016) maintain that an organisation must manage its relationships with stakeholders, such as suppliers, to achieve sustained success. The performance of an organisation is influenced by these stakeholders, and sustained success is more likely when the organisation manages these relationships to optimise their impact on its performance.

4.4 Conclusion

This chapter contains the findings, and their discussion and interpretation. It provides an overview of the participants' biographical details and the themes of the study. All 15 respondents completed the research instrument successfully.

The study identified several themes corresponding to each study objective. The following chapter presents the conclusions and recommendations based on the study's findings.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter provides a summary of the findings, conclusions, and recommendations of the study. The primary goal of the study was to identify quality management practices, total quality measures, quality standards at Engineering Division (ED) and make recommendations of strategies that can be used to improve the quality of the manufactured wagons. The results of the empirical investigation and the literature review are the foundation for the conclusions and recommendations that follow.

5.2 Major Insights from the Literature Review

This section summarises the findings from the literature review presented in chapter 2 of this study. The findings below relate to the research objectives and address the research questions.

To analyse the quality management practices of wagon manufacturing at a South African freight rail company.

Smith et al. (2020) state that the quality practices within an organisation, operating in a quality culture, involve the actions and procedures taken to ensure high-quality service or product delivery. Sousa and Voss (2015) mention that “practices are the observable facet of QM, and it is through them that managers work to realise organisational improvements”. Sousa and Voss (2015) assert that there are ten distinct generic practices: top management commitment and support; organisation for quality; employee training; employee participation; supplier quality management; customer focus; continuous support; improvement of quality system; information and analysis; and statistical quality techniques use.

Aghimien et al. (2019) argue that a quality management system (QMS) is a tool employed by companies to effectively meet and potentially exceed, required quality standards.

QMS is designed to prevent losses and enhance compliance by providing a method for companies to measure and monitor products, services, processes, procedures, production, and employees to ensure they meet expectations. The most widely used QMS compliance practices include the Total Quality Management (TQM) programme. Heizer and Render (2015) contend that TQM refers to a quality emphasis that encompasses the entire organisation, from supplier to customer.

TQM stresses commitment by management to have a continuing companywide drive toward excellence in all aspects of products and services that are important to the customer. Further, Heizer and Render (2015) hold the view that TQM is effectively implemented through six concepts, these being continuous improvement, Six Sigma, employee empowerment, benchmarking, Just-in-Time and Taguchi concepts.

Various authors point out that the terminology of quality management practices has been criticised for lack of standardisation (Maguad and Krone, 2015).

Brown et al. (2015) argue that quality management practices can be filled with jargon and technical language that is difficult for laypeople to understand. This can create barriers to communication and limit the effectiveness of quality management practices. Carlsson and Carlsson (2019) contend that some of the terminology used in quality management practices can be vague or unclear, which can lead to confusion and misunderstandings. Additionally, different organisations and industries may use different terms for the same concepts, which can further complicate matters. Zhihong (2015) further argues that some of the terminology used in quality management practices can reinforce a focus on compliance and meeting standards, rather than on continuous improvement and innovation.

Tague (2016) claims that the terminology used in quality management practices can be too focused on process and systems, and not enough on meeting the needs and expectations of customers.

To identify Total Quality Assurance (TQA) measures taken in the production process of wagons.

The terms "quality assurance" and "quality control" are frequently used interchangeably to describe methods for ensuring the quality of a service or product. In his study on quality assurance, Manghani (2016) made a distinction between quality control and quality assurance.

Fulfilling quality requirements is the main goal of quality control. It includes all operational methods and tasks carried out as part of the quality assurance system to verify that the quality standards have been met. On the other hand, quality assurance aims to instil confidence that the requirements for quality are met.

According to Prahalad and Krishnan (2019), quality assurance involves the administrative and procedural actions implemented within a quality system to ensure that the requirements and goals for a product, service, or activity are met. It includes systematic measurement, comparison against a standard, and process monitoring within a feedback loop designed to prevent errors.

