

A quality improvement plan for a technical department within a petrochemical company

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ABSTRACT

Quality improvement initiatives have been implemented by various manufacturing companies. Through initiatives such as international standards organization, lean production, total quality management systems and six sigma, quality has improved dramatically while optimizing production and costs.

This study gives insight into the constraints that the case study organization experiences due to restructuring initiatives. The review assisted in identifying barriers that inhibit the implementation of the full potential of the current quality management systems.

The study included a quantitative and qualitative analysis of the current organization culture and perceptions. Through the analysis of this data, a quality improvement plan was developed to assist the organization in the implementation of the quality management systems.

It is critical for a company to have leadership commitment towards quality and assist in the development of its personnel. This promotes continuous improvement of an organization and ensures that it is competitive in the global market.

“Quality is not an act, it is a habit” - Aristotle

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TABLE OF CONTENTS

PLAGIARISM DECLARATION.....	II
ABSTRACT	III
ACKNOWLEDGMENTS.....	IV
LIST OF FIGURES.....	VIII
LIST OF TABLES	IX
LIST OF ABBREVIATIONS.....	X
KEYWORDS	XI
1. INTRODUCTION AND OVERVIEW	1
1.1 Introduction	1
1.2 Background.....	1
1.3 Problem Statement	2
1.4 Research Objectives	3
1.4.1 Scope and boundary limits	3
1.4.2 Research Aim	3
1.4.3 Specific Research Objectives	3
1.5 Layout of the Dissertation:	4
2. LITERATURE STUDY	5
2.1 Introduction	5
2.2 Quality Management Literature	5
2.2.1 The history of quality	5
2.2.2 Introduction.....	7
2.2.3 Quality Management Systems.....	8
2.2.4 QMS ISO 9000 and Principles.....	9
2.2.5 ISO 9001	14
2.2.6 ISO 9004	17
2.2.7 ISO Conclusion.....	22
2.2.8 Lean Production	23
2.2.9 Six Sigma	33
2.2.10 Quality Improvement plan.....	44
2.2.11 Literature study conclusion	49
2.3 Case study literature	51
2.3.1 Introduction.....	51
2.3.2 Knowledge capture and transfer procedure for retiring employees	52
2.3.3 Engineering Health Management System in Project Execution (EHMS)	
54	
2.3.4 Peer Assist Procedure	64

2.3.5	Case study literature conclusion.....	68
2.4	Final Conclusion.....	69
3.	EXPERIMENTAL DESIGN.....	70
3.1	Introduction	70
3.2	Experimental Method	70
3.3	Survey Design.....	71
3.4	Survey Validity	75
3.5	Study Population	75
3.6	Data Collection and Analysis.....	77
3.7	Summary and conclusion.....	77
4.	PRESENTATION AND DISCUSSION OF RESULTS	79
4.1	Introduction	79
4.2	Participation Rate.....	79
4.3	Analysis of Results.....	79
4.3.1	Overall Mean Data:.....	80
4.3.2	Results According to Constructs:.....	89
4.3.3	Results of the Qualitative Investigation:.....	93
4.4	Discussion and Interpretation:.....	98
4.4.1	Introduction.....	98
4.4.2	Quantitative Summary	99
4.4.3	Qualitative Summary	99
4.4.4	Critical assessment and interpretation.....	100
4.5	Verification of Results:	103
4.6	Discussion of quality improvement plan	104
5.	CONCLUSIONS AND RECOMMENDATIONS	105
5.1	Introduction	105
5.2	Research aim conclusions	105
5.2.1	Research Objectives	105
5.3	Recommendations	106
5.4	Limitations and Future Work	107
5.5	Concluding Thoughts	108
6.	LIST OF REFERENCES	109
	APPENDIX A: RESEARCH QUESTIONNAIRE	115
	APPENDIX B: Proposal for Sasol case study	124
	APPENDIX C: Knowledge transfer plan.....	130
	APPENDIX D: Peer Assist Preparation	136
	APPENDIX E: Peer Assistant agenda.....	137

APPENDIX F: Peer Assist Report	138
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LIST OF FIGURES

FIGURE 1: QUALITY TIMELINE (EDVARDSSON, 1999)	5
FIGURE 2. SEVEN QUALITY MANAGEMENT PRINCIPLES (INTERNATIONAL ORGANIZATION FOR STANDARDS, 2005)	9
FIGURE 3 : ISO 9000 PROCESS	14
FIGURE 4 - SCHEMATIC REPRESENTATION OF THE ELEMENTS OF A SINGLE PROCESS (ISO 9001, 2015)	16
FIGURE 5 - PDCA CYCLE (ISO 9001, 2015)	17
FIGURE 6 - EXTENDED MODEL OF A PROCESS-BASED QUALITY MANAGEMENT SYSTEM (ISO 9004, 2009)	18
FIGURE 7: EIGHT WASTES IDENTIFIED BY LEAN MANUFACTURING (SOLUTIONS, N.D.)	25
FIGURE 8: LEAN BUILDING BLOCKS (SUBRAMANIAM, ANAND, 2016)	26
FIGURE 9: 5S SYSTEM (BMS & BEST MACHINE SHOP, 2006)	27
FIGURE 10: TOTAL QUALITY MANAGEMENT MODEL	30
FIGURE 11: TOTAL QUALITY MANAGEMENT MODEL (TRANSTUTORS, N.D.)	31
FIGURE 12: TQM FRAMEWORK (KOTWAL, N.D.)	32
FIGURE 13: SIX SIGMA (INITIUTE, N.D.)	35
FIGURE 14: SIX SIGMA MEASURE FLOWCHART (SHUMULA.COM, THE MEASURE PHASE, N.D.)	37
FIGURE 15: SIX SIGMA: ANALYSE FLOWCHART (SHUMULA.COM, SHUMULA.COM, N.D.)	38
FIGURE 16: SIX SIGMA IMPROVE FLOWCHART (SHUMULA.COM, SHUMULA.COM, N.D.)	40
FIGURE 17: SIX SIGMA CONTROL FLOWCHART	41
FIGURE 18: QUALITY IMPROVEMENT CYCLE (QUALITY, N.D.)	45
FIGURE 19: FLOW CHART SYMBOLS (NEW YORK STATE OFFICE OF MENTAL HEALTH , 2005)	47
FIGURE 20: CAUSE AND EFFECT DIAGRAM (USMANI F., 2016)	48
FIGURE 21: CAPTURE OF KNOWLEDGE FLOWCHART	53
FIGURE 22: ENGINEERING HEALTH MONITORING SYSTEM	57
FIGURE 23: PROJECT PHASE GOVERNANCE - GENERIC PROCESS FOR EACH PHASE	58
FIGURE 24: QUALITY ASSURANCE PROCESS	59
FIGURE 25: ENGINEERING PHASE GOVERNANCE MODEL	60
FIGURE 26: LEVEL OF QUALITY CHECKING	62
FIGURE 27: KNOWLEDGE PROCESS FLOW	66
FIGURE 28: MIXED METHOD DESIGN	72
FIGURE 29: POPULATION PERCENTAGE	76
FIGURE 30: DEPARTMENT PERCENTAGE	77
FIGURE 31: MEAN SURVEY SCORES PER QUESTION	80
FIGURE 32: MEAN DATA FOR LEADERSHIP COMMITMENT AND ACCOUNTABILITY	81
FIGURE 33: MEAN DATA FOR PLANNING INITIATIVES	82
FIGURE 34: MEAN DATA FOR INFRASTRUCTURE AVAILABILITY	83
FIGURE 35: MEAN DATA FOR FOCUS & ROLL-OUT OF PROCEDURES	84
FIGURE 36: MEAN DATA FOR TRAINING OF PERSONNEL	85
FIGURE 37: MEAN DATA FOR RESOURCES AVAILABILITY	86
FIGURE 38: MEAN DATA FOR INFORMATION AND COMMUNICATION	87
FIGURE 39: MEAN DATA PER CONSTRUCT FOR ENTIRE POPULATION	89
FIGURE 40: MEAN SCORE PER POPULATION GROUP.	90
FIGURE 41: MEAN DATA FOR "MANAGEMENT" AND "NON-MANAGEMENT" POPULATIONS.	92

LIST OF TABLES

TABLE 1 - NEEDS AND EXPECTATIONS (ISO 9004, 2009)	20
TABLE 2: SIGMA PERFORMANCE SCALE (WATSON G.H. , 2005)	34
TABLE 3: DMAIC SIX SIGMA TABLE (ISIXSIGMA, 2016)	42
TABLE 4 : PDCA CYCLE AND LEAN MANUFACTURING LINK (CHIARINI A., 2011)	50
TABLE 5: FINAL REPORTING TABLE	64
TABLE 6: POPULATION MAKE-UP	75
TABLE 8: SURVEY PARTICIPATION RATE	79
TABLE 9: SURVEY QUESTION SCALE	80
TABLE 10: POSITIVELY SCORED QUESTIONS	88
TABLE 11: NEGATIVELY SCORED QUESTIONS	88
TABLE 12: CLOSE TO NEUTRAL SCORED QUESTIONS	89
TABLE 13: MEAN DATA FOR POPULATION AND CONSTRUCTS	91
TABLE 14: MEAN DATA FOR MANAGEMENT AND NON-MANAGEMENT OVER ALL CONSTRUCTS	92
TABLE 15: CRONBACH'S ALPHA COEFFICIENT FOR ALL CONSTRUCTS	103

LIST OF ABBREVIATIONS

AC	After Christ
AIA	Authorised Inspection Authority
ASQ	American society of quality
BC	Before Christ
BD&I	Business Development and Implementation Model
CTQ	Critical to Quality
DM	Definition of Victory
DMAIC	Define, measure, analyse, improve and control
DOC	Design of Experiment
DOV	Centre of Competency
DPMO	Defects per million opportunities
EEP	Discipline Manager
EHMS	Engineering Health Management System
ELT	Engineering Execution Plan
EM	Engineering Leadership Team
ETQP	Engineering track quality plan
FMEA	Failure Modes and Effects
GRR	Gate Readiness Review
HR	Human Resources
IP	Intellectual Property
ISO	International standards organization
JSE	Johannesburg Stock exchange
KFA	Key Focus Area
KM	Knowledge Management
KOL	Knowledge Online
KPA	Key Performance Area
KPI	Key Performance Indicator
LDE	Lead Discipline Engineer
LM	Line management
MIL-STD	Military standards
PDCA	Plan-Do-Check-Act
PEP	Project Execution Plan
PMT	Project Management Team
QA	Quality Assurance
QC	Quality Control
QMP	Quality Management Principles
QMS	Quality Management System
R&D	Research and development
RACI	responsible, accountable, to be consulted to be informed
RCA	Route cause Analysis
RE	Retiring employee
RSA	Republic of South Africa
SAP	Systems, Applications and Products

SAP	
PS	Systems, Applications and Products project systems
SIPOC	Suppliers, inputs, process, outputs, and customers
SPQ	Statistical process control
TOC	Theory of constraints
TQM	Total Quality Management
UK	United Kingdom
US	United States

KEYWORDS

Quality Management System, International Standard organization , Lean Production, Six Sigma, Total Quality Management, Quality Assurance

1. INTRODUCTION AND OVERVIEW

1.1 Introduction

JSE-listed companies have actively rolled out restructuring of business units, introduced robust cost-saving measures, improved efficiencies and researched new technologies for more streamlined business models, but at what cost to its engineering divisions?

What are the benefits to employees and firms associated with new organizations' structures and engineering approaches? In this study, there will be a mixed method approach and summary of how this affects individuals and teams – is there a quality improvement in teams, or are there now self-directed teams?

After Sasol introduced the Phoenix restructuring programme, there have been several changes in how the functional groups between engineering functions have changed. Group technology has an engineering and project management function and delivers these services to the Sasol group.

Engineering had distinct independence between project management and discipline; lines of accountability were segregated. Engineering managers directly coordinated with the project managers. It meant that at any point in time, you would interface through your engineering manager to third parties. This has changed in that the interfacing is now done through project managers, to the extent that project managers are expected to understand discipline specific requirements that are not in line with technical requirements. This makes it difficult for engineering disciplines to fully execute sound engineering and quality practices because of different priorities.

The discipline roles prioritize the quality and legal requirements. Project managers prioritize schedule and cost. This results in a delicate balancing act for the project managers, as it makes quality management control for engineering disciplines very difficult. This has led to certain sequential steps to be fast-tracked and puts a lot of pressure on engineering disciplines to prioritize quality, as the line of report is now directly to the project managers that also influence merit discussions.

1.2 Background

The implementation of the Phoenix restructuring started in 2014 and was implemented across all levels in Sasol. The aim of the business model was to streamline business processes and simplify the way the business works. The restructuring started from the previous level 1 management and was implemented down to level 13.

Examining the Phoenix restructuring expectations and comparing to the actual operating model that is currently being implemented, exposed a major gap in the positions that engineering is prioritized. It was evident that the business was going to experience long-term quality management problems in terms of sustainable implementation.

The aim of the research is to provide insight of how this staff reduction and restructuring influences the quality of management and how this influences the long-term strategy of the Sasol business.

It is of importance to give recommendation of how this current operating model should be adapted to improve quality management focus and improve the functional deliverables of discipline engineers. The recommendations can be evaluated and implemented to achieve better alignment between functional and project management functions to improve sustainable future for the business.

It would be of great value for the Sasol business as a whole to streamline business processes that ensure adequate quality management implementations and execution to ensure a sustainable future for Sasol and staff.

1.3 Problem Statement

It is evident that quality management in Sasol environment is of high importance as it provides the basis for good engineering governance and high-quality deliverables to be produced.

As a result of restructuring, there are certain basic engineering principles that are not implemented that have an impact on quality management. In this research, the impact of restructuring and staff reduction on the quality management function will be examined and how knowledge is currently being transferred between peers. This includes how the perception of quality management is currently viewed within the organisation.

It will also be established how constant restructuring within the petrochemical industry results in staff not acquiring/learning the correct fundamental principles and also lets the engineering field lose valuable practical engineering knowledge that is not passed from senior engineers to junior engineers.

Problem systems include:

- Fundamentally how engineering problems cannot be solved due to lack of coaching. The impact of engineering defects during construction will be evaluated.
- Production cost that soar out of control due to engineering defects.
- Low staff morale.
- Fundamental defects are not identified during the design phase. Engineering defects have to be rectified in the field through change events, which result in changes in the scope of work.

There should be established how specialist fields recover due to restructuring and develop due to practical knowledge, training and time and scale of investment. Specialist are currently leaving the industry due to more lucrative international opportunities; this leaves a gap in the local economy. It forces the industry to get specialists from overseas and do not develop local specialists.

Problem systems include:

- High cost of specialists.
- Time delay to mobilise specialists due to geographical locations.
- Diminishing local competency.

In the current industry conditions, there is a big drive to cut cost and save money, but at what cost to quality on projects? Project Management is forcing engineering to fast-track engineering that results in fundamental sequential steps being skipped.

1.4 Research Objectives

The primary research objectives are presented first as the high-level research aim, followed by the secondary objectives, which describe the processes that would lead to the research aim being achieved.

1.4.1 Scope and boundary limits

The research will be conducted on a study population that consists of Sasol, Sasolburg region, and not the entire Sasol population.

Because of the time and demographical constraints, a low-level analysis could not be conducted, and further investigations should be conducted to implement in-depth corrective measures.

The analysis that will be conducted will be at a high level due to continuous changes to the quality management systems within the organization and set time frame for the analysis of the research problem. Thus, a detailed analysis will not be conducted and an in-depth review not possible.

Because of the complexity of the organization systems, it is recommended that a task team be assigned to develop suggested focus points in the quality improvement plan proposal. Due to lack of resources and complexity, the author of the plan could not develop the full strategies but rather the give guidance to the company.

1.4.2 Research Aim

Sasol Phoenix was a restructuring programme that aimed to streamline business principles and make Sasol business easier to operate. This would have enabled the Sasol business to achieve the main objective of sustainable profitability in an increasingly global market and due to current depressed global economy.

The high-level aim of the research is to establish the impact of restructuring and staff reduction on the quality management function and to identify the inhibiting factors that impact the successful implementation of quality management and recommend corrective measures so that the desired quality deliverables are achieved.

1.4.3 Specific Research Objectives

The specific research objectives include:

1. Study the current quality management system and compare to requirements identified in literature.

2. Study the current organization culture towards quality management systems and compare against quality management system requirements as provided in the literature study.
3. Compile a quality improvement plan proposal to assist in closing quality management gaps.

1.5 Layout of the Dissertation:

Chapter 2: Literature Study

The literature study will involve identifying research and scholarly sources. This will establish how quality management is implemented in other companies.

Chapter 3: Experimental Design

Qualitative and quantitative data analysis methods will be used as a data capturing system. It will be detailed how these methods were selected and used.

Chapter 4: Presentation and Discussion of Results

The results of study and the accompanying discussion are presented in this chapter. The analysis of the data obtained from the study is presented, followed by the discussion and interpretation of the data and concludes with the verification of results.

Chapter 5: Conclusions and Recommendations

The results of the research will be discussed and presented. The interpretation of the experimental design will be discussed and how the data and results will be verified.

2. LITERATURE STUDY

2.1 Introduction

The literature approach was to study in detail available literature on the quality management system subject from external scholarly sources and international standards. The organization for the case study as referred to in “A management plan for mitigating and allocating quality management systems within an organization; Sasol as a case study” was used as additional resource to investigate existing systems and specifications within the organization. It was done to investigate different models, definitions and fundamental principles that are used in the current industry as of 2016.

The second part of the literature study will focus on the case study literature. This section will focus what the organisation’s current QMS system looks like and where the company envisions the company to be regarding quality management.

The case study and quality management literature will then be investigated for similarities and differences in the quality management process. As the researcher was employed by the organization, the case study was made available for review on any findings. The literature study on both the quality management as well as case study was then used to execute the experimental design, results and recommendations.

2.2 Quality Management Literature

2.2.1 The history of quality

The history of quality can be traced across the ages and there are many instances in history where quality have been prioritized for construction of great achievement. This can be traced back to the construction of the pyramids in 2584 BC where the construction was so precise and professionally done there should have been some sort of quality management system used to achieve this marvel. Hieroglyphics have been found in the pyramids showing inspectors of workmanship and show that there was quality assurance and control. The quality timeline is attached in figure 1.

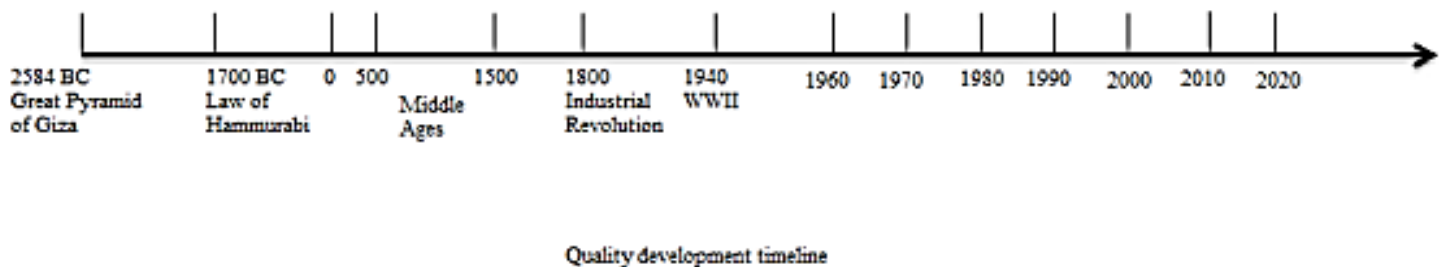


Figure 1: Quality Timeline (Edvardsson, 1999)

It can also be traced back to legal systems as with Law of Hammurabi in 1700 BC that implemented building laws where it stated that if the owner of a building was killed due to the builder's workmanship, the builder will be executed and also if one of the owners of the building's children were killed due to workmanship one of the builder's children will be killed. This may seem like a very cruel way of implementing quality in the modern ages, but this brought in an era where quality and workmanship was taken very seriously and showed that product and labour liability was of great importance. During this period, there was also a focus on legislation regarding labour wages, agreements and transaction between parties (Edvardsson, 1999).

Before the middle ages < 500AC the Roman and Greek empires made great contributions towards the modern approach to quality. During these times the Roman Empire focused on how to approach construction in a structured way and gave birth to the Colosseum that is still till today a marvel of its time. The Greek empire focused on the development of justice and authority systems that focussed on accountability and ownership. There is a clear focus on quality during this period of the Greek and Roman empires (Edvardsson, 1999).

During the Middle Ages, 500 to 1500 AC, there was a big focus on craftsmanship that included metal, steel and leather. Guilds were formed that consisted of groups of craftsmen that governed the manufacture and quality of their trades. There were levels of authority in these structures where the most highly skilled craftsman was the master craftsman and the learner the apprentice and this relationship insured that the apprentice was taught the skills to manufacture and assure quality of the trade (Evans, 2007).

During 1800AC the industrial revolution was born. This was an important era for the development of quality management. The concept of interchangeable parts between different machines and inventions were developed. The concept was originally founded in France by a gunsmith, Honore Le Blanc, and worked very successfully and later implemented in America and was not successful due to too much variation between different parts (Evans, J., 2008).

During 1900 AC, Frederick Taylor developed a new manufacturing and management philosophy that was called Taylorism and focused on improving production without additional employees. The idea around this was to separate the planning and production function and let the engineering function focus on planning and development and the craftsmen be responsible for manufacturing and quality control. During the development, quality assurance was also later separated from the manufacturing function and was handled by another group of specialists. The introduction of the first assembly line was introduced by Ford that split the craftsman into different work stations during the manufacturing process (Evans, 2007).

During 1940 AC, the Second World War required that guns and ammunition to be reliable and be of the same quality. The United States Army required the suppliers of weapons to use SPC as quality assurance method that involved active monitoring and control of processes through statistical methods that ensured that the process operates at full potential. During the war, the US Army created the requirement which

all the suppliers had to meet. The MIL-STD was the first standard that was widely used (Evans, 2007).

Three organizations were founded in 1946 that led to the revolution in focus on safety:

- American Society for Quality Control
- International Organization for Standardization
- Japanese Union for Scientist and Engineering

American Society for Quality was founded in the end of the Second World War when US experts wanted to pursue ways to continue improving quality (ASQ, American Society for Quality, 2017).

The international organization of standardization was founded in London. This was done by the gathering of 25 countries and served as the standard to standardize quality and to facilitate the international coordination and unification of industrial standards across the world.

During the 1950s, the consumer-based era was born. It started in America and the focus was quantity over quality and was fuelled by the high demand over consumer products. Japan had another approach and focused on quality over quantity. This led to quality declining in America and improvement in quality in Japan.

During the 1960s, there was a big focus on quality and there was a big drive to learn about the usage of statistical methods in manufacturing in Japan. There was a drive to create quality tools and the focus was to make it as simple as possible for employees to be able to use them.

During the 1970s, there was an era where America realized that the quality of their products was not in line with that of Japan. Philip Crosby greatly influenced the way that efficiency, reliability and then profitability is approached (ASQ, American Society for Quality, 2017).

During the 1990s, there was a focus on multiple quality initiatives. Six Sigma was developed that focused on lowering failure rates of products and was developed by General Electric. Lean manufacturing was also developed and that focused on reducing waste in manufacturing and was developed by Toyota.

2.2.2 Introduction

Quality has become more important over the last decades as mass manufacturing of goods and services have become a modern standard and more companies have shown its dedication to high quality standards. The competitive environment companies are facing have forced companies to turn their attention to quality.

Currently used quality management systems include ISO standard, Lean Production, Six Sigma and TQM. The concepts of quality management principles between the different models are similar but with different supporting principles, emphasis, focus area, implementation tools and methodologies

The quality management literature study review examines the quality management systems. Currently there are publications by the ISO that focus on the fundamental principles, approach and requirements for a quality management system. The quality management literature study focuses on ISO 9000 series its principles, implementation and requirements.

It can be determined that Six Sigma and Lean manufacturing are efficiency driven methodologies. According to Rational Efficiency, “the more organizations adopt an innovation, the more knowledge about the innovation’s true efficiency is disseminated” (Abrahamson, 1990). The quality management methodologies originated in the 1980s but were only effectively implemented by more companies in the mid-1990s. General electric adopted the Six Sigma methodologies to be their quality management system and integrated it to work for their requirements and optimize their processes. Lean manufacturing was developed by Toyota and has been one of the management systems that have been implemented most across various companies.

The ISO 9000 series quality management system was developed to standardize quality and create unity between processes and focuses on a formal approach to managing quality in companies. Certification to international organizations for standardization is only given after fulfilment of all the quality requirements as per their requirements. This gives companies the backup to show their competitors and customer base that they subscribe to a formal quality management system. The purpose of the quality management system was to make it easier for companies to approach quality in a more formal and systematic way. It has become a common practice for companies to be forced to adapt ISO 9000 accreditation by its customers to prove that their quality of the product is of an acceptable standard. This type of approach is not sensible because real quality comes within a company and there must be a desire to make quality an important aspect of the company’s values.

The quality management literature study also focuses on the relationship between Lean Production, Six Sigma, TQM and ISO 9000 QMS certification and implementation requirements and also the relationship between implementation and organization performance.

2.2.3 Quality Management Systems

“For having a good quality product, an organization not only needs to have a good quality process but also a good quality management system” (Ahmed S, 2003).

QMS is a formal system that includes documenting the structure, responsibilities and processes required to achieve effective quality management. In addition, quality management is defined by the American Society for Quality as follows: “The application of a quality management system in managing a process to achieve maximum customer satisfaction at the lowest overall cost to the organization while continuing to improve the process” (ASQ, American Society for Quality, 2016).

The quality management system definition is the management system that improves and manages the quality of services and products. Quality systems are comprised out of basic inspections in the beginning and have progressed over years of development

of these systems to QA and from that point to total quality management systems. The three fundamental principles of total quality management include:

- Continuous improvement of systems
- Customer focus and delivery
- Management directed employee engagement

“In order to implement total quality management successfully, organizations must use a set of practices and techniques to support the three fundamental principles” (Evans, 2007).

2.2.4 QMS ISO 9000 and Principles

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. 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 (International Organization for Standards, 2005).

The QMPs can be used as a foundation to guide an organization’s performance improvement as can be seen in figure 2.

The seven QMPs are:

1. Customer focus
2. Leadership
3. Engagement of people
4. Process approach
5. Improvement
6. Evidence-based decision making
7. Relationship management



Figure 2. Seven Quality Management Principles (International Organization for Standards, 2005)

2.2.4.1 Customer focus

Customer specification and requirements have to meet and there should always be a drive to exceed the customer expectations. If a customer's confidence is met and retained, sustained success is achieved. Value is added with continued customer interaction and understanding future requirements. The benefit of this is increased customer value, satisfaction, revenue and loyalty. It greatly enhances repeated business and reputation. Ultimately, this will expand your customer base.

Customer focus is met by recognizing that direct and indirect receive value from the organization. By linking organisational objectives to the customer expectation and needs you have better alignment to desired results. Communication is very important and by emphasizing the customer need, the company has a better focus point. Planning, design development, production, delivery and support enhances the customer satisfaction. It is also very important that relationships have to be actively management between the organization and customer (International Organization for Standards, 2005).

2.2.4.2 Leadership

Purpose and direction within the organization is very important and leaders and managers have to establish unity with its people. By doing this, organizations will be better equipped to achieve the organization objectives.

Alignment of policies, processes and strategies to achieve organization objectives is very important and it greatly increases efficiency in quality objectives. The organization enhances the coordination between levels and functions, which improves the capability of the organization to deliver desired results.

The organization should communicate the vision, mission, strategies, processes and policies throughout the organization. The organization should create and sustain shared values at all levels of the organization. A culture of trust and integrity should be established within the organization. A commitment of quality should be encouraged throughout the organization accountability should be given to the organization with a positive attitude from leadership. There should be strived to inspire and recognize the people within the organization (International Organization for Standards, 2005).

2.2.4.3 Engagement of people

Throughout all levels of the organization, people should be empowered and engaged to increase the capability for service delivery. People should be respected as individuals at all levels of the organization. Through constant recognition and empowerment, the organization enhances its position to achieve quality objectives. This will improve the understanding and perception of the organization's objectives. Enhancement of people's activities, personal development, creativity, satisfaction, trust and collaboration is achieved.

It is very important to keep constant communication to promote understanding and collaboration throughout the organization. Open discussions and knowledge sharing should be engaged in the organization. The constraints that deter performance should be identified and mitigated. Constant acknowledgement of people's improvement and contribution enhances organization capability. Surveys should be conducted to determine satisfaction within the organization (International Organization for Standards, 2005).

2.2.4.4 Process approach

Processes that function in a coherent system give predictable and sustained consistency in the organization. Interrelated systems and processes are part of the quality management system and optimization in the organization is achieved by understanding how results are produced.

This approach gives the enhanced capability for key processes to be focused on and gives much more predictable results because of alignment in the system. Effective process management gives optimized performance and effectively engaged resources for processes.

Objectives should be defined while giving accountability, responsibility and authority. Resource constraints should be identified and how interdependent systems interact to create the system as a whole, if interrelations between functions are managed as a whole the organization will be effective and efficient. Empower people to improve and operate the system and evaluate the system as whole and not isolated functions.

2.2.4.5 Improvement

Success is achieved by focusing on continuous improvement. Improvement should always be encouraged and is essential for the organization to maintain performance. Where opportunities are created through reaction to internal and external changes the opportunities should be identified, and solutions should be explored.

The capabilities and performance of the organization is improved through encouragement to embrace change. Root cause Analysis focus should be enhanced to identify and eliminate problems. It puts the organization in a better position to react to sudden changes and create opportunities to use these changes to the organization advantage. This greatly enhances the drive of innovation.

Improvements in terms of objectives must be promoted. The workforce should be trained in how to apply basic tools to make improvements. Competency should be driven to improve the workforce. Processes should be implemented to improve projects. Continuous monitoring of results to allow for driving improvements in the organization. Improvements should be recognized in the organization (International Organization for Standards, 2005).

2.2.4.6 Evidence-based decision making

Data should be evaluated based on analysis, which will drive envisioned results. Multiple inputs should be interpreted and can involve complex processes. The organization should understand the relationship and impacts that decisions have on the business. Defined and correct data can have a great influence on the organization.

Process of decision-making organization performance and efficiency can be improved. Decisions can easily be improved because of good understanding of what is going on in the organization. It also makes it easy to track historic decisions.

Key indicators should be identified and tracked. The correct people should have the correct data and data distribution should be optimized. Make sure that data is reliable and accurate. Suitable methods should be used to analyse the data. Competent people should be in place to evaluate the data. It is very important to drive decisions through analysed and proven data (International Organization for Standards, 2005).

2.2.4.7 Relationship management

Supplier relationships have to be managed in an effective way. Invested parties can have an impact on the way the organization performs. Invested parties should have good working relationships and networks should be built between all parties.

Constraints of invested parties should be identified and should be consulted to improve as it has an impact on all parties. If values and vision is in line between different parties, everyone works to a common goal. A stable supply chain is created, and an increased continuous improvement is created.

Different relations should be identified and prioritized. A balance between short-term and long-term goals should be identified with each invested party. Knowledge sharing is important between different parties. There should be continuous monitoring of invested parties' performance as it makes it easy to identify constraints and bottlenecks. There should be continuous recognition between parties and achievements should be embraced (International Organization for Standards, 2005).

2.2.4.8 ISO 9000 Principles

According to ISO 9000 the International Standard provides the fundamental concepts, principles and vocabulary for quality management systems 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, in order to be able to effectively and efficiently implement a QMS and realize value from other QMS standards.

This International Standard proposes a well-defined QMS, based on a framework that integrates established fundamental concepts, principles, processes and

resources related to quality, in order to help organizations realize their objectives. It is applicable to all organizations, regardless of size, complexity or business model. Its aim is to increase an organization's awareness of its duties and commitment in fulfilling the needs and expectations of its customers and interested parties, and in achieving satisfaction with its products and services (European Committee for Standardization, 2015).

According to ISO 9000 the quality management concepts and principles described in this International Standard give the organization the capacity to meet challenges presented by an environment that is profoundly different from recent decades. The context in which an organization works today is characterized by accelerated change, globalization of markets and the emergence of knowledge as a principal resource. The impact of quality extends beyond customer satisfaction: it can also have a direct impact on the organization's reputation.

Society has become better educated and more demanding, making interested parties increasingly more influential. By providing fundamental concepts and principles to be used in the development of a QMS, this International Standard provides a way of thinking about the organization more broadly.

All concepts, principles and their interrelationships should be seen as a whole and not in isolation of each other. No individual concept or principle is more important than another. At any one time, finding the right balance in application is critical (European Committee for Standardization, 2015).

Formally planned and unplanned quality, management activities will always form part of an organization and ISO provides guidance to set up these systems successfully. Current systems have to be revised to determine if they are in line with the ISO standards. ISO 9001 and 9004 can be used to establish cohesive quality management systems.

The advantage of a QMS is that it gives a framework of planning, executing, monitoring and improving the performance of quality management activities. QMS documents have to be very simple and must capture the requirements of an organization.

QMS planning is not done through a single event but is done through a continuous process of reviewing and improving with experience in the organization. The QMP has to be continuously monitored and evaluated to see if the plan is performing to company requirements, otherwise changes have to be implemented to better steer the QMS to the desired result. Continuous audits make it possible to determine the QMS effectiveness. QMS development can lead to breakthrough in innovation and can enhance the performance of the organization.

All these principles are interlinked and forms part of the elements to implement the ISO 9000 process as can be seen in figure 3.



Figure 3 : ISO 9000 Process

2.2.5 ISO 9001

ISO 9001 specifies the requirements needed for a quality management system. It involves the planning of actions and how to address risk and opportunities; it gives you quality objectives and the means to achieve them. It also gives guidance to how changes can be planned for during further development (ISO 9001, 2015).

Guidance to support structures in terms of resource planning gives an overview of infrastructure, environmental aspects to operations. It also gives principles in competence, awareness communication and information that need to be documented.

Operational guidance regarding planning and control is very important and to be aware of what planning and control needs to be in place regarding customer communication, review and change requirements of products and services. Design and development of products and services have to be addressed during operation; this includes

planning, inputs, controls and changes. Externally provided processes for products and services also have to be addressed. Production and service provisions have to be established through control, identification, traceability, preservations, post-delivery activities and changes (ISO 9001, 2015).