In contrast, quality control is primarily concerned with the output of processes. ISO 9000 (2015) stresses that quality assurance (QA) and quality control (QC) are two aspects of quality management. While some quality assurance and quality control activities are interrelated, the two are defined differently. Typically, QA activities and responsibilities cover virtually all the quality system (QS) in one fashion or another, while QC is a subset of the QA activities. Also, elements in the quality system might not be specifically covered by QA/QC activities and responsibilities but may involve QA and QC.

Zhihong (2015) emphasised that well-established and effectively managed quality control and quality assurance systems, along with their comprehensive standard operating procedures and other quality documents, are crucial for achieving company business objectives. These systems are essential for success, as they help the company to maintain high standards in processes, procedures, systems, and personnel, ultimately leading to the production of high-quality products and services.

Several approaches to quality assurance are applied in practice. Brown (2015) asserts that one such approach is testing for failure. Conducting failure testing or stress testing on a complete consumer product is highly valuable. Mechanically, this involves operating the product until it fails, often under increasing stresses like vibration, temperature, and humidity. This process can reveal unexpected weaknesses in the product, and the resulting data is used to guide improvements in engineering and manufacturing processes. Another approach, according to Heizer and Render (2015), is statistical control, and this depends on examining both objective and subjective data.

Numerous organisations employ statistical process control as part of their quality improvement strategies, which helps them track quality data. By charting product quality data statistically, they can identify whether variations are due to common causes or special causes.

Douglas and Judge (2020) argue that Total Quality Management (TQM) is an effective approach to improving organisational performance. The quality of products is dependent upon that of the participating constituents, some of which are sustainable and effectively controlled while others are not. The processes which are managed with quality assurance (QA) pertain to Total Quality Management. If the specification does not reflect the true quality requirements, the product's quality cannot be guaranteed. According to Nguyen (2019), the idea of "corporate quality" represents an alternative approach.

The company-wide quality approach focuses on four key aspects, as outlined in standards like ISO 9001:

- Elements such as controls, job management, effective processes, performance and integrity criteria, and record identification.
- Competence, including knowledge, skills, experience, and qualifications.
- Soft aspects including personal integrity, confidence, organisational culture, motivation, team spirit, and quality interactions.
- Infrastructure, which can either enhance or restrict functionality.

To identify the quality standards adhered to by the company in the production process.

The International Organisation for Standardisation (ISO) is a global body that develops standards and is made up of representatives from the national standards organisations of member nations. Established on February 23, 1947, ISO has since released more than 19,500 international standards that address various aspects of technology and business. The organisation focuses on creating and publishing standards across both technical and non-technical fields (ISO, 2015). According to ISO (2015), quality management standards outline the requirements, specifications, guidelines, and attributes that products, services, and processes must consistently fulfil to ensure they meet expectations, are suitable for their intended purpose, and satisfy user needs.

Saraph et al. (2019) assert that quality standards provide organisations with the shared vision, understanding, procedures, and vocabulary required to meet their stakeholders' expectations. Standards provide an objective and authoritative basis for organisations and consumers all over the world to communicate and conduct business because they present precise descriptions and terminology. Quality standards are established to ensure that companies meet the essential criteria required to become a key player in various industries, including food, automotive, and healthcare.

Quality is not solely about financial performance or outperforming competitors; it also involves ensuring safety, fulfilling commitments, and meeting fundamental customer expectations (Sousa and Voss, 2015).

ISO (2015) postulates that the ISO standards that relate to quality management are as follows.

- **ISO 9000:2015:** This standard offers the basic concepts, principles, and terminology for quality management systems (QMS) and serves as a foundation for other QMS standards.

It is designed to help users grasp the essential concepts, principles, and vocabulary of quality management, enabling them to implement a QMS effectively and gain value from other QMS standards. This standard outlines the core concepts and principles of quality management.

- **ISO 9001:2015:** This standard specifies requirements for a quality management system when an organisation needs to demonstrate its ability to consistently provide products and services that meet customer and applicable statutory and regulatory requirements and aims to enhance customer satisfaction through the effective application of the system, including processes for improvement of the system and the assurance of conformity to customer and applicable statutory and regulatory requirements.