Performance evaluation has to be addresses through continuous monitoring, measurement, analysis and evaluation. Up to this point, improvements can be implemented through nonconformity and corrective action and driving continuous improvement.

2.2.5.1 Process approach

According to ISO 9001, the International Standard promotes the adoption of a process approach when developing, implementing and improving the effectiveness of a quality management system, to enhance customer satisfaction by meeting customer requirements (ISO 9001, 2015).

Interrelations between systems have to be understood and managed and can contribute to organization efficiency and effectiveness for achieving the required result. Through understanding the interrelations, it can be controlled, and interdependency can be understood.

The process approach involves the systematic definition and management of processes, and their interactions, so as to achieve the intended results in accordance with the quality policy and strategic direction of the organization. Management of the processes and the system as a whole can be achieved using the PDCA cycle with an overall focus on risk-based thinking aimed at taking advantage of opportunities and preventing undesirable results (ISO 9001, 2015).

Process approach in the QMS enables:

- Consistency in understanding meeting requirements
- How processes can add value
- Efficient process performance
- Improvements of processes through quality data

Figure 4 shows the flow of processes and interrelations between each stage. Monitoring of stages that is required for control is specific to each process and will have different risks related to them.

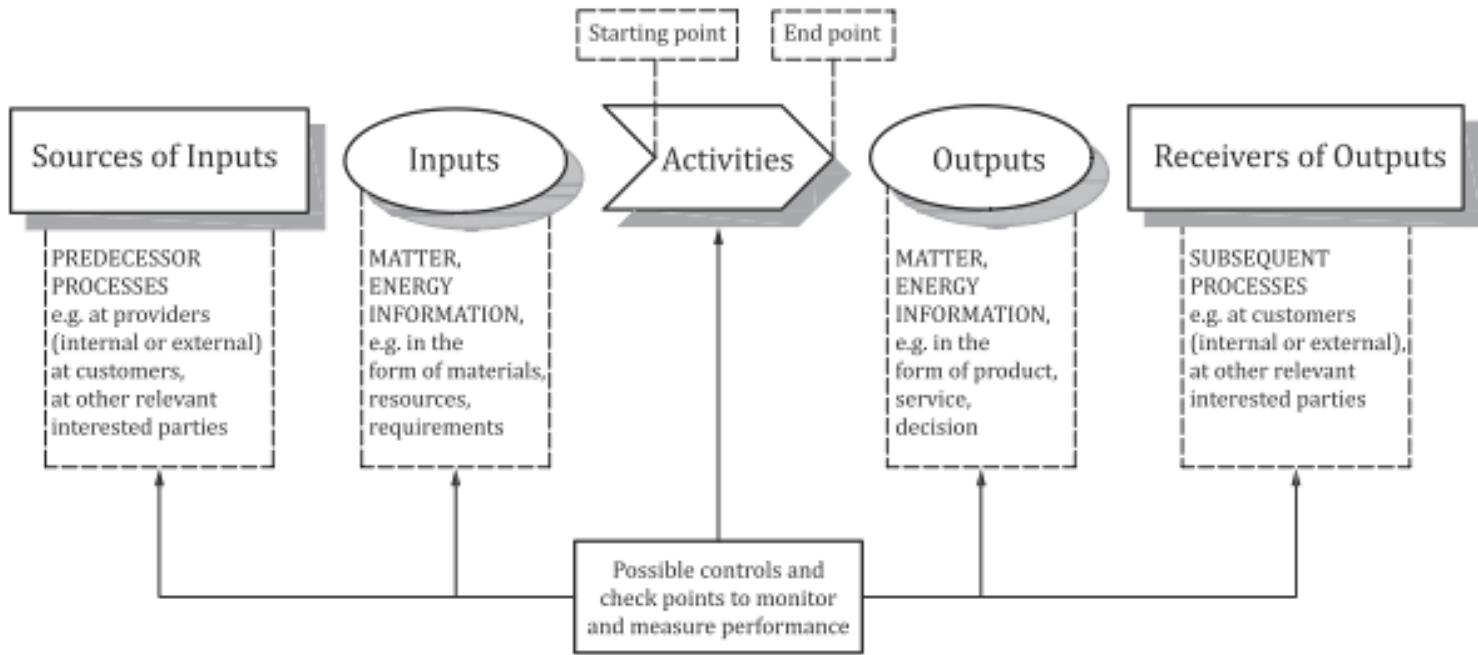


Figure 4 - Schematic representation of the elements of a single process (ISO 9001, 2015)

2.2.5.2 Plan-Do-Check-Act Cycle

For the whole quality management system, the PDCA can be applied over all processes as can be seen in figure 5.

The PDCA Cycle can be described in the following steps:

PLAN: Objectives should be established in this phase including resourcing requirements, risks and opportunities should be identified.

DO: This phase addresses the implementation of the planned phase.

CHECK: The implementation should be monitored and measured to check if implementation is successful.

ACT: The objectives are to act on any problems and improve performance.

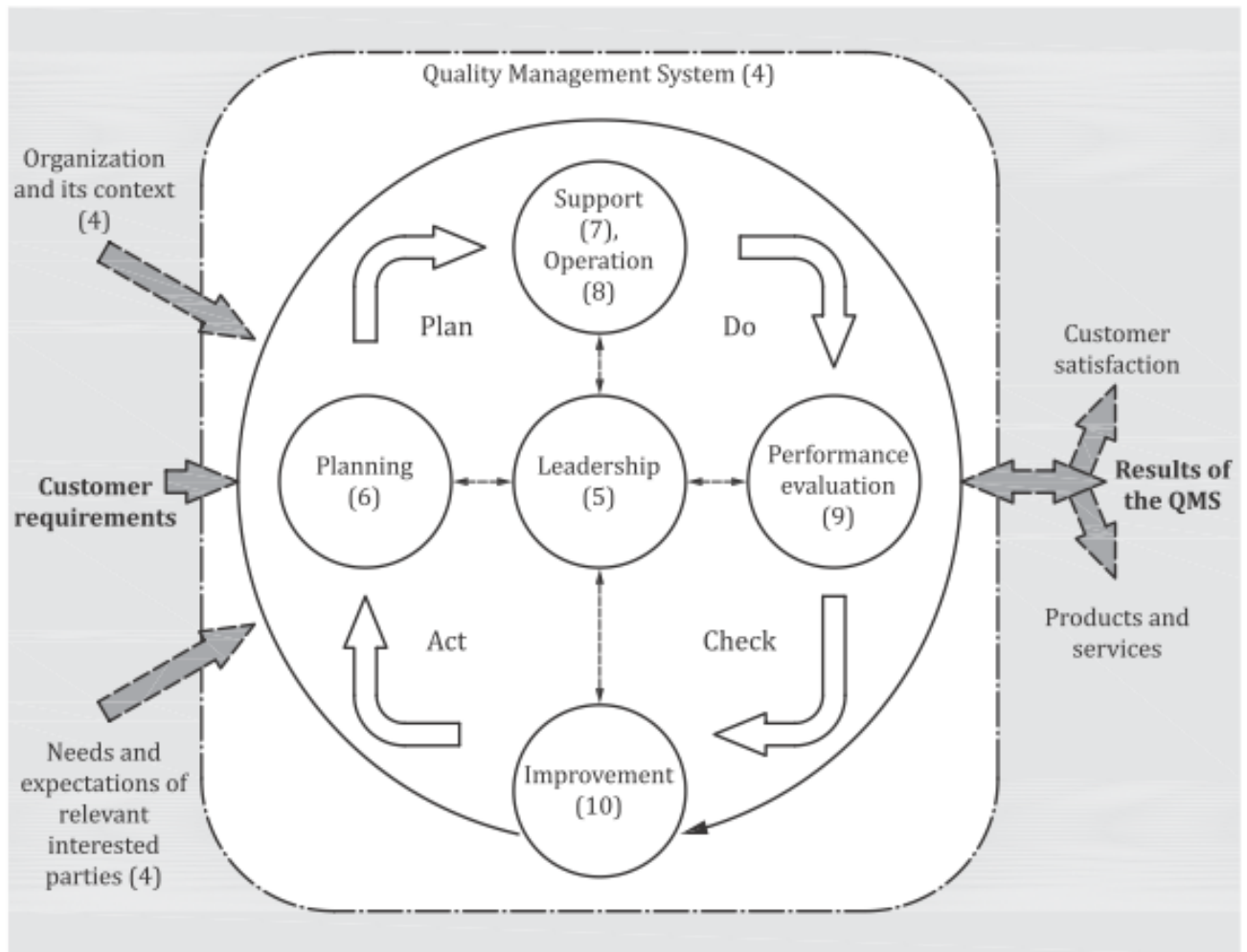


Figure 5 - PDCA Cycle (ISO 9001, 2015)

2.2.6 ISO 9004

This International Standard provides guidance to support the achievement of sustained success for any organization in a complex, demanding, and ever-changing environment, by a quality management approach.

The sustained success of an organization is achieved by its ability to meet the needs and expectations of its customers and other interested parties, over the long-term and in a balanced way. Sustained success can be achieved by the effective management of the organization, through awareness of the organization's environment, by learning, and by the appropriate application of either improvements, or innovations, or both.

This International Standard promotes self-assessment as an important tool for the review of the maturity level of the organization, covering its leadership, strategy, management system, resources and processes, to identify areas of strength and weakness and opportunities for either improvements, or innovations, or both.

This International Standard provides a wider focus on quality management than ISO 9001; it addresses the needs and expectations of all relevant interested parties and provides guidance for the systematic and continual improvement of the organization's overall performance. An extended model of a process-based quality management system incorporating the elements of ISO 9001 and ISO 9004 is given in Figure 6 (ISO 9004, 2009).

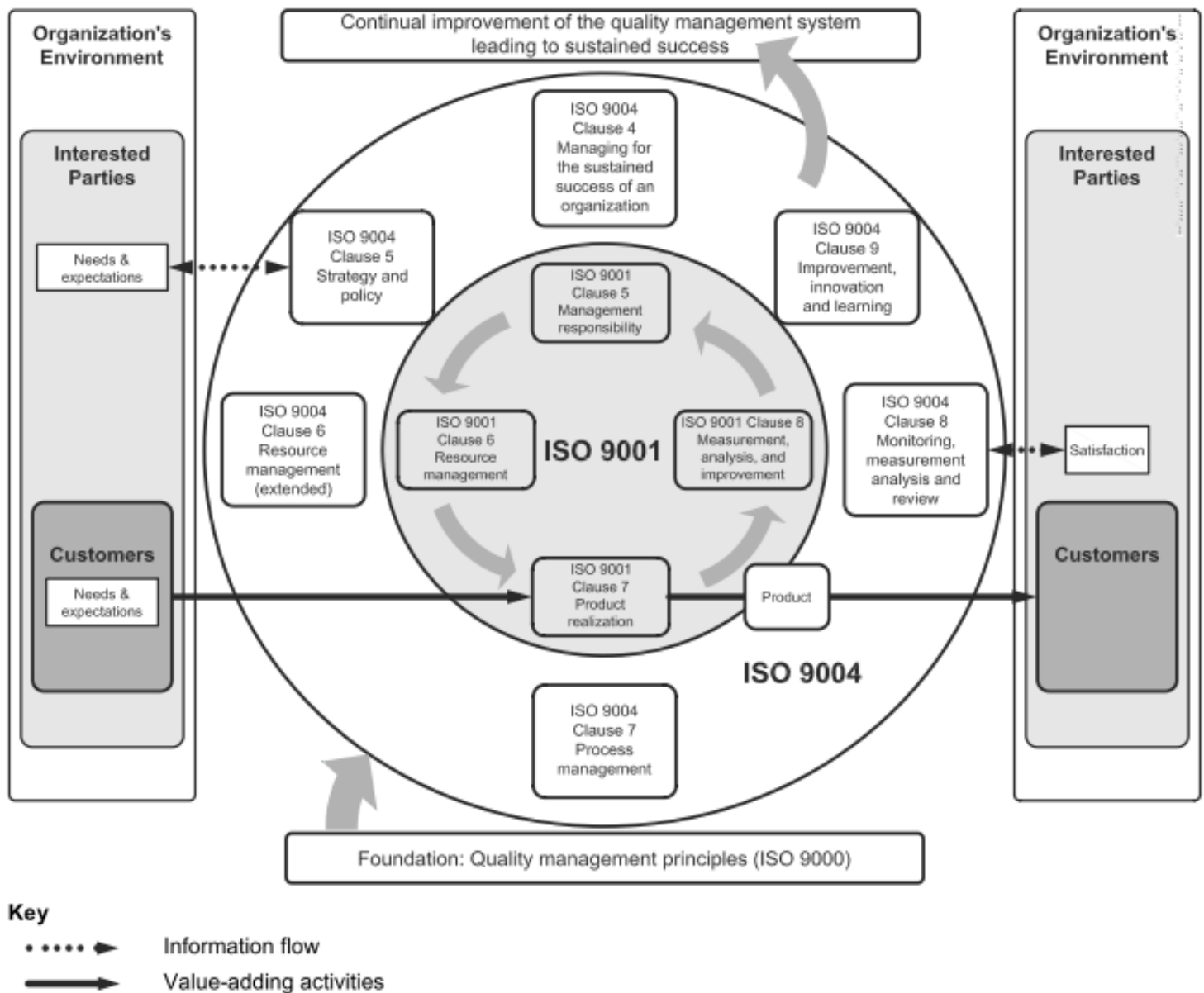


Figure 6 - Extended model of a process-based quality management system (ISO 9004, 2009)

Sustained success is achieved when top management adopts a quality management approach and it filters down into the organization. An organization's quality management approach should be based on ISO 9000 as earlier discussed in this Thesis. Success is only achieved when top management applies these principles within the

organization and this should become part of the culture of the organization. This includes the development of a quality management systems that ensures-

- Resources that are efficiently used;
- Decisions that is made on factual data; and
- Focus should be on customer satisfaction and focusing on the relevant parties' expectations and needs.

There should be a focus on the long-term and consistently meeting expectations and needs of interested parties. An organization is ever evolving with the needs and requirements of the time and top management should have the following in place (ISO 9004, 2009):

- Long-term planning perspective.
- Organization environment should be continuously monitored.
- Balance should be achieved between relevant parties' potential impact on the organization as well as needs and expectation.
- Communication is very important and relevant parties should be informed and engaged with the organization activities and plans.
- A mutual beneficial relationship should be established with suppliers and other invested parties.
- Negotiation and mediation should be used to balance the needs and expectations of invested parties.
- Risk should be continuously monitored that include long and short-term risk. Risk strategy should be continuously monitored so that impacts of expected risk are effectively handled within the organization.
- Resource management and future requirements should be managed.
- Processes should be implemented that is in line with the company strategy.
- The processes compliance should be continuously monitored and addressed.
- The organization should be encouraged to learn.
- Innovation and continuous improvement should be encouraged.

All organizations go through change continuously regardless of the size, product, activities or type, thus change should be monitored and evaluated constantly to ensure that systems are kept up to date. If this is done, the organization should be able to identify, assess and manage the risk associated with this change effectively.

Interested parties are individuals and other entities that add value to the organization, or are otherwise interested in, or affected by, the activities of the organization. Meeting the needs and expectations of interested parties contributes to the achievement of sustained success by the organization (ISO 9004, 2009).

Different invested parties have different needs and can very easily be in conflict with other invested parties and means that expectations and needs can be satisfied in many different forms as can be seen in table 1.

Table 1 - Needs and expectations (ISO 9004, 2009)

Interested party	Needs and expectations
Customers	Quality, price and delivery performance of products
Owners/shareholders	Sustained profitability Transparency
People in the organization	Good work environment Job security Recognition and reward
Suppliers and partners	Mutual benefits and continuity
Society	Environmental protection Ethical behaviour Compliance with statutory and regulatory requirements

2.2.6.1 Strategy and policy formulation

The organization's strategy and policies should be set out clearly by top management in order to get support for its mission and vision by relevant parties and because of continuous change, it should be monitored and adapted as needed. In order for an organization to be sustainable the business should have the following in order:

- The organization environment should be continuously monitored.
- Interested parties' expectations and needs should be identified.
- Process capabilities and constraints should be identified and evaluated.
- Future resources and technology should be identified.
- Strategy, processes and policies should be regularly updated according to needs.
- Determine the outputs required to meet invested parties needs and expectations.

2.2.6.2 Strategy and policy deployment

Strategy and policy implementation for sustained success is achieved through strategy and policies that have measurable objectives. Proper planning through appropriate time lines for objectives will give adequate structure and measurable milestones. Evaluation of risk and establishing counter measures will help mitigate risks. Resource planning to achieve objectives and executing these objectives effectively will ensure that deployment is done adequately.

2.2.6.3 Resource management

Internal and external resources should be identified by the organization that will make long- and short-term objectives achievable. Processes should be in place to provide, allocate, monitor, evaluate, optimize, maintain and protect those resources.

Future events should be identified, and proper resource planning should be done to avoid the possibility of shortfall in resources. This should be continuously monitored and improved through optimizing processes and technology.

External resources should also be monitored as this can cause a problem if outsourced activities cannot be met. This data should be used as input to improve the organization's strategies (ISO 9004, 2009).

2.2.6.4 Process management

Processes are adapted specific to an organization. Activities for each process should be optimized for the specific company's needs.

It is very important that the company should proactively manage these processes to ensure that the objectives are met effectively and efficiently. This can be facilitated by adopting a "process approach" that includes establishing processes, interdependencies, constraints and shared resources. Processes should be monitored continuously and improved as needed to achieve organization objectives.

Processes should be approached on a systems basis and interrelationships between processes should be identified and a systems approach to management should be achieved.

2.2.6.5 Monitoring, measurement, analysis and review

Sustained success is achieved if the organization constantly monitors, measures, analyses and reviews its performance.

Management should establish required processes for monitoring its environment by identifying the needs and expectations of relevant parties and can be achieved by:

1. Assessing strengths, weaknesses, opportunities and threats.
2. Establish if old products and offerings are adequate and improve where necessary. By determining current technologies and evaluating current markets.
3. Regulations and statutory requirements should be understood and adapted to anticipated changes and requirements.
4. Evaluating the labour market and understanding the social and economic trend on local culture.
5. Long-term natural resource planning, current process capabilities should be identified and evaluated and exploited for improvement (ISO 9004, 2009).

6. Management should assess results against processes, functions, strategies and objectives at all levels of the organization.
7. Effective decision making can be done through effective monitoring of progress and performance.
8. Key performance indicators are critical to measuring and monitoring of the organization.

These key performance indicators include risk control and assessment, information gathering through interviews and surveys.

1. Benchmarking the organization against competitors.
2. Reviewing of performance of suppliers and invested parties.

Management should analyse information through monitoring of the organization's planning of risk mitigation and eliminations. Through this, factual decision making can be done and long-term objectives and needs of relevant parties can be met. Products and activities that are value-adding can be identified and improved for existing products. New products can be identified and developed to meet requirements and needs. Long-term evolution of the company can be developed and aligned.

A systematic approach should be used by management and data collected should be reviewed and captured through monitoring the environment of the organization that includes:

1. Key performance indicator measurement.
2. Integrity of the measurements process that is assessed. Results that have been generated
3. Benchmarking in internal audits. Risk assessments that are conducted and invested party feedback.

2.2.6.6 Improvement, innovation and learning

The organization's environment, improvement, innovations and learnings can be necessary for sustained success.

Improvement, innovations and learnings can be applied to products, processes, structures, management systems, human aspects and culture, infrastructure and relationships to invested parties.

The organization should harvest a culture of improvement, innovation and learnings and can give it a fundamental efficiency and effectiveness advantage over competitors. This will enable the people within the organization to make informed decision based on factual data (ISO 9004, 2009).

2.2.7 ISO Conclusion

The International Standard Organization has integrated well-established principles and has created a standardized vocabulary and quality management principle

guideline for any organization to use. Through customer and stakeholder focus and people integration, ISO is the fundamental cornerstone to manage quality.

2.2.8 Lean Production

2.2.8.1 History

Lean manufacturing or production has been used for many years. The lean manufacturing began with Toyota production system development by Taiichi Ohno and this was after the 2nd world war. Western civilization started to adopt the lean production methodologies in the 1980s in a drive to become more competitive and efficient.

Primary implementation in early stages used Just-in-Time pull systems that used a card-based Kanban. There was also a creation of continuous improvement teams known as Kaizen teams that involved workers that identified areas of improvement in the process to reduce waste and improve efficiency of their systems.

This was driven by mass production that started in the 1940s after the 2nd world war to where there was a drive for mass customization to improve systems across the board. Figure 7 shows this timeline and evolution of the lean production system.

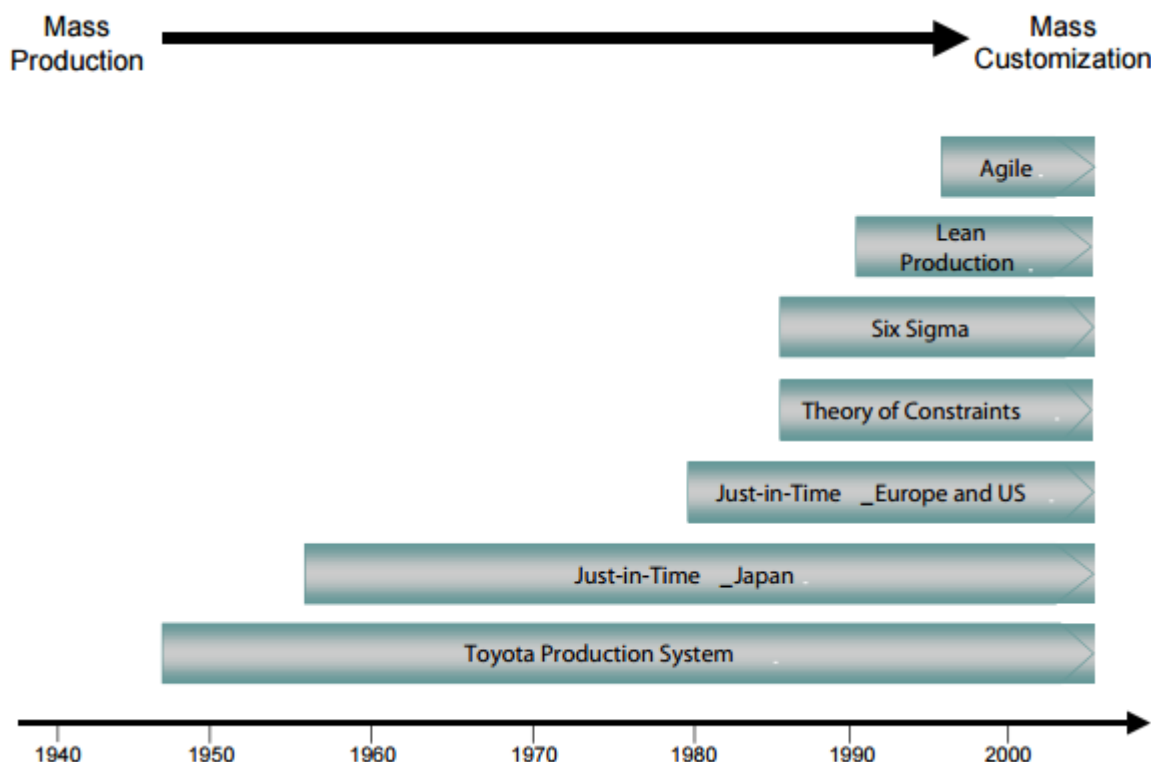


Figure 7: Lean manufacturing time line

Lean manufacturing incorporates many other manufacturing philosophies that include Toyota production system, Just-In-Time, theory of constraints, Six Sigma, lean

production and Agile manufacturing. Most of the implementation of lean manufacturing philosophy before the 1980s were concentrated in the eastern countries, the West only started focusing on these philosophies after the 1980s; this was also only concentrated in the automotive industries.

The definition of lean manufacturing is value adding activities with customer focus and the reduction and elimination of waste through systematic identification and then continued improvement of these systems.

2.2.8.2 Introduction

Lean practices improve the quality system and are compatible with ISO 9001 (Amjoran, 2013). Both lean and ISO 9001 QMS can be used inside organizations (Hammer, M, 2014). The broader goals of a company must be provided by ISO and this should then pave the way for lean manufacturing to be implemented to ensure the elimination of waste. A company should create a quality management system to standardize requirements and should not be a factor of size or sector they fall under. The lean manufacturing can identify areas where processes can be optimized and then focus to address the requirements of ISO 9001. The ISO management system provides the minimum requirements for companies to follow and Lean Manufacturing creates focus areas to identify to eliminate waste and increase productivity. Continuous improvement is one of ISO 9001 key principles and lean can guide the company to how these improvements to their systems can be achieved. The efficiency and effectiveness are different, thus the benefits of implementing QMS can vary in different companies (Leong, TK., 2014).

The word “lean” is basically created based on the Toyota Production System (Ahmad, S.A.S., 2013). It is not just a tool, it is more than that. LM concepts have been used across industries and regions to improve value chain performance of the producing units (Sharma, V., 2015). It is very important to focus on the time it takes from where the customer has placed the order to where the product is sent to the customer. Lean helps to identify the areas of improvement between these two stations to help eliminate waste and increase efficiency. This not only helps the customer with getting his product earlier but also helps the company to work more efficiently. The quality management and assurance are also very important as this ensures that the customer is satisfied and will return because of satisfaction.

Lean manufacturing and production focus on eliminating any unnecessary resources that are not required for the focus on the end product and if it is not value adding it is seen as waste, this then helps eliminate any waste and gives you more value for less work. The goals for using LM in companies are to generate less waste, less human effort, less manufacturing space, less investment in tools and less engineering to develop a new product (Anvari, A., 2011). Lean manufacturing gives you a set of tools to identify and eliminate waste in systems and is defined as anything that does not add value. Figure 8 identifies the eight wastes identified by Lean manufacturing.



Figure 7: Eight wastes identified by Lean manufacturing (solutions, n.d.)

Many companies have implemented lean management to reduce the cost of their products. Because of this there has been development of many lean management tools and techniques and as the lean manufacturing progresses, many techniques become obsolete and are replaced by newer variations and developments, this is because of constant evolution of the company as it faces different challenges in different stages of its lifetime.

There are two sides to Lean manufacturing soft lean manufacturing and hard Lean manufacturing. The critical success factors of lean manufacturing can be categorized into five sections; organization culture, strategic orientation, management system implementation process, and implementation team (Noori, 2015). For Toyota, the lean manufacturing model the SLM side is the Toyota way and the HLM side is the Toyota production system that has all the tools and techniques and the reason why many companies are not successful in implementing the lean manufacturing system and cannot be sustained is because there is large focus on the tools and techniques a company uses but not enough focus on the cultural change needed to be sustainable and successful on the lean manufacturing philosophy (Ahmad, S.A.S., 2013).

Figure 9 gives an indication of the building blocks for the lean manufacturing system and should be the main focus of the company to be successful not neglecting the cultural changes needed to make it successful.

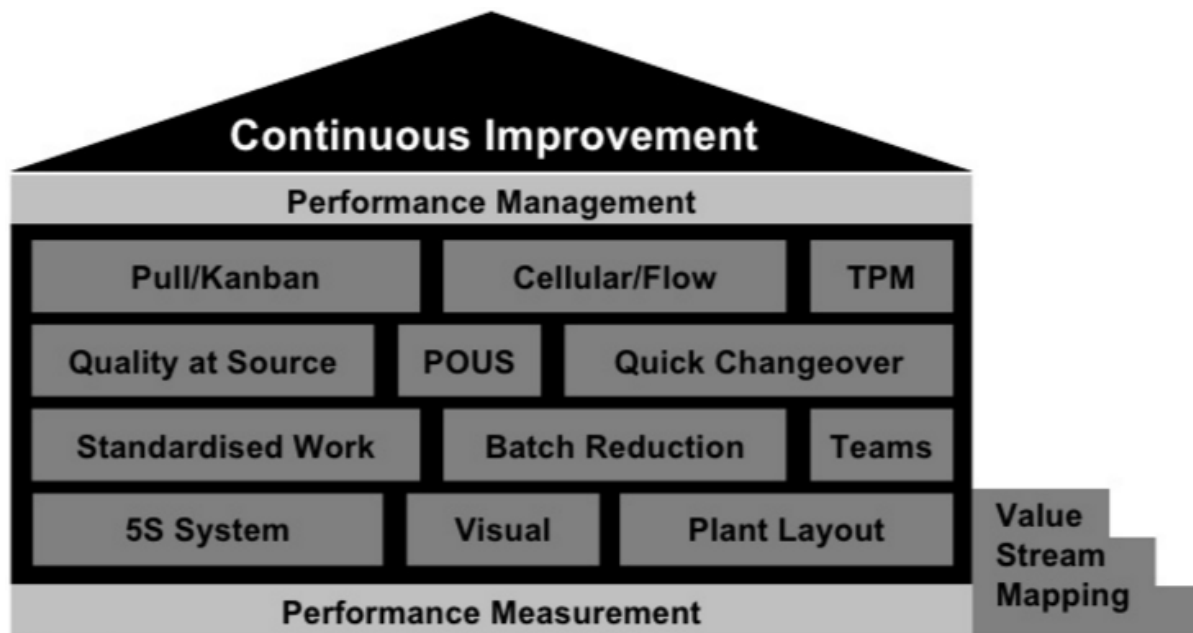


Figure 8: Lean building blocks (Subramaniam, Anand, 2016)

2.2.8.3 Value Stream Mapping

This is the visual representation of the production process, this helps to identify value adding and non-value adding processes and helps to identify which processes to eliminate. Value Stream is defined as “the set of all the specific actions Required to bring a specific product through the three critical management tasks of any business: Problem Solving, Information Management and Physical Transformation”. A mapping of all information flow and materials should be made and should indicate what activities and process should be followed to deliver the product. This map then serves as the starting point to identify where wastage can be addresses and eliminated (Subramaniam, Anand, 2016).

2.2.8.4 Point of Use Storage (POUS)

The lean process requires that all materials be transferred directly from the vendor to the point where it is used in the assembly process. This indicates the point of storage. It is critical that material be stored at the work station. Inventory tracking can be achieved by any visual tool such as cards or record boards.

2.2.8.5 Total Productive Maintenance (TPM)

Total productive maintenance refers to high performance of equipment and is achieved by constant and efficient maintenance to ensure equipment reliability and ensures that there are minimal equipment failures in the process. Preventative and proactive maintenance is very important and includes the buy-in of operators, engineering support, equipment suppliers and supporting personnel. In this way

breakdowns are eliminated that causes unplanned downtime that improves higher throughput (Subramaniam, Anand, 2016).

2.2.8.6 5S system

The 5S system is key for keeping a visual workplace, it is a great system for improving processes and can be applied in various areas of the map to ensure that optimization of the system is achieved and continuously improved. Figure 10 gives the life cycle of the five-s system (BMS & Best machine shop, 2006).

The 5S steps:

- Sort (to eliminate useless items)
- Shine (to keep workplace clean)
- Set in order (to keep everything in place)
- Standardize (keep everything the same)
- Sustain (to assure continuity)

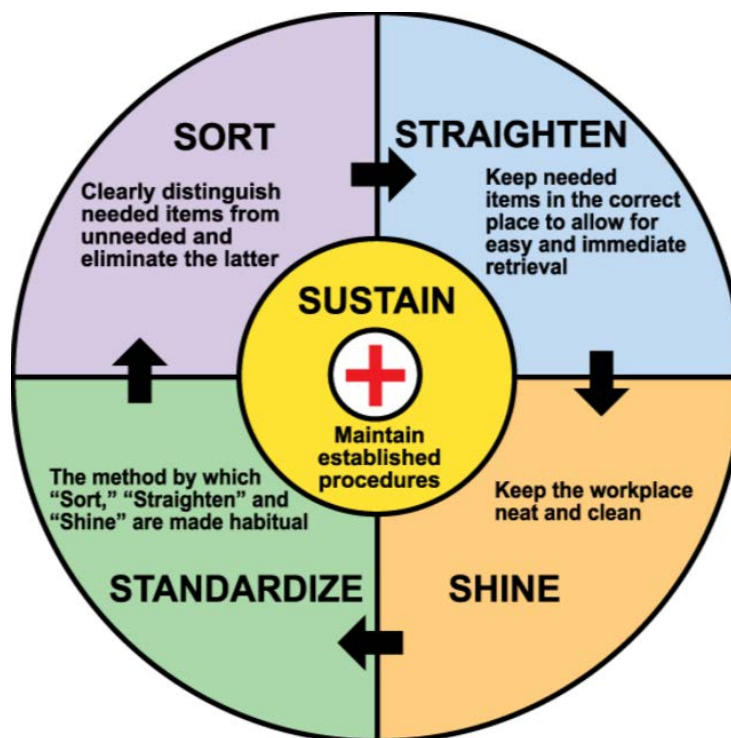


Figure 9: 5S system (BMS & Best machine shop, 2006)

2.2.8.7 Standardized work

It is important that operators do processes the same work and it eliminates the constant supervision of supervisors. The value of this is that process is monitored and measured, and the most efficient process is followed.

2.2.8.8 Kanban

To control inventory, the Kanban system was created as part of the lean manufacturing system and control the production and supply of parts for the process. The information of the current process and information for the next process is stated and improves the response to changes and makes it quicker, which achieves better coordination between different processes. Kanban is a sub-system of the Toyota Production System, which was created to control inventory levels, the production and supply of components, and in some cases, raw material (Lage Junior, 2010).

2.2.8.9 Cellular/Flow

One-Piece Flow refers to the concept of moving one part at a time between operations within a cell. One-piece flow production system considers factors such as sequencing, setup time and make-to-order policy. Thus, consideration is given to the factors encountered during scheduling of production (Sundar, R., 2014).

2.2.8.10 Quick changeover

Single minute exchange means that the setup changeover is reduced to minimum time. This helps manufacturing with reduction of inventory and makes the system more responsive to change. It also contributes establish the fast turnover for identifying non-value adding processes and elimination that reducing waiting time and ultimately reduction of cost of the product (Lage Junior, 2010).