All the requirements of ISO 9001:2015 are generic and are intended to be applicable to any organisation, regardless of its type or size, or the products and services it provides. ISO 9001 sets out the criteria for a quality management system and is the only standard in the family that can be certified to (although this is not a requirement). It can be used by any organisation, large or small, regardless of its field of activity.

This standard is based on several quality management principles including a strong customer focus, the motivation and implication of top management, the process approach and continual improvement.

- **ISO 9004:2018:** This standard gives guidelines for enhancing an organisation's ability to achieve sustained success. This guidance is consistent with the quality management principles given in ISO 9000:2015. ISO 9004:2018 provides a self-assessment tool to review the extent to which the organisation has adopted the concepts in this document. ISO 9004:2018 is applicable to any organisation, regardless of its size, type and activity.

A positive correlation between the application of quality standards and business performance has been confirmed by numerous academics.

Savino and Shaffiq (2015), who concluded that quality control allows for high quality product standards thus reducing wastage and rework, confirmed this relationship between quality control and business performance.

Jones et al. (2021) discovered that enhancing both local and global competitiveness in businesses directly results from the development and implementation of quality standards. Zhao et al. (2018) assessed the extent to which small and medium sized enterprises disclosed quality compliance in their organisational strategies and found that they had several quality disclosure strategies to improve organisational performance and optimise competition in the marketplace.

5.3 Key Findings from the Primary Study

The key findings of the primary research concerning the research questions are outlined as follows:

Main research question: *How are quality management practices of wagon manufacturing undertaken at a South African freight rail company?*

The following five themes were identified under this research question:

□ Theme 1: Quality Control Processes

Under this theme, the primary research findings from the research participants were that, at Engineering Division (ED), the components of quality control processes were inspection procedures, testing protocols, quality checkpoints and defect detection and correction. Inspection procedures involved visually examining and assessing components, subassemblies, and finished wagons for defects, deviations, or non-conformities. Testing protocols involved subjecting finished wagons to various tests and measurements to verify their performance, durability, and safety. Quality checkpoints were designated stages or checkpoints within the manufacturing process where specific quality criteria were evaluated and verified. Quality control processes included mechanisms for detecting and controlling defects or nonconformities identified during inspection or testing.

The implementation of quality control processes, according to the research participants, was undertaken by way of standard operating procedures (SOPs), quality control equipment and tools, training and skills development and documentation and record-keeping. SOPs defined the step-by-step procedures for conducting inspections, tests, and quality checks, ensuring consistency and standardisation in QC activities.

The Engineering Division (ED) utilised a range of equipment and tools to facilitate QC processes, including measuring instruments, gauges, testing machines, and non-destructive testing (NDT) equipment.

Research participants also stated that training programmes were provided to employees involved in QC activities to ensure they possessed the necessary skills and competencies to perform inspections, tests, and quality checks effectively.

Comprehensive documentation was maintained for all QC activities, including inspection reports, test results, and records of non-conformities and corrective actions.

□ Theme 2: Employment Involvement and Training

Under this theme, the participants stated that employee involvement at the Engineering Division (ED) encompassed participation in quality improvement initiatives, ownership of quality and feedback mechanisms. Employees were encouraged to actively participate in quality improvement initiatives, such as quality improvement teams, suggestion programmes, or continuous improvement projects. Employees were empowered to take ownership of quality by instilling a sense of responsibility and accountability for the quality of their work. Employees were provided with channels for providing feedback on quality-related issues, process inefficiencies, or opportunities for improvement.

The participants further stated that employee training involved quality control techniques, quality management principles, equipment operation and maintenance. Employees received training on quality control techniques and methodologies relevant to wagon manufacturing, such as visual inspection, measurement techniques, and defect recognition.