2.2.8.11 Quality at source

“Poka-yoke” is a Japanese term that means preventing mistakes. This methodology is where processes are developed to correct mistakes early on in the process. This aid in costly rework in correcting mistakes later in the production process. There are 3 primary methods that are used and include contract, counting and motion sequence. This is where an early warning system is utilized, and each method has its own system of identifying mistakes (Sundar, R., 2014).

2.2.8.12 Plant layout

It is very important to have the optimized plant layout and workstations, this means that traveling time between different processes are eliminated resulting in high efficiency of processes. It can be as simple as a workstation that is correctly places and each item is in the correct position for the next component.

2.2.8.13 Batch reduction

Large batches should be eliminated through building multiple items on the same production line. This reduces pressure on upstream processes and improves inventory as well as the need for changeover of the production line. Production smoothing is the aim of levelling production. This reduces the waste and improves the efficiency of the process value chain and does not put unnecessary pressure on equipment and personnel (Sundar, R., 2014).

2.2.8.14 Visual

Through visual indication, the system is optimized as it signals information between different processes. Communication is important and should be available quickly only showing necessary information that does not overwhelm the operator and create confusion. Through visual communication, the system response time is quicker, which eliminates waste and also improves efficiency.

2.2.8.15 Teams

Throughout the production process, there are different sub-processes. It is very important to understand that these sub-sections should function as a bigger team for the operational success and that success is not achieved by a single unit but as a whole. Team interaction between different processes are very important and should be well established as this could be a major cause of confusion and waste during the process. The value chain interaction is very important but teams within sub-sections should also work well together as it can cause a bottle neck for the system as a whole (Sundar, R., 2014).

2.2.8.16 Introduction

The global market has become very competitive due to effective transportation and trade barriers that diminished. The competition between different companies has increased substantially; information and communication has become faster and effective. This forces companies to maximize the value of its product, so the customer has the satisfaction that he is getting value for his money at low cost and quality product for him to be sustainable in his market.

Total quality management is about minimizing the cost of production while giving the customer a high-quality product that is to his satisfaction. Productivity is not an indication of efficiency, but it should be measured against effectiveness. Thus, a company can be efficient in production but not effective in ensuring that it is what the customer wants.

2.2.8.17 Total Quality management model

The total quality management concept and its implementation is the critical need for the survival of industries. Figure 11 shows a very simple Total Quality management

model and shows the two main components of the Total Quality management system, Total Quality management philosophy, system and tools. It is very important that the Total Quality management philosophy be accepted by the company management. If accepted by management, there will be an effective drive to implement different tools and systems, but the philosophy should be the core.

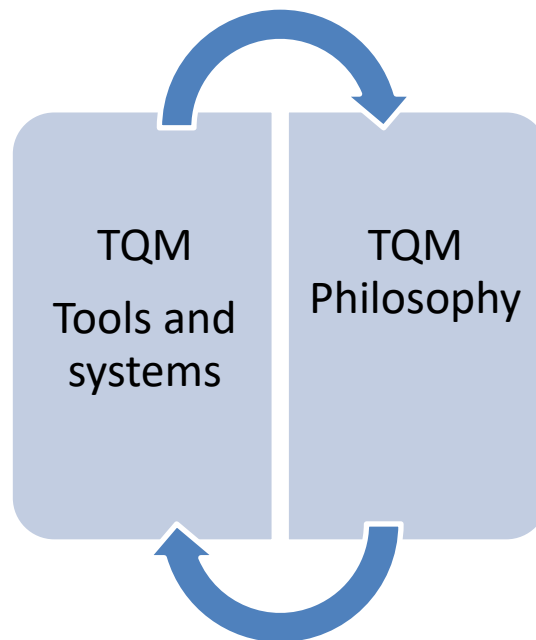


Figure 10: Total Quality management model

Total quality management philosophy is based on four principles:

- Focus on the customer
- Continuous improvement
- Benchmarking
- Employee empowerment

The Total quality management philosophy should ensure effective efficiency by enveloping systems that deliver products according to customer expectations. This ensures that companies have greater effective productivity and make them competitive in the global market. Customer satisfaction creates a sustainable advantage for the company and makes it more effective against its competition. The fast changes in technology and customer demands force companies to be proactive in their strategies to retain customer and market share. Thus, it is very important for a company have continuous improvement to insure its survival in the market.

Through continuous incremental improvements, effective productivity is enhanced, and costs are decreased, and performance is improved. Performance is enhanced through greater responsiveness, shorter cycle times for new products or services, better products, shorter throughput time and unique marketing, engineering or production strategies. Costs decline by reducing errors, defects and wastage (Marius-Dan, 2001).

By implementing total quality management, performance is improved and would result in reduction of costs, increased revenue and improve profitability. Productivity is defined as achieving higher output through lesser inputs and if the same output is achieved in a shorter time, so it is important to consider time as a resource. Total quality management should be seen as effective leadership through efficient planning and improvement of the process. Continuous improvement should be a leading focus and is an on-going process through the life of the company.

There are certain factors that can influence productivity in a negative manner and includes the following:

- Lack of buy-in of senior management
- Uncommitted middle management
- Uncommitted line management
- Poor employee communication
- Financial limitations
- Insufficient engineering support
- Incorrect programs that are implemented
- Insufficient investment in training for employees and management.
- Insufficient planning of strategies.

If total quality management programmes are implemented effectively, it can direct the company towards better quality, better customer service and satisfaction giving it the competitive edge in the market. Total quality management diverts the focus away from normal focus points like cost cutting and redirect the focus to effective use of resources. If continuous improvement is a main focus point, it will stimulate creativity in the company that will drive effective use of resources (Marius-Dan, 2001).

Quality is determined through an effectiveness of productivity improvement program and there should be clear, pre-established quality objectives before productivity improvement programmes are initiated. It is very important that effective communication between top- and middle-management is achieved down to the employees and will reinforce the commitment to programmes through clear objectives and buy-in.

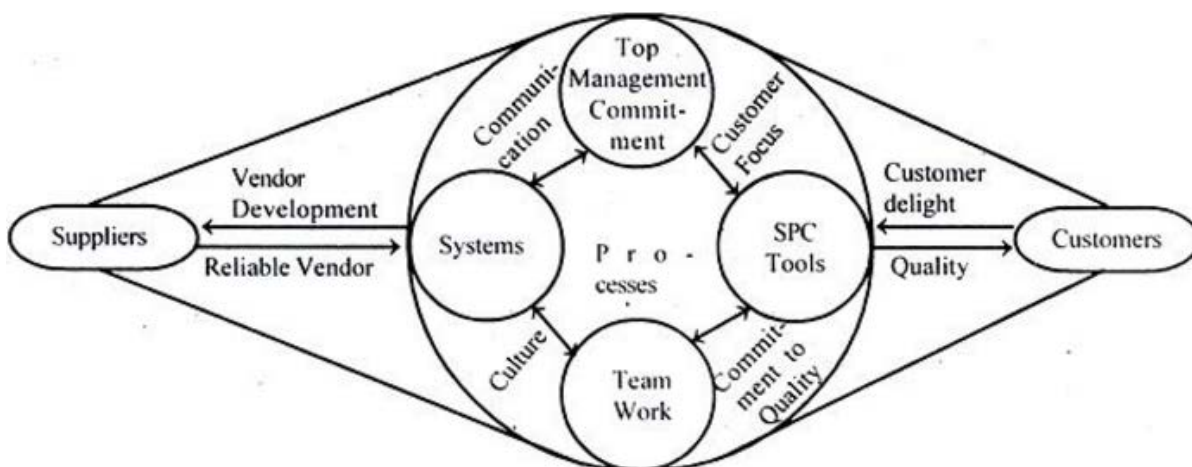


Figure 11: Total quality management model (Transtutors, n.d.)

Figure 11 shows the relationship between different interfaces in a company where it essentially begins with the supplier, processed by the company and delivered to the customer. Suppliers should be developed by the company to ensure that they deliver quality resources that are reliable. Top management commitment and communication ensures that effective systems and tools are available to the employee that reinforces a culture of commitment towards quality product towards the customer that ensures customer satisfaction as can be seen in figure 12.

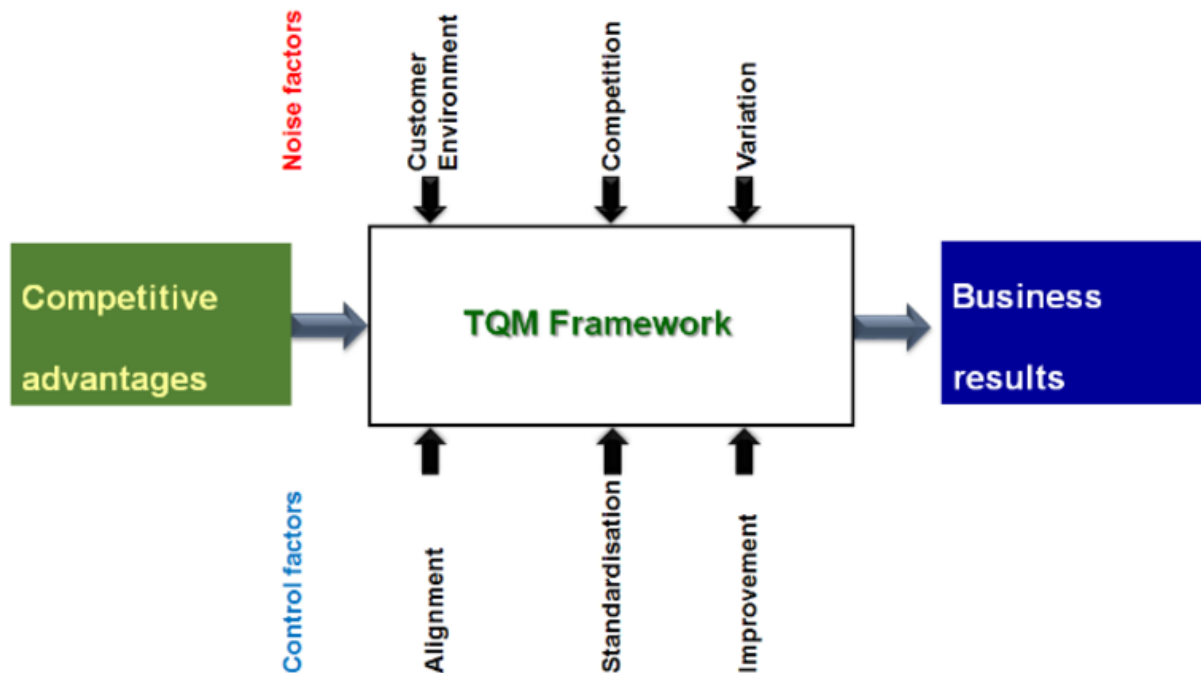


Figure 12: TQM Framework (Kotwal, n.d.)

The TQM Framework should be clearly defined and should start at competitive advantage through control factors such as alignment, standardization and continuous improvement, taking into account external factors such as customer environment, competition and variation leading to clear business results.

Constraint management is very important to manage and is continuously improvement on the system level. Productivity is improved by focusing on improving bottlenecks in the system. Productivity is determined by how effectively resources are managed to produce the product. This can be defined as producing more with the same amount of available resources or producing the same with fewer resources.

The bottleneck in the system is defined as a resource that constrains the maximum output of the process. The focus on improving operations and expecting better productivity will give undesirable results; the focus should be on improving productivity through improving or eliminating bottlenecks in the system. It is a continuous process as bottlenecks are improved or eliminated and process become faster another production limitation is developed becoming the new bottleneck. The bottleneck will then have to be improved to increase further productivity.

Constraint management should be seen as a linear flow of dependant function that includes setting clear goals in collecting data to find constraints and then focussing on reducing volume losses and waste (Shahram T, 2006).

Total quality management creates a proactive culture opposed to a reactive culture that focus on customer satisfaction through continuous improvement and quality. The involvement and alignment of every employee in the company from top management down to employee level should be well structured to ensure consistency.

If lean management, total quality management and constraint management is effectively managed it can improve efficiency, productivity and quality. This can have a great beneficial impact through:

- Reducing production inventory with a pull-based system from high performing supplier.
- Increase yield and reduce waste in the system.
- Enabling employees to continuously improve the process.
- Quick decision making and problem solving.
- Driving business changes through constant benchmarking.

Creating the right tools and systems in an organization can optimize quality and improve resilience in the global market.

2.2.9 Six Sigma

2.2.9.1 History

Six Sigma is a methodology that focuses on the optimization of processes, problem solving and cultural changes cannot be accurately defined because it uses so many different techniques. It uses a set of complex and an extensive set of tools that use advanced statistical and mathematical tools that can produce quick and effective results. The correct and effective implementation of this methodology can have a significant impact on cultural change within organizations as it makes it more effective and efficient.

The roots of sigma as a measurement standard goes back to Carl Fredrick Gauss (1777-1855), who introduced the concept of the normal curve or distribution. Walter Shewhart introduced three sigma's as a measurement of output variation in 1922 and stated that process intervention was needed when the output went beyond this limit (Raisinghani, 2005).

Six Sigma was developed in the 1980s by Motorola for manufacturing optimization. Motorola realized that they were losing a big share of their market due to quality issues. It included defective parts and reliability of its products in the market. They lost 2600 parts per million due to productivity and quality non-conformance. Bob Galvin, the chairman of Motorola at that time, introduced intense efforts to address these issues and Bill Smith, an engineer at that time, measured a quality level corresponding to a failure rate of two part per million and implemented the standard. Through this process

the Six Sigma was developed through comprehensive tools and techniques with a systematic approach that is the methodology today (Raisinghani, 2005).

2.2.9.2 Introduction

The Greek letter σ is known as Sigma and is used in statistical mathematics to show standard deviation from population. The term Six Sigma then refers to 6σ , which shows reference to a six-standard deviation from the population/customer specification. This gives a statistical 3.4 defects per million. Six Sigma can then be seen as a very close standard to perfection in the quality, as can be seen in Table 2 (Watson G.H. , 2005).

Table 2: Sigma performance scale (Watson G.H. , 2005)

Sigma Performance Level	Defects per Million Opportunities	Process Yield	Estimated Cost or Poor Quality (% Revenue)
1.0 σ	670 000	33%	>40%
2.0 σ	308 537	69.2%	30-40%
3.0 σ	66 807	93.32	20-30%
4.0 σ	6 210	99.38%	15-20%
5.0 σ	233	99.9767%	10-15%
6.0 σ	3.4	99.99966%	<10%

Six Sigma can be seen as a tool to improve business performance by removing errors in the system to minimize defects. The approach is to focus on the outputs that are most critical and then prioritizing the inputs that affect those outputs. This can then influence to improve the cost, yield and lead time of a product that leads to customer satisfaction (Watson G.H. , 2005).

Six Sigma project teams are developed that consists of multiple project members with specific functions, they are well trained and certified for their specific field.

The implementation of Six Sigma can be disruptive to an organization at first; this is because it needs constant attention, is resource intensive and will need the dedication and buy-in of senior management and because the active management resource allocation and project intensiveness can be neglected that makes the system fail. It is

training intensive and requires employees to be dedicated to the implementation of the methodologies and tools.

The Six Sigma approach requires intense activities and projects that develop into breakthrough goals that effect the whole organization. The Six Sigma methodologies include as can be seen in figure 13:

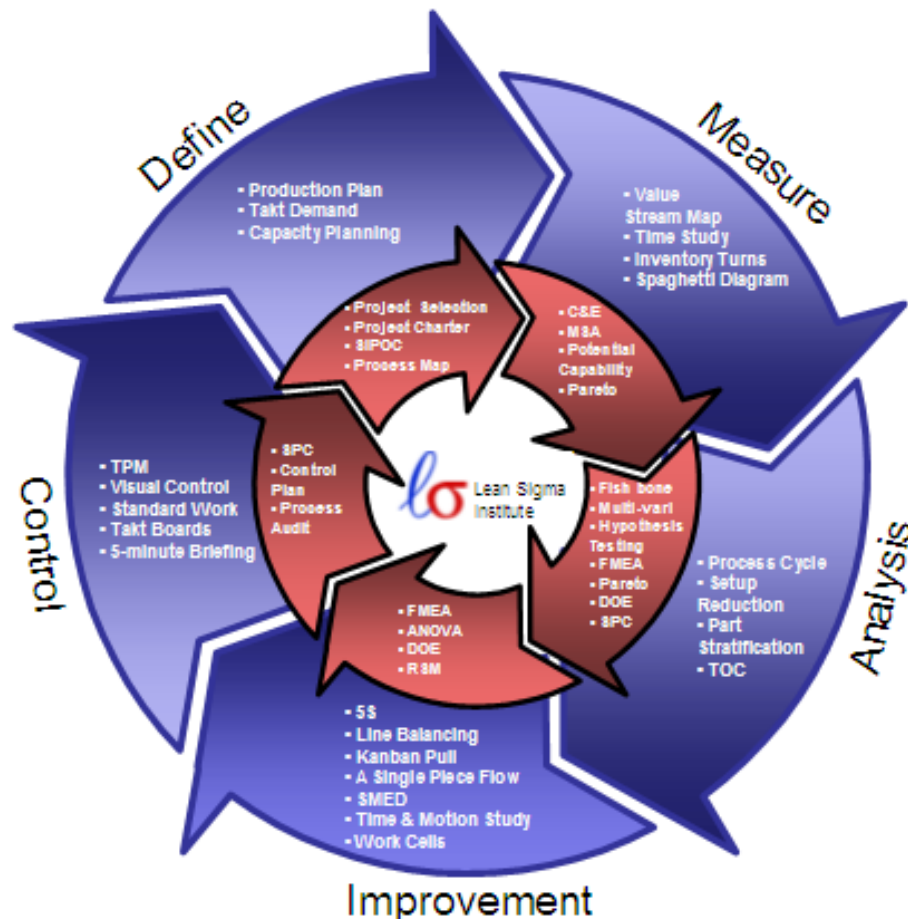


Figure 13: Six Sigma (intitute, n.d.)