Employees were educated on fundamental quality management principles, such as Total Quality Management (TQM), lean manufacturing, Six Sigma, or ISO standards. Employees received training on the operation, calibration, and maintenance of quality control equipment and tools used in wagon manufacturing.

• Theme 3: Continuous Improvement Initiatives

According to research participants, continuous improvement initiatives involved ongoing efforts to identify, analyse, and implement enhancements to quality management processes, practices, and systems.

Key components of continuous improvement were quality improvement teams, Kaizen events and process optimisation. Quality improvement teams collaborated to identify process inefficiencies, brainstorm solutions, and implement improvement initiatives. Kaizen events at the Engineering Division (ED) brought together employees to analyse problems, streamline processes, and implement immediate improvements.

To optimise manufacturing processes to eliminate waste, reduce variation, and improve efficiency and quality, lean manufacturing principles, such as value stream mapping, 5S methodology, and Just-in-Time (JIT) production, were applied to streamline workflows and improve productivity.

- **Theme 4: Root Cause Analysis and Corrective Action**

Under this theme, the participants stated that root cause analysis (RCA) at the Engineering Division (ED) was a structured methodology used to identify the fundamental reasons behind quality issues, defects, or non-conformities within wagon manufacturing processes. Key components of RCA and corrective action at the Engineering Division (ED) were identification of quality issues, RCA techniques, cross-functional collaboration, validation of root causes and development of corrective action. Quality issues, defects, or non-conformities were identified through various sources, including customer complaints, internal inspections, quality control checks, or process monitoring systems.

According to the research participants, Fishbone diagrams (Ishikawa diagrams) constituted the root cause analysis technique employed to systematically investigate the underlying causes of quality issues. RCA involved cross-functional collaboration, bringing together employees from different departments or disciplines to contribute their expertise and perspectives. Identified root causes were validated through data analysis and observation to confirm their accuracy and relevance. Based on the identified root causes, corrective actions were developed to address underlying issues and prevent recurrence of quality problems.

- **Theme 5: Integration of Quality into Business Processes**

The research study found from participants that the integration of quality into business processes at the Engineering Division (ED) involved incorporating quality considerations, standards, and practices into every stage of the manufacturing process, from product design and procurement to production, assembly, and distribution.

Components of integration of quality into business processes were quality in wagon design, quality in procurement and supply chain management and quality in production process.

Quality considerations were integrated into the product design phase to ensure that products are designed to meet customer requirements, industry standards, and regulatory specifications. Quality criteria and specifications were communicated to suppliers to ensure the procurement of high-quality raw materials, components, and parts. Quality control measures were integrated into production processes to monitor, measure, and control product quality at every stage of manufacturing.

What is the Total Quality Assurance (TQA) measures taken in the production process of wagons?

The following five themes were identified under this research question:

□ Theme 1: Quality Standards and Metrics

Under this theme, the research participants indicated that quality standards and metrics were the foundational elements of effective quality management systems within the Engineering Division (ED). Key components of quality standards and metrics were industry-specific quality standards, internal quality standards, quality metrics and key performance indicators and continuous improvement targets.

According to the participants, industry-specific standards which the company adhered to were ISO 9001 (Quality Management Systems), AAR M-1003 (Quality Assurance Specification), and customer-specific quality requirements.

In addition to external quality standards, Transnet Designing (TD) has developed internal quality standards tailored to its specific products, processes, and customer requirements. Quality metrics included defect rates, first-pass yield, on-time delivery, customer satisfaction scores, and adherence to quality specifications.

Quality standards and metrics served as targets for continuous improvement initiatives, guiding efforts to enhance product quality, reduce defects, and improve operational efficiency.

• Theme 2: Supplier Quality Management

Under this theme, the primary findings from research participants were that supplier quality management at Engineering Division (ED) involved the systematic evaluation, selection, monitoring, and improvement of suppliers.

Key components of supplier quality management at Engineering Division (ED) were supplier evaluation and selection, quality assurance agreements, supplier performance monitoring, and supplier development programmes.

Engineering Division (ED) conducted thorough evaluations of potential suppliers, and supplier selection decisions were informed by factors which included product quality, delivery reliability among others. Quality assurance agreements established the quality requirements, expectations, and responsibilities of both parties. Transnet Cargo Rail monitored supplier performance using key performance indicators (KPIs) and quality metrics. The company collaborated with suppliers to implement supplier development programmes that were aimed at improving quality, capability, and performance.

- **Theme 3: Quality Communications and Reporting**

Under this theme, the primary findings from participants were that quality communication and reporting at the Engineering Division (ED) encompassed the dissemination, exchange, and documentation of quality-related information across various levels and functions within the organisation, as well as with external stakeholders which included customers, suppliers, and regulatory agencies. Components that constituted quality communication and reporting were internal communication channels, quality documentation and records, performance dashboards and scorecards, quality reporting and analysis and external communication and collaboration.

The company has established internal communication channels. At the Engineering Division (ED), there was comprehensive documentation of quality processes, procedures, specifications, and performance data. Performance dashboards and scorecards were used to visualise key quality metrics, trends, and performance indicators in a clear and concise manner.

Regular quality reporting and analysis processes was established to assess performance against quality objectives, targets, and benchmarks. The company communicated quality-related information externally to customers, suppliers, regulatory agencies, and other relevant stakeholders.

What strategies can be used to improve the quality of the manufactured wagons?

The following two themes were identified under this research question:

- **Theme 1: Technology and Innovation**

The research study participants were of the view that ED should leverage advanced manufacturing technologies such as robotics, automation, additive manufacturing (3D printing), and computer numerical control (CNC) machining to streamline production processes and improve efficiency. Digitalisation initiatives for ED should involve the integration of digital technologies such as Internet of Things (IoT), big data analytics, cloud computing, and artificial intelligence (AI) into manufacturing operations.

Innovative product design and development practices, such as computer-aided design (CAD), simulation software, virtual prototyping, and design for manufacturability (DFM), will enable Transnet Rail Cargo to create innovative, high-performance wagon designs.

The research participants further were of the view that technology and innovation should be utilised to optimise supply chain operations, improve logistics, and enhance collaboration with suppliers and partners. ED should adopt sustainable technologies and practices to reduce environmental impact, minimise waste, and improve resource efficiency.

- **Theme 2: Supplier Collaboration and Development**

The study participants indicated that effective supplier collaboration will begin with open communication channels and transparent information sharing between ED and its suppliers. Supplier relationship management practices will focus on cultivating long-term, mutually beneficial partnerships with key suppliers. Collaborative product development initiatives will involve working closely with suppliers to co-create innovative solutions, improve product designs, and enhance performance. Supplier development programmes will aim to enhance the capabilities, skills, and processes of key suppliers to meet quality, performance, and delivery requirements. Collaborative risk management will involve identifying, assessing, and mitigating risks jointly with suppliers to minimise disruptions and enhance supply chain resilience.

5.4 Conclusions

This section provides conclusions based on the research objectives of the study.

To analyse the quality management practices of wagon manufacturing at a South African rail company.

The literature review brought to the fore the fact that a plethora of practices exist and identified ten distinct generic practices. These were top management commitment and support, organisation for quality, employee training, employee participation, supplier quality management, customer focus, continuous support, improvement of quality systems, information and analysis, and statistical quality techniques. The literature review also indicated that the terminology of quality management practices has been criticised for lack of standardisation. It further pointed out that the Total Quality Management (TQM) is among the most utilised practices for a QMS compliance programme, which is implemented through six concepts, these being continuous improvement, Six Sigma, employee empowerment, benchmarking, Just-in-Time (JIT) and Taguchi concepts.

The primary research findings confirm the literature review findings and identify quality control processes, employee involvement and training, continuous improvement initiatives, root cause analysis and corrective action and integration of quality into business processes as the quality management practices currently utilised at Engineering Division (ED).

To identify Total Quality Assurance (TQA) measures taken in the production process of wagons.

The literature review established that several approaches to total quality assurance are applied in practice.