2.2.9.3 Six Sigma methodologies

The define, measure, analyse, improve and control (DMAIC) problem solving technique is defined in five steps. This is a step by step logical process flow that captures the critical improvement areas that is converted in mathematical statistical that are defined, measured, analysed, improved and controlled (G.H, Watson, 2004).

2.2.9.3.1 Define

The first step of DMAIC is the identification of the problem. It is defined as a problem that can be a process bottleneck, product failure and inefficiency in the process. The owner of the problem should be well defined so that a clear objective can be determined. There should be a well-defined project scope as well as dedicated resources for the project allocated. This can then set a well-defined cost and potential cost saving for the project. A project charter is developed to clearly define the roles and responsibilities of the project team. It also establishes the objectives and who the main stakeholders are. The project charter is a revolving document that is updated as the project progresses (Watson G.H. , 2005).

The most critical focus point and tools used during the define phase is:

1. **Problem statement** - A problem statement is a brief description of the issues that need to be addressed by a problem-solving team and should be presented to them (or created by them) before they try to solve a problem.
2. **Operational definitions** - An operational definition can be defined as a clear and understandable description of what is to be observed and measured, such that different people collecting, using and interpreting data will do so consistently.
3. **Theory of constraint** - The theory of constraints is relatively easy to understand. It is a philosophy of management based on the idea that to improve a system or process one must find and address the one aspect of the system that most limits the entire process from being optimum.
4. **Process roadmap** - A plan or strategy intended to achieve a particular goal.
5. **Customer critical quality characteristics** - Critical to quality trees help you translate broad customer needs into specific, actionable, measurable performance requirements. You can then use these requirements to deliver high quality products and services.
6. **Suppliers, inputs, process, outputs, and customers (SIPOC)** - A SIPOC diagram is a tool used by a team to identify all relevant elements of a process improvement project before work begins. It helps define a complex project that may not be well scoped.

2.2.9.3.2 Measure

The Measure phase begins after the project has been defined. It is important to identify the processes that are related to the problem; then the process flowchart, measurement system, Data collection plan and Feedback (communication) system is developed. The process is then sub divided between different logical models that provide a holistic and quantitative understanding of the process. Through the data collection the evaluation and measurement of the process can start through reasonable data analysis (G.H, Watson, 2004).

Process performance information is very important for the purpose of evaluation and reliable accurate data should be gathered to get the best interpretation of the process. The project team may need to set up a new measurement system as it is very likely that data needed was not gathered or not accurate enough prior to the project (George L., 2002).

The data can then show the focus areas that have to be focused and that can give the most potential for improvement of the process. This gives a very accurate analysis as the decisions made for improvement based on data rather than in accurate guessing (Watson G.H. , 2005).

The next step is through the baseline performance that is shown through the data collection through an accurate comparison will give indicators to what changes should be made for best performance. This data can then be used to identify the best areas to focus on without major capital investment. This best performance can be set up through benchmarking against competitors, historical best-known performance, or through theoretical calculation. This will give an accurate prediction of potential for improvement and project feasibility (Watson G.H. , 2005). Figure 14 shows the flowchart of the measure flowchart:

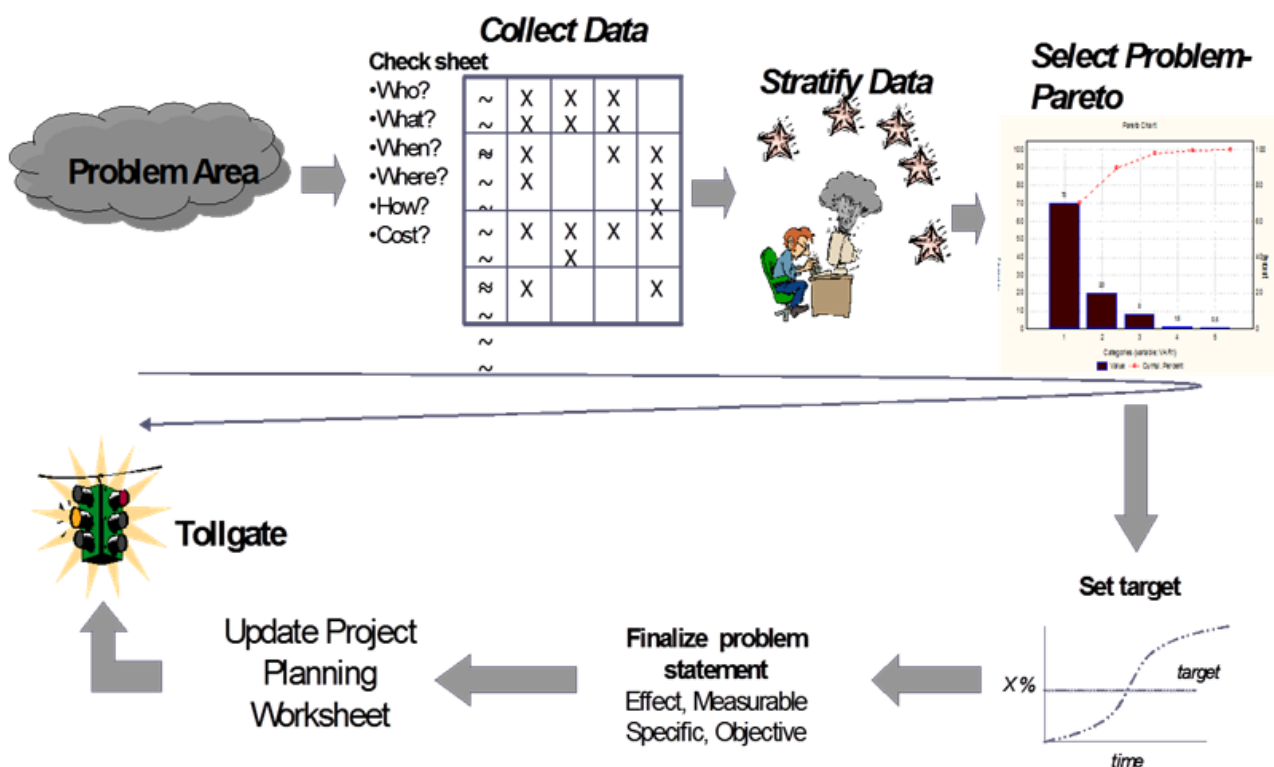


Figure 14: Six Sigma Measure flowchart (Shumula.com, The MEASURE Phase, n.d.)

The most critical focus point and tools used during the measure phase is: (Isixsigma, 2016)

1. **Process Flowchart** – This will show where the best improvement can be made, cycle time constraints and where smooth transition is not made.

2. **Data Collection Plan** - The goals, operational definitions, methodologies and objectives should be well defined. This should ensure repeatability, accuracy and stability. The data is collected through a process and interpreted.
3. **Benchmarking** – This is a stage where a comparison is made against known competitors, similar processes.
4. **Voice of the Customer Gathering** - The customer should be consulted to hear from the user point of view regarding quality and product data. This is very useful information as it gives direct input of requirements.
5. **Process Sigma Calculation** – The most important factors are to define the defects, measure the opportunities and defects, and calculate the yield.

2.2.9.3.3 Analyse

The most important step is to have the business problem well defined before going to the analyse step; this should include fully defined process and performance levels. The best controllable variable should be identified in the process during the analysing phase. This should establish a baseline for opportunities to improve on the process. This will give a known output performance that will drive the optimization of the output. Figure 15 shows the flowchart of the analysis flowchart.

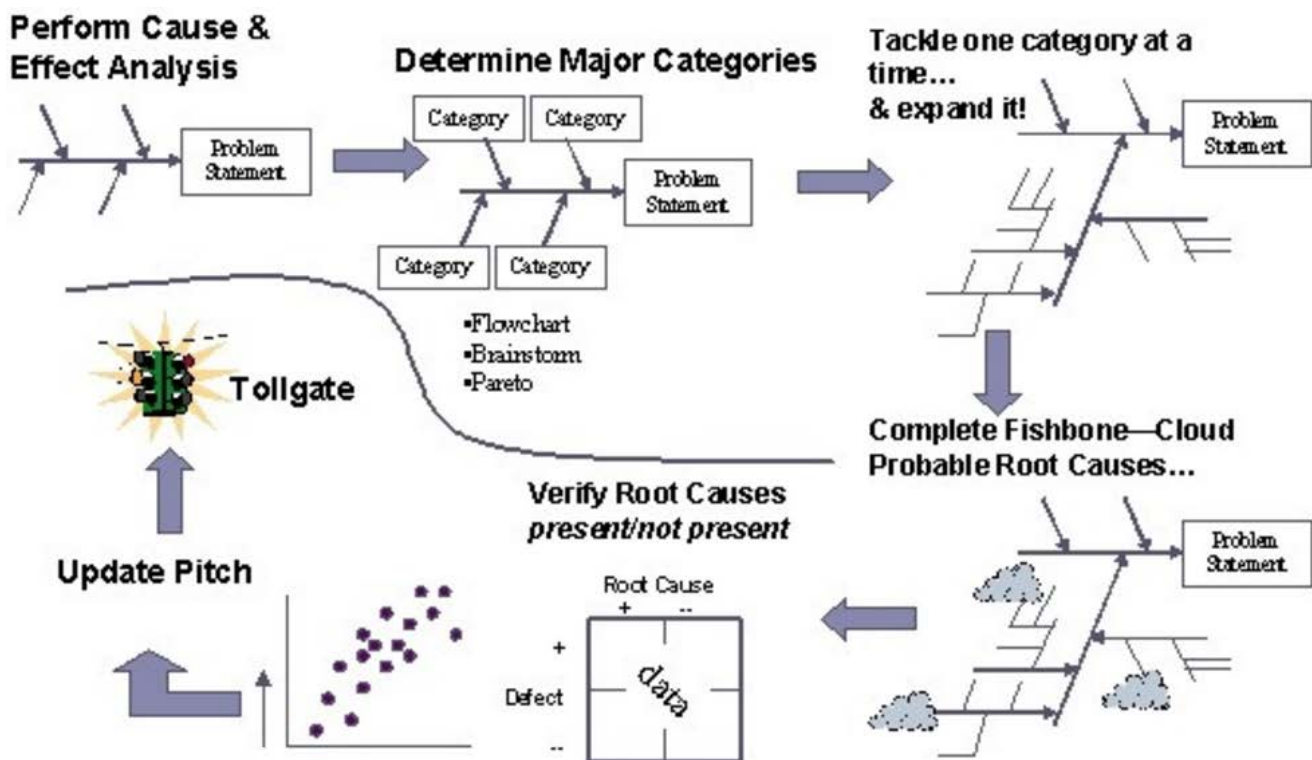


Figure 15: Six Sigma: analyse flowchart (Shumula.com, Shumula.com, n.d.)

It is critical to identify most important input that influences the output performance. Statistical analysis tools will be used to identify the sensitivity of each variation in the input that gives most variance in the output process. (George L., 2002). There should be interaction between different inputs and this can also be quantified during the

analysing process. A Pareto chart is a very helpful tool during this step and can help in the periodization of the hypothetical testing of the inputs (G.H, Watson, 2004) .

The most critical focus point and tools used during the measure phase is: (Isixsigma, 2016)

1. **Histogram** – A histogram is a relationship between frequency and response variance, this is divided into different segments with data points to establish a history between different periods.
2. **Pareto Chart** - A Pareto chart is a relationship between frequency and cumulative percentage in relation to process names, this is divided into different segments with data points to establish a history between different processes.
3. **Time Series/Run Chart** – This is a performance measure of a process over a specified period of time used to identify trends or patterns.
4. **Scatter Plot** – A graph in which the values of two variables are plotted along two axes, the pattern of the resulting points revealing any correlation present.
5. **Regression Analysis** - Statistical process for estimating the relationships among variables.
6. **Cause and Effect/Fishbone Diagram** – It is a cause and effect diagram that is a visualization tool for categorizing the potential causes of a problem in order to identify its root causes.
7. **5 Whys** - Is an iterative interrogative technique used to explore the cause-and-effect relationships underlying a particular problem.
8. **Process Map Review and Analysis** – Is an inputs, outputs and process steps that give a high-level overview of the system.
9. **Statistical Analysis** – It is the collection, exploring and presenting large amounts of data to discover underlying patterns and trends.
10. **Hypothesis Testing** – It is the theory, methods, and practice of testing a hypothesis by comparing it with the null hypothesis. The null hypothesis is only rejected if its probability falls below a predetermined significance level, in which case the hypothesis being tested is said to have that level of significance.

2.2.9.3.4 Improve

During the analysis phase the agreed focus areas have been identified. During the improvement phase, the statistical solutions are identified where it is then validated. The statistical solution can be a mean point shift or variation reduction or a combination of both these optimization patterns. There has to be an observed change in the process before validation of the resulting factor changes can be processed. Figure 16 shows the flowchart of the improve flowchart (George L., 2002).

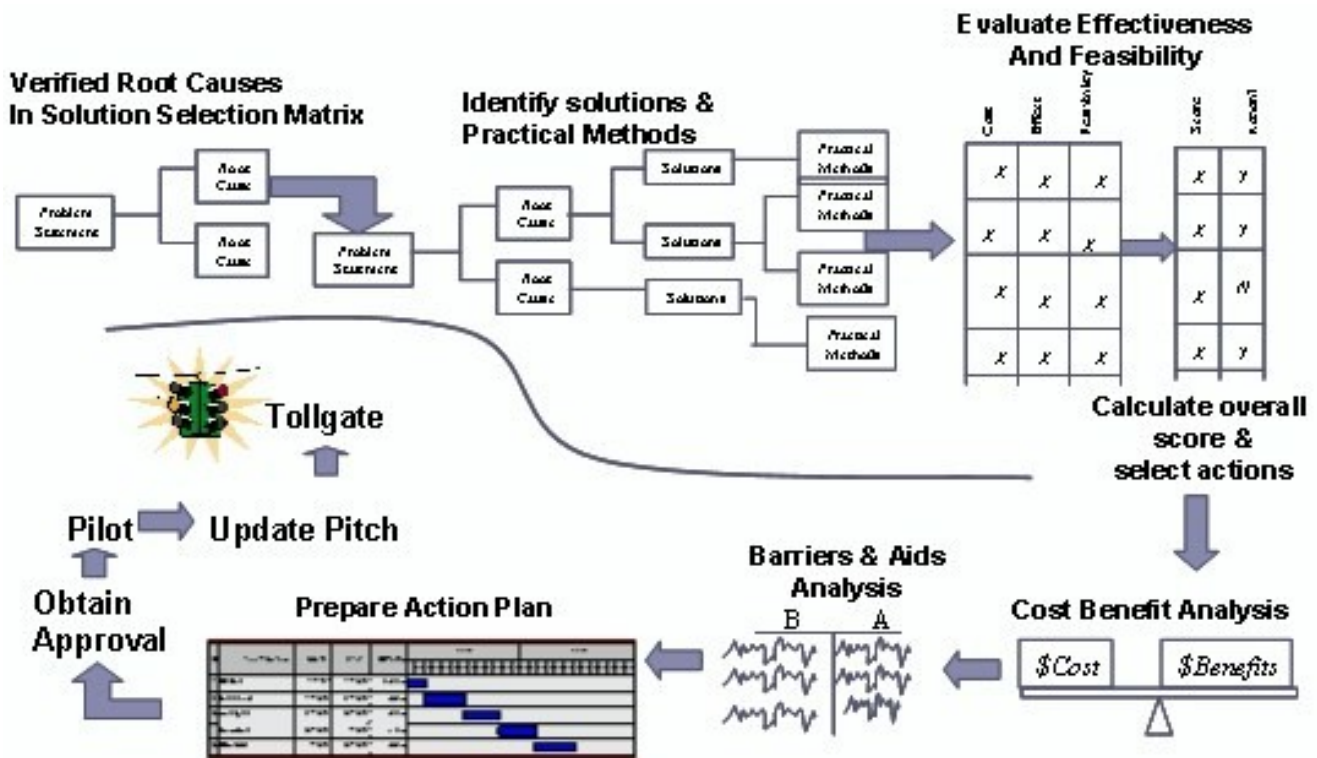


Figure 16: Six Sigma Improve flowchart (Shumula.com, Shumula.com, n.d.)

DOE testing is done as part of the validation process; this gives a clear indication if the process change is successful. The critical factors will be controlled after the solution has been validated to ensure that continues improvement on the process is maintained. Changing the process will lead to other problems arising and should be closely monitored to identify these negative effects and ensure that they are addressed accordingly. It is critical that the process be monitored in a complete system and not isolated processes as this can cause the system as a whole to be negatively influenced by changing critical factors (Watson G.H. , 2005).