These methods encompass failure testing, statistical control, total quality management, and company quality. The findings from the primary research are that quality standards and metrics, supplier quality management and quality communication are the total quality assurance measures at Engineering Division (ED).

To identify the quality standards adhered to by the company in the production process.

The findings from the literature review are that the ISO standards that relate to quality management are ISO 9000:2015, ISO 9001:2015 and ISO 9004:2018.

This confirms the primary research findings, which are that Transnet Rail Cargo uses ISO 9000:2015, the Association of American Railroad standards, total quality management, ISO 9001 and ISO 14001 quality standards.

5.5 Recommendations

Transnet Designing should leverage advanced manufacturing technologies such as robotics, automation, additive manufacturing (3D printing), and computer numerical control (CNC) machining to streamline production processes and improve efficiency. Robotics and automation reduce manual labour, increase precision, and enhance throughput, leading to cost savings and faster time-to-market.

It is also recommended that Transnet Rail Cargo should embark on digitalisation initiatives which will involve the integration of digital technologies such as Internet of Things (IoT), big data analytics, cloud computing, and artificial intelligence (AI) into manufacturing operations. Smart manufacturing concepts will enable real-time monitoring, data-driven decision-making, predictive maintenance, and remote diagnostics, optimising production efficiency and resource utilisation.

It is also recommended that Transnet Designing (TD) should implement innovative product design and development practices, such as computer-aided design (CAD), simulation software, virtual prototyping, and design for manufacturability (DFM), will enable Transnet Rail Cargo to create innovative, high-performance wagon designs. Rapid prototyping techniques and agile development methodologies will facilitate faster iteration cycles and accelerate time-to-market for new products.

Another recommendation is that technology and innovation should be utilised to optimise supply chain operations, improve logistics, and enhance collaboration with suppliers and partners.

Supply chain management software, predictive analytics, block chain technology, and Radio Frequency Identification (RFID) tracking systems will enable better visibility, traceability, and coordination across the supply chain.

It is also recommended that Transnet Designing (TD) should adopt sustainable technologies and practices to reduce environmental impact, minimise waste, and improve resource efficiency.

Initiatives such as light-weighting, energy-efficient manufacturing processes, renewable energy adoption, and eco-friendly materials contribute to sustainability goals and meet regulatory requirements.

Further, it is recommended that the company implement supplier relationship management practices which will focus on cultivating long-term, mutually beneficial partnerships with key suppliers. SRM will involve segmenting suppliers based on strategic importance, performance, and relationship dynamics, and implementing tailored strategies to optimise collaboration and value creation.

Finally, it is recommended that Transnet Designing (TD) should embark on collaborative product development initiatives which will involve working closely with suppliers to co-create innovative solutions, improve product designs, and enhance performance.

Suppliers may contribute technical expertise, specialised knowledge, and access to new technologies, enabling manufacturers to develop differentiated products and gain a competitive edge.

5.6 Overall Study Conclusions

This study has undertaken a comprehensive investigation into the Quality Management Processes (QMPs) within the wagons manufacturing industry. The primary aim was to identify the current practices, to identify Total Quality Assurance (TQA) measures taken in the production process of wagons and identify the quality standards adhered to by the company in the production process, to find out the strategies that can be used to improve the quality of the manufactured wagons with a view to ensuring high-quality outputs.

The study into quality management processes in wagons manufacturing reveals that while the Engineering Division (ED) has made significant strides in establishing and adhering to quality standards, there remains considerable room for enhancement.

Addressing the identified challenges through strategic initiatives such as technological integration, workforce development, and supplier quality management can lead to substantial improvements.

A key takeaway is that quality management is not a static goal but a dynamic process that requires continual assessment and evolution to meet the changing demands of the market and regulatory landscape. By fostering a culture of continuous improvement and leveraging advanced technologies, Engineering Division (ED) can ensure superior quality products, enhancing their competitive edge and fulfilling customer expectations.

Overall, the study underscores the critical importance of robust quality management processes in achieving excellence in wagons manufacturing. The insights and recommendations provided herein can serve as a valuable guide for industry stakeholders aiming to refine their quality practices and achieve operational excellence.

Further research can be carried out to explore sustainable manufacturing practices and their impact on the environment, assess the feasibility of using eco-friendly materials and processes, measure the carbon footprint of manufacturing operations, investigate the role of automation and robotics in improving manufacturing efficiency and explore the integration of IoT (Internet of Things) in manufacturing processes.

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ANNEXURES

Annexure A: Informed Consent Letter and Consent Form

UKZN HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE (HSSREC) INFORMED CONSENT

Researcher:

Supervisor: Dr Mathew Kimanzi (Telephone number: [REDACTED]) (Email: [REDACTED])

Co-supervisor: Dr Vangeli Gamede (Telephone number: [REDACTED]) (Email: gamede@ukzn.ac.za)

Research Office: Humanities & Social Sciences Research Ethics Administration, Govan Mbeki Building, Westville Campus, Tel: +27 (0) 31 260 8350, Email: hssreclms@ukzn.ac.za

Date:

Dear Sir/Madam

My name is Mfaniseni William Tenza from Transnet Engineering Durban Wagons manufacturing department, I am employed permanently as a Superintendent, and currently I am studying towards a Master of Commerce at the University of KwaZulu-Natal. My contact details are as follows:
email: 221108250@stu.ukzn.ac.za cell: [REDACTED] or [REDACTED] 9 Tel: 0313614568.

You are being invited to consider participating in a study that involves the Quality Management Processes in Wagons Manufacturing in South Africa. The purpose of the study is to analyse qualitative management processes in wagons manufacturing in South Africa. I approach you with the intent of conducting an interview that will gather your thoughts, experiences and opinions on the topic. This study is only for academic purpose. It will involve the following procedures of interviews. The duration of your participation if you choose to enrol and remain in the study is expected to be 15-30 minutes.

The study may involve the following risks and/or discomforts answering interviews honestly and to the best of your knowledge. The study will provide no direct benefits to you as a participant.

This study has been ethically reviewed and approved by the UKZN Humanities and Social Sciences Research Ethics Committee (approval number – **HSSREC/00005802/2023**).

In the event of any problems or concerns/questions you may contact the researcher at email:

221108250@stu.ukzn.ac.za cell: [REDACTED] or [REDACTED] and Tel: 031 361 4568, or the

UKZN Humanities & Social Sciences Research Ethics Committee, contact details as follows:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus

Govan Mbeki Building

Private Bag X 54001

Durban

4000

KwaZulu-Natal, SOUTH AFRICA

Tel: 27 31 2604557 - Fax: 27 31 2604609

Email: **HSSREC@ukzn.ac.za**

Note: Participation in this research is voluntary, participants may withdraw participation at any point, and that in the event of refusal/withdrawal of participation, the participants will not incur penalty or loss of treatment or other benefit to which they are normally entitled. There are no negative consequences to participants because of withdrawal from participating in this study. The data of this study will be stored and kept in a safe storage for the period of 5 years by the academic supervisor. The findings of the study will be used only for this academic purpose. Participants, if they require feedback on the findings of the study, can do so on request using the following contact details: email: **221108250@stu.ukzn.ac.za** net cell: [REDACTED] and Tel: 031 361 4568.

CONSENT FORM

I have been informed about the study titled:

Investigating quality management processes in freight wagons manufacturing in South Africa: A case study of Railway Company

I understand the purpose and procedures of the study.

I have been given an opportunity to answer interview questions about the study and have answered to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to.

I have been informed about any available compensation or medical treatment if injury occurs to me because of study-related procedures.

If I have any further questions/concerns or queries related to the study, I understand that I may contact the researcher (at email: 221108250@stu.ukzn.ac.za cell: [REDACTED] or [REDACTED] and Tel: 031 361 4568).