The most critical focus point and tools used during the improve phase is: (Isixsigma, 2016)

- **Brainstorming** - This is where a group discussion is held to generate ideas.
- **Mistake Proofing** – This is referred to poka-yoke (pronounced PO-ka yo-KAY), is the use of any automatic device or method that either makes it impossible for an error to occur or makes the error immediately obvious once it has occurred.
- **Design of Experiments** - This is a systematic method to determine the relationship between factors affecting a process and the output of that process. In other words, it is used to find cause-and-effect relationships. This information is needed to manage process inputs in order to optimize the output.
- **Pugh Matrix** – This is a tool used to facilitate a disciplined, team-based process for concept generation and selection. Several concepts are evaluated according to their strengths and weaknesses against a reference concept called the datum (base concept).
- **House of Quality** - This is a diagram, whose structure resembles that of a house, which aids in determining how a product is living up to customer needs. The roof is

a diagonal matrix of "How's vs. How's" and the body of the house is a matrix of "What's vs. How's".

- **Failure Modes and Effects Analysis (FMEA)** – This is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service. "Failure modes" means the ways, or modes, in which something might fail.

2.2.9.3.5 Control

After the process has been improved, it is critical to conduct proper control of the processes as well as the system. During this phase the solutions for the processes are implemented and properly maintained. This is often where many companies fail as they focus very well on the solution of problems but do not properly maintain the solutions and at a later stage fail. During the control of the process, critical inputs have to be monitored and control and the output should be equally managed. This will ensure that the process does not revert back to a bad performing state (G.H, Watson, 2004) (George L., 2002).

It is very important that a cultural change occurs during this stage that will insure that changes are taken as a norm and accepted throughout the company. The only reason why these changes can be revoked is if there has been a better solution proposed and will ensure better performance (George L., 2002). Figure 17 shows the control flowchart:

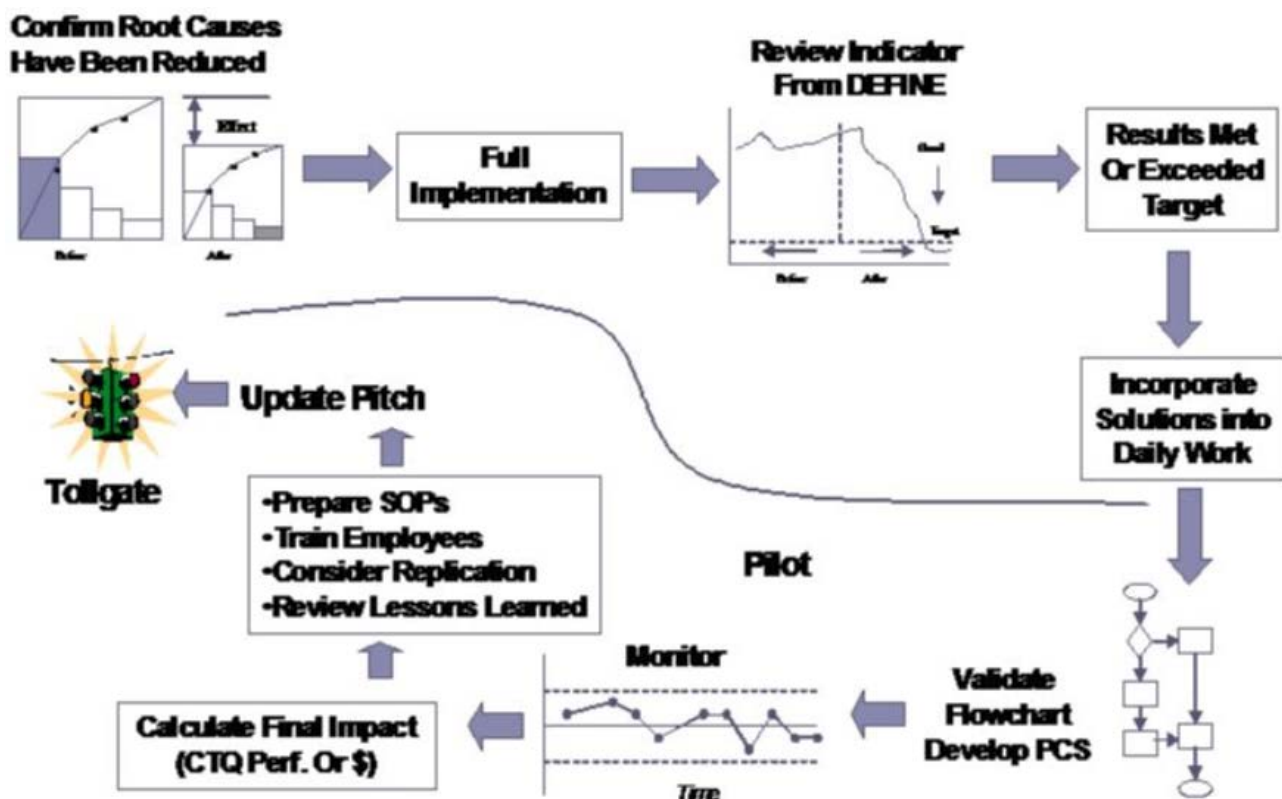


Figure 17: Six Sigma control flowchart

The most critical focus point and tools used during the control phase is: (American Standards of Quality, 2016).

- **Process Sigma Calculation** - Process sigma is a measure of the variation in a process relative to customer requirements. We measure defects on a scale of defects per million opportunities (DPMO).
- **Control Charts** – This is a graph used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average, an upper line for the upper control limit and a lower line for the lower control limit. These lines are determined from historical data.
- **Cost Savings Calculations** – This is critical as it will determine the feasibility of the proposed solution.
- **Control Plan** – This is a method for documenting the functional elements of quality control that are to be implemented in order to assure that quality standards are met for a particular product or service. The intent of the control plan is to formalize and document the system of control that will be utilized.

Table 3 gives a breakdown of the DMAIC steps and tools that are used for this methodology.

Table 3: DMAIC Six Sigma table (Isixsigma, 2016)

DMAIC Phase Steps	Tools Used
D – Define Phase: Define the project goals and customer (internal and external) deliverables.	
• Define Customers and Requirements (CTQs) • Develop Problem Statement, Goals and Benefits • Identify Champion, Process Owner and Team • Define Resources • Evaluate Key Organizational Support • Develop Project Plan and Milestones • Develop High Level Process Map	• Project Charter • Process Flowchart • SIPOC Diagram • Stakeholder Analysis • DMAIC Work Breakdown Structure • CTQ Definitions • Voice of the Customer Gathering
Define Review	
M – Measure Phase: Measure the process to determine current performance; quantify the problem.	
• Define Defect, Opportunity, Unit and Metrics • Detailed Process Map of Appropriate Areas • Develop Data Collection Plan • Validate the Measurement System • Collect the Data • Begin Developing $Y=f(x)$ Relationship • Determine Process Capability and Sigma Baseline	• Process Flowchart • Data Collection Plan/Example • Benchmarking • Measurement System Analysis/Gage R&R • Voice of the Customer Gathering • Process Sigma Calculation
Measure Review	

DMAIC Phase Steps		Tools Used	
A – Analyse Phase: Analyse and determine the root cause(s) of the defects			
• Define Performance Objectives • Identify Value/Non-Value-Added Process Steps • Identify Sources of Variation • Determine Root Cause(s) • Determine Vital Few x's, Y=f(x) Relationship		• Histogram • Pareto Chart • Time Series/Run Chart • Scatter Plot • Regression Analysis • Cause and Effect/Fishbone Diagram • 5 Whys • Process Map Review and Analysis • Statistical Analysis • Hypothesis Testing (Continuous and Discrete)	
Analyse Review			
I – Improve Phase: Improve the process by eliminating defects			
• Perform Design of Experiments • Develop Potential Solutions • Define Operating Tolerances of Potential System • Assess Failure Modes of Potential Solutions • Validate Potential Improvement by Pilot Studies • Correct/Re-Evaluate Potential Solution		• Brainstorming • Mistake Proofing • Design of Experiments • Pugh Matrix • House of Quality • Failure Modes and Effects Analysis (FMEA) • Simulation Software	
Improve Review			
C – Control Phase: Control future process performance.			
• Define and Validate Monitoring and Control System • Develop Standards and Procedures • Implement Statistical Process Control • Determine Process Capability • Develop Transfer Plan, Handoff to Process Owner • Verify Benefits, Cost Savings/Avoidance, Profit Growth • Close Project, Finalize Documentation • Communicate to Business, Celebrate		• Process Sigma Calculation • Control Charts (Variable and Attribute) • Cost Savings Calculations • Control Plan	
Control Review			

2.2.10 Quality Improvement plan

2.2.10.1 Introduction

A quality improvement plan is a detailed work plan for the improvement of quality within the organization. The quality improvement plan is developed by leadership within an organization to give accountability and expectation of the quality standard within the organization. It then serves as a roadmap for all quality activities and goals. This type of improvement plan is an ever-evolving document as it has to adapt to the specific quality requirements as the organization changes and grows.

A well-structured and effective quality improvement plan has to be based on the following principles: (ABC Provider Company, 2015)

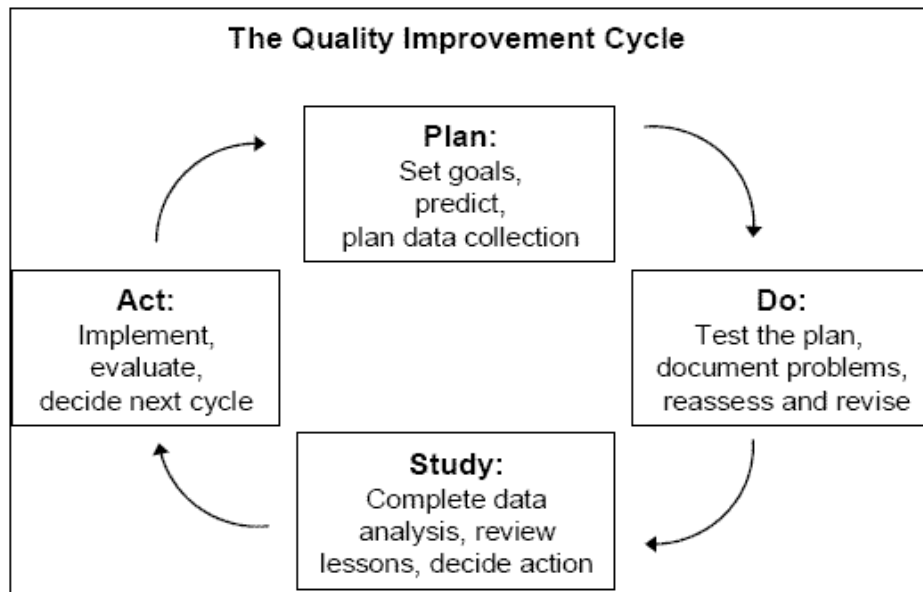
1. Clearly define quality improvement objectives, goals and expectations.
2. Clearly define all activities to meet the quality improvement objectives, goals and expectations.
3. Explain how quality activities will be measured and assessed.
4. Clearly define the training that will be required to meet all quality improvement objectives, goals and expectations.
5. Clearly define how the communication structure will work to meet quality improvement objectives, goals and expectations.
6. Describe how the quality assurance and control will be used to assess the effectiveness of the quality improvement plan.

2.2.10.2 Quality improvement planning

Defining a vision and mission will help individuals and team understand the goals that the organization wants to achieve. This includes defining what quality means for the organization and help to manage expectations (U. S. Department of Health and Human Services, 2011).

A quality improvement plan should be structured in a logical, chronological order to ensure that the plan can be followed without difficulty. There are very specific activities that should be taken into account when developing the quality improvement plan. There should be clear accountability and responsibility defined to the activities and there should be timelines added to ensure that there is continuous movement and progression. To implement a quality improvement plan, it is critical that the correct resources and materials needed to achieve the success of the activity be clearly defined.

Upon completion of the activity, it is important to evaluate and establish if the activity has been successful and it should be measured against a predetermined expectation. After the evaluation is completed, it is important to review the plan and continuously improve the cycle of quality management as can be seen in Figure 19.



Source: Adapted from Langley G, Nolan K, Nolan T, et al. The Improvement Guide: A Practical Approach to Enhancing Organizational Performance. San Francisco: Jossey-Bass Publishers, 1996.

Figure 18: Quality improvement cycle (quality, n.d.)

There are certain areas that have to be focussed on during the execution of a quality improvement plan and the following areas are very important to address:

1. Training and development
2. People
3. Technology
4. Positive climate
5. Short- and long-term objectives
6. Collaboration
7. Accountability and empowerment

2.2.10.3 Training and Development

Training is an essential part of development and it is important to ensure that people within the organization are competent to execute the required deliverables. In many instances there should be a focus to review existing training philosophies and identify where new training is required. Continuous development ensures that the organization is in line with current organization requirements and also helps to stimulate creativity and improvement suggestions (Collaborative for Excellence in Healthcare Quality, 2012).

2.2.10.4 People

Managing staff turnover is important and succession planning and redundancy within the organization should be managed. Rotating staff within the organization helps to diversify personnel and stimulate continuous improvement. Managing new people

transitioning into the organization is critical and will help make them more productive in a shorter amount of time as the expectation of the work requirements are clearly defined.

Setting up a personal development plan for individuals helps to grow and develop their capabilities. It is also important to realise that change can be emotionally stressful and should be managed closely.

Activities will be affected by the quality of the staff, high performing individuals should be identified, and retention strategies should be put in place to ensure that quality staff is retained (Collaborative for Excellence in Healthcare Quality, 2012).

2.2.10.5 Technology

Technology is progressing rapidly and ensuring that the organization is in line with current technological innovation and tools gives the business and distinctive edge to competition. Using online training, an electronics documentation method etc. makes the organisation more effective and competitive.

2.2.10.6 Positive climate

The organization should ensure that there is a positive climate that is healthy for development. Through continuous improvement, there will always be mistakes made that can be learned from and improved. Ensuring that people feel safe to make mistakes will ensure that the organization will continuously improve and develop.

2.2.10.7 Short and long-term objectives

By creating short and long-term objectives it gives the organization clear focus and goals. This will also ensure that management and workers are aligned with the requirement and objectives. Setting goals will help people be more focused on objectives (Collaborative for Excellence in Healthcare Quality, 2012).

2.2.10.8 Collaboration

Ultimately, organizational objectives are not met by individuals but by teams working together to a common collective. Ensuring that there is continuous collaboration between individual in teams as well as between different teams will help align the core organization requirements.

2.2.10.9 Accountability and empowerment

During implementation of activities, there should be clear roles and responsibilities for individuals that will guide them to what is expected of them and ensure that ownership is taken of activities. Empowering individuals to make decisions will ensure that there are no decision deadlocks and create an environment where there is continuous progression of workflow.

2.2.10.10 Quality improvement tools

2.2.10.10.1 Flow charts

Flowcharts can be used to help a team better understand the flow of a certain process. It gives a depiction of what sequential steps should be followed during a process. This can show a team how a process should flow. This flowchart can be used initially and after implementation of a process it can be modified to incorporate all the changes to indicate how the refined process should work (New York State Office of Mental Health , 2005).

The benefits of flowcharts include:

1. Can be easily used for training purposes.
2. Gives a visual indication of a process that is easier to understand.
3. Can help to understand bottlenecks in a process.

Figure 19 gives a representation of how a flowchart can be used; during the design there can be specific symbols assigned to different intents of the specific process. This can then help for people to better understand the intent of the process.

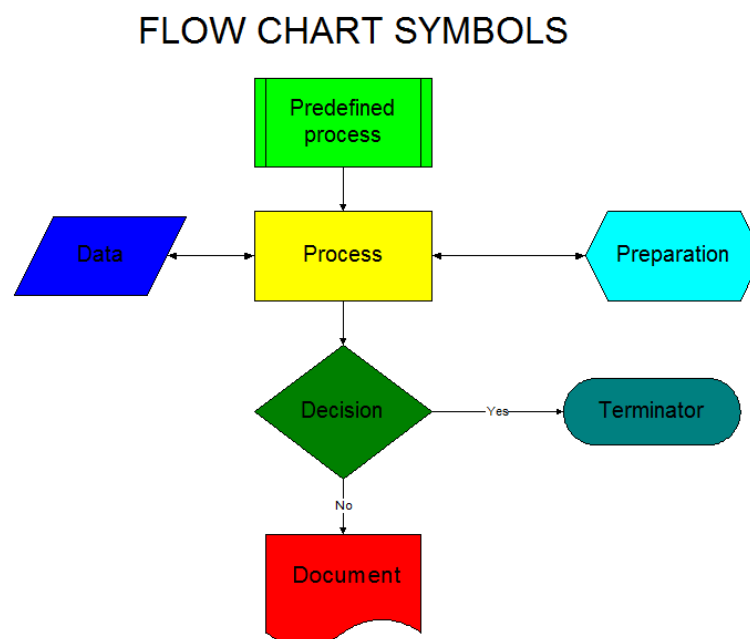


Figure 19: Flow chart symbols (New York State Office of Mental Health , 2005)

2.2.10.10.2 Brainstorming

This tool is used to generate ideas in a team, each team member can contribute an idea that is explored and discussed within the team. This creates an environment where any idea should be explored and not criticised, this is a very creative process.