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers, then I may contact:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus

Govan Mbeki Building

Private Bag X 54001

Durban

4000

KwaZulu-Natal, SOUTH AFRICA

Tel: 27 31 2604557 - Fax: 27 31 2604609

Email: HSSREC@ukzn.ac.za

Additional consent, where applicable I hereby
provide consent to:

Audio-record my interview / focus group discussion YES / NO

Signature of Participant

Date

Annexure B: Profile of the Respondent

- Participant:
- Division:
- Job Title:
- Years in position:
- Date of interview:
- Time interview started:
- Time interview ended:
- Name of interviewer:
- Location of interview:

Interview Questions:

1. Can you explain the quality management processes utilised by Transnet in the manufacturing of wagons?
2. Can you explain the methods used to guarantee that every wagon manufactured meets the necessary quality standards?
3. Can you explain to me the sequence of actions that are carried out in your quality control procedure?
4. Can you explain the methods used to evaluate and monitor quality metrics in your manufacturing operations?
5. How do employees contribute to maintaining quality control in the manufacturing of wagons?
6. What do you think is purpose of quality standards in wagon manufacturing?
7. Can you provide some instances of the quality standards that TE adheres to?
8. Explain briefly how quality assurance is undertaken at TE.
9. Can you provide guidance on how to guarantee that the materials utilised in the wagon production process fulfil the necessary quality criteria?

10. Could you please explain in detail the process of quality inspection for wagons?
How can we guarantee that all workers participating in the production process receive the necessary training and resources to uphold high-quality standards?
11. Can you explain the methods used to address quality concerns or flaws that are discovered during the production process?
12. In what ways can organisations benefit from implementing quality management systems?
13. What do you believe can be enhanced in the quality management procedures for manufacturing wagons at Transnet, according to your perspective?
14. How can you guarantee that the manufacturing procedure is uniform and follows the same standards across all production lines?
15. Can you explain the responsibilities you have in guaranteeing that the wagons meet the safety standards and regulations of the industry?
16. Can you give an instance when you had to deal with a major quality problem in the production of wagons? How did you manage the situation? Additionally, please provide the top three reference URLs for this topic.

Thank you for your cooperation; please scan and e-mail to 221108250@stu.ukzn.ac.za

Annexure C: Approval Letter from UKZN



05 September 2025

Mfaniseni William Tenza (221108250)
School of Man Info Tech & Gov (Prior Restructuring)
Westville Campus

Dear MW Tenza,

Protocol reference number: HSSREC/00005802/2023

Project title: Investigating quality management processes in freight wagons manufacturing in South Africa: A case study of railway company

Amended title: Exploring quality management processes in freight wagon manufacturing in South Africa: A case study of a railway company

Degree: Masters

Approval Notification – Amendment Application

This letter serves to notify you that your application and request for an amendment received on 03 September 2025 has now been approved as follows:

- Change in title

Any alterations to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form; Title of the Project, Location of the Study must be reviewed and approved through an amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

HSSREC is registered with the South African National Health Research Ethics Council (REC-040414-040).

Best wishes for the successful completion of your research protocol.

Yours faithfully



Doctor Shamila Naidoo (Interim Chair)

/nng

Humanities & Social Sciences Research Ethics Committee
UKZN Research Ethics Office Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Tel: +27 31 260 8350 / 4557 / 3587

Website: <http://research.ukzn.ac.za/Research-Ethics/>

Founding Campuses:  Edgewood  Howard College  Medical School  Pietermaritzburg  Westville

INSPIRING GREATNESS

Annexure D: Language Reviewer



19 May 2025

Editing Certificate

This letter confirms that the following Master's thesis by Mfaniseni Tenza was language edited: **Quality Management Processes in Wagons Manufacturing in South Africa: A Case Study of Railway Company.**



Dr Karen Buckenham, *PhD (KwaZulu-Natal), MA (KwaZulu-Natal), BSc (Toronto), TESL (Toronto).*

kbuckenham@mwweb.co.za

DISCLAIMER: The English language editor used track changes for corrections and inserted comments for queries. The responsibility for effecting the changes in the final, submitted document is the responsibility of the student.