The benefits of brainstorming:

1. Creativity is encouraged.
2. Help to build relationships within a team.
3. Team can take ownership after final decision.
4. Generates a large number of ideas that can be explored.

2.2.10.10.3 Cause and effect diagram

This diagram can easily be used to help identify and sort a process in a visual way. It can help to understand a specific outcome through identifying any influential factors that can affect the outcome. It gives the team a systematic visual interpretation that can be used to identify root causes (New York State Office of Mental Health , 2005).

The benefits of the cause and effect diagram:

1. Structured approach to identify root cause.
2. Systematic representation to a process and outcome.
3. Generates a better understanding of a process.

As can be seen in figure 20, there is a continuous input into the work stream, ranging from a wide variety of topics. Every possible cause is explored to be able to determine the effect.

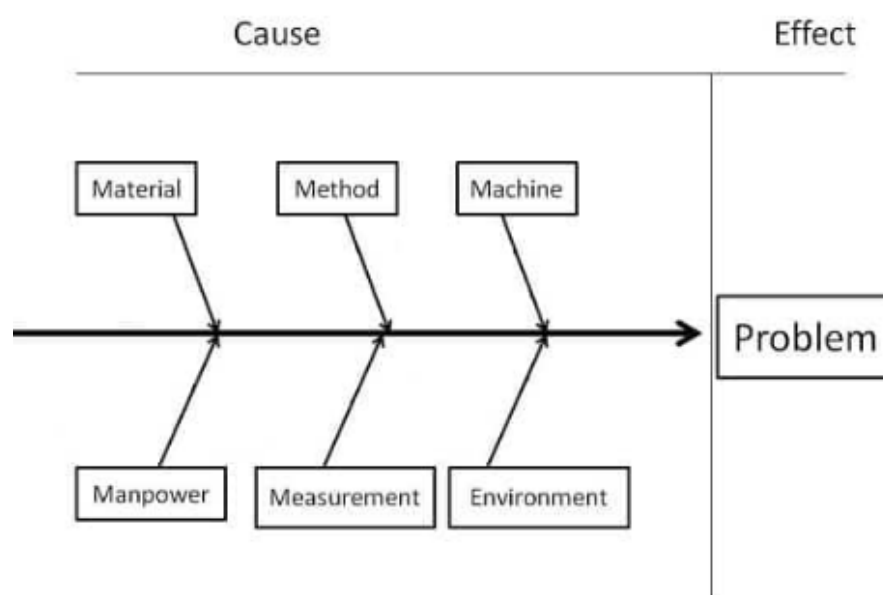


Figure 20: Cause and effect diagram (Usmani F., 2016)

2.2.11 Literature study conclusion

Six Sigma looks at series of processes with variations as a whole and determines where there are insufficiencies and waste in the system. The processes that have the biggest production performance impact are prioritized. The Six Sigma methodology involves statistical analysis that identify the repeated causes of variation. Focusing on these identified processes improves quality on a continuous basis and ensures cost reduction for the business.

Lean manufacturing and production focus on eliminating any unnecessary resources that are not required help to improve quality and performance of an organization. Through focusing on the end product and eliminating any waste will help eliminate any unwanted costs and give you more value for less work. In the challenging market, it is very important for organization to optimize their processes and focus on improving their systems.

The International Standard Organization has integrated well-established principles and has created a standardized vocabulary and quality management principle guideline for any organization to use. Through customer and stakeholder focus and people integration it gives the fundamental corner stone to manage quality.

The total quality management system helps to create a fundamental philosophy for a quality management system within an organization. Creating the right tools and systems allows an organization to optimize quality and improve resilience in the global market.

There is wide variety of tools available to be able to solve problems during the development of a quality improvement plan. The Plan, Do, Study and Act principle is important, and a quality improvement plan should be a continuous evolving document. Getting feedback and from the output to improve on the previous input. As discussed earlier in this chapter, it is important that the basic principles and focus areas be addressed to ensure that the correct action is taken during the execution of the quality improvement plan.

By integrating quality management systems and lean manufacturing it can improve the way processes are identified and wastes are removed and eliminated. This creates a smoother flowing process and leads to customer satisfaction. There was a study conducted where there was guide lines were proposed for integrating quality management systems and ISO 9001. It was stated that academics and practitioners where they used the principles and guidelines to propose ways how to integrate lean manufacturing and ISO 9001 and analysing how it impacts documentation like works procedures, instruction and quality documentation. By implementing a lean quality management system, a business can improve efficiency by reducing waste and become more competitive in the global market. (Chiarini A., 2011)

Many manufacturing companies have reached ISO 9001 accreditation by implementing lean manufacturing into their organizations. This is initiated by lean manufacturing projects that are implemented through the development of tools that are linked between ISO 9001 and Quality management systems.

There was a book published called “Lean ISO 9001” that indicated the lean principle of the 5S tool can be used the effectively administrate the documentation of ISO 9001 and should be used complimentary of each other. (Micklewright M., 2010)

The innovative spirit of a company is very important and being creative is an essential value that the company should focus on. This is important as it makes the company more open to change and continuous improvement and there is a clear link between IOS 90001 and lean manufacturing. If this is considered a process of ISO 9001 with the focus on process measurement, improvement and analysis will cause change of the product through these activities of product realization, management responsibility and resource management. (Bolea, 2017)

Table 4 : PDCA Cycle and Lean manufacturing link (Chiarini A., 2011)

Through the study of the link of quality management systems and lean manufacturing there was a summary concluded based on PDCA of the ISO 9001. As shown in table 4 the link is shown between QMS ISO 9001 and lean manufacturing (Chiarini A., 2011). PDCA (Plan-Do-Check-Act)			
Plan	Do	Check	Act
Hoshin Kanri establish the objectives and processes necessary to deliver results in accordance with the customer requirements and the organization's policies.	Kaizen events and all the tools Implement the processes.	Lean metrics Visual control and management Monitor and measure processes and product against policies, objectives and requirements for the product and reports the results.	Hoshin Kanri Kaizen events Take actions to continuously improve process Performance.

ISO 9001 has become a mandatory quality management system in global business companies and it is advantages to implement lean manufacturing principles into the ISO 9001 system as this helps to make the quality management system more effective and so leads to the company being more competitive.

Integration of Lean manufacturing, ISO standard, TQM and Six Sigma into the business models it ensures that companies stay competitive and minimal processes are bottlenecks within the system. In conclusion not only one quality management system can be isolated as the best system as all these systems must be integrated into the company to ensure that a wide variety of problems can be addressed.

2.3 Case study literature

2.3.1 Introduction

Sasol Group technology is the technology-based division of Sasol. It drives innovation and commercialisation that ensures a sustainable future for Sasol business through the integration and optimisation of Sasol's value chain. They focus application of innovative technical solutions at existing sites and selectively developing or licensing technology for business growth. It focuses on Sasol businesses that allows Sasol to be agile, fast, responsive and flexible.

Critical success factors Group technology focusses on is taking accountability for new technology innovation, pro-active leadership, portfolio management (short- and long-term), identifying and developing people's competencies and capacities, ensuring a coherent and performing business system.

Group technology is divided in five sub-sections that include:

Research & Development (R&D): a function of Group technology that is responsible for research and process development for the Sasol group, both through undertaking in-house R&D and through the management of outside research and collaborative programmes.

Engineering & Project Management: a function of Group technology that is responsible for design, engineering and project management for capital and other projects for the group. Engineering support and project management services are part of this scope.

Technology & New Business Development: a function of Group technology that is responsible for the development of new business ventures for Sasol and for the development and improvement of technologies and the licensing of Sasol's Slurry Phase Fischer-Tropsch process and other technologies. This includes all front-end design activities associated with the Sasol Slurry phase Distillate process and technical support for Sasol.

Process Commercialisation: a function of Group technology that is responsible for conceptual design, front-end scoping and cost estimating for Sasol's capital projects. This includes selection, adaptation and integration of licensed-in technologies.

International Projects & Co-ordination: a function of Group technology that is responsible for the execution of major capital projects outside southern Africa, management of the co-ordination between Group technology and Sasol companies based outside South Africa, line management for R&D facilities based in St Andrews (UK) and Twente (The Netherlands).

Group technology functions include:

- Concept Development
- Cost Engineering
- Engineering
- Engineering Management
- Financial
- Governance and Systems
- Human Resources
- Information Management
- Knowledge Optimisation
- New Business Development
- Operations Profitability Improvement
- Process Engineering
- Procurement and Supply Management
- Project Management
- Research and Development
- Technology Management

All of these functions together have developed a quality management system that forms the quality of Sasol's knowledge.

The focus for this case study will be three quality management systems that include:

- Knowledge Capture and Transfer Procedure for Retiring Employees (QMS/033P, Rev 1)
- Engineering Health Management System in Project Execution (QMS/912P, Rev 1)
- Peer Assist Procedure (QMS/034P, Rev 1)

2.3.2 Knowledge capture and transfer procedure for retiring employees

The purpose of the quality management procedure is to describe the steps involved to ensure knowledge is captured and retained way in advance (18 months or more), when it is imminent that an employee will be retiring from his / her current position. This procedure aims to support existing organisational hand-over mechanisms already in place.

The main role players in this procedure are:

- Line Management (LM)
- Retiring Employee (RE)
- Knowledge management consultant (KM)
- Human resources consultant (HR)

2.3.2.1 Roles and responsibilities

Line Management (LM)

The line manager is responsible to set up a kick-off meeting with a retiring employee, knowledge management consultant and human resources consultant. The knowledge management consultant helps to facilitate the meeting.

The knowledge transfer plan is populated by the retiring employee and line manager authorises the content thereof. The line manager should monitor the knowledge transfer progress and ensure that all actions as part of the plan are executed. He is also responsible to identify, where necessary, experts to validate knowledge content.

Retiring Employee (RE)

Populates the Knowledge Transfer Plan and executes all activities as stated in the plan.

Human Resources consultant (HR)

Informs the knowledge management team of imminent retiring employees at least 18 months in advance. The Human Resources consultant then advises the line manager on the appropriate HR intervention (e.g. coaching, mentoring, etc.) to transfer skills and knowledge between retiring resource and others.

Knowledge management consultant (KM)

The knowledge management consultant facilitates the process; ensures that knowledge identified has been captured and disseminated according to the plan and supports that captured knowledge is correctly added to Knowledge Online when applicable as can be seen in figure 21.

2.3.2.2 Process flow

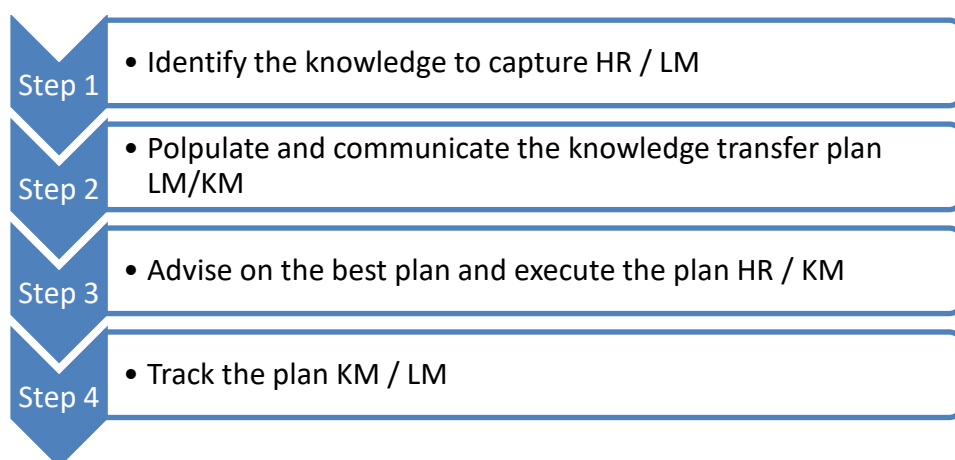


Figure 21: Capture of knowledge flowchart

Step 1: Identify Knowledge to Capture

First the need to capture knowledge, which must be retained in the organisation whenever a person retires or leaves their current position should be identified.

Knowledge management consultant or Functional Knowledge management coordinator should be notified of imminent retirement

A session is then set up with the retiring employee to identify the knowledge and requirements for the transfer thereof.

Step 2: The Knowledge Transfer Plan

A Knowledge Transfer Plan is then developed that identifies the possible knowledge areas and determine actions to be taken to ensure that knowledge is retained and transferred within the organisation. The Knowledge Transfer Plan is then transferred to the Human resources consultant.

Step 3: Execute the Plan

The Human Resources consultant then advises the Line Manager and Knowledge management consultant on the appropriate Human resources intervention that will optimally transfer skills and knowledge between the retiring employee and identified personnel, based on the actions stipulated in the Knowledge Transfer Plan. The Human Resources consultant then supports the Line Manager with selected Human resources intervention and appropriate guidelines for the execution of relevant intervention, i.e. coaching.

Step 4: Track the Plan

The Knowledge management consultant then provides assistance where required with the execution and tracking of the Knowledge Transfer Plan. The knowledge specialist identifies all knowledge areas the Retiring Employee was responsible for and ensures that the Transfer Plan activities are executed, and targets are reached.

A copy of the knowledge transfer plan can be seen in appendix C

2.3.3 Engineering Health Management System in Project Execution (EHMS)

The intent of the Engineering Health Management System (EHMS) is to achieve engineering execution quality requirements within the project development and execution process ultimately resulting in continuous improvement in the inherent safety and integrity of the facility. Several factors associated with the project development and execution process are considered in order to determine the most

critical areas of focus that would support the strategic intent. The following four focus areas have been identified as having the biggest impact on the objective of achieving engineering excellence. These are:

Resources

Ensuring appropriate selection and allocation of competent resources. In principle, this covers three particular areas that include Internal Group technology and External resources (e.g. contractors, manufacturers, suppliers, consultants) and technical specialists.

Quality

Improving quality focus assists in the technical performance and hence the quality output during engineering execution. The focus here is primarily on the technical content of each of the discipline's work.

Knowledge Management

The intention of knowledge management is to ensure re-use of proven knowledge thus resulting in a robust product ultimately leading to improved integrity, maintainability and safety. Each Lead Discipline Engineer must ensure that appropriate best practices and knowledge is incorporated within the particular phase of a project. Knowledge is attainable from a discipline knowledge database (information captured from lessons learnt) and the person who is knowledgeable on a particular subject (Centre of Competencies). Governance in this regard has been instituted by means of a knowledge management check during the quality assurance process.

Technical Risks

Identifying and managing technical risks at the discipline level.

2.3.3.1 Roles and Responsibilities

Identification of Stakeholders

The stakeholders involved in the planning, implementation, final review and measurements of the engineering quality plan are those with an interest in the quality of the engineering track deliverables of the project. Typically, that would include the Project Manager, Engineering Manager, Discipline Engineers, Discipline Managers, Manager, Engineering, QA/QC Department and Plant Owner or Operations representatives.

Accountabilities

Overall, accountability for the planning, co-ordination and measurement of the discipline specific metrics rests with the Discipline Manager. The Discipline Managers are accountable for ensuring that projects are adequately resourced both in terms of number of technical resources and the competency profile of the resources. Each Discipline Manager will be accountable for the discipline specific BD&I checklists, knowledge management, quality assurance and ultimately governance. Similarly, the Manager is finally accountable for the overall rolled up engineering metrics. The overall planning of the measurement process must be integrated with the project's overall plan and therefore must tie up with predetermined milestones, gates and phases in the project BD&I model. The establishment of engineering metrics complements the projects drive of ensuring engineering integrity and should not be viewed as a duplication of effort. It is, therefore, essential that there is sufficient collaboration between the Engineering Manager, Project Manager and Discipline Managers in the planning of a particular phase of a project. The Engineering Manager in conjunction with the Manager, Engineering will be accountable for the integrated engineering review which is held just prior to the project GRR. This review includes project alerts that have arisen subsequent to the discipline performance evaluation process and Serve as a final endorsement of all engineering technical risks prior to holding the gate specific review.

2.3.3.2 Engineering Quality Model

2.3.3.2.1 Quality Principles

The Engineering Quality model is dependent on a few key principles which are listed below:

1. The BD&I model will be followed.
2. Group technology has a prioritised project list in terms of Risk versus Impact.
3. The Project phase governance process will be covered in two parts:
4. Project phase completeness by PMT GRR
5. Project phase quality by discipline (ETQP review)
6. Only approved manufacturers lists will be utilised. Any additions and/or removal of manufacturers to be agreed by the approved engineering authority.
7. Sasol specifications will be used as the basis for South African based projects. The interpretation alignment and application of these specifications remains pivotal to the project quality.
8. Knowledge is managed at the discipline level and is transferred appropriately to the project.

2.3.3.2.2 Overall Engineering Quality Philosophy and Model

The overall philosophy for the Engineering Health model is shown in the diagram below. In principle, each discipline will measure the health of projects in terms of four key performance areas, namely, Quality, Resources, Knowledge and Risks and feed this information into an overall EHMS.

For each project, the specific health key performance indicators will be used in conjunction with the project risk profile to formulate final attention reports for each of the low / medium / high risk categories.

The purpose of the attention reports is to primarily provide management with “Project Alerts”. These alerts will effectively tell management which projects are in need of support and in what area. The Engineering Leadership Team must use this information constructively to assist the project team in a suitably agreed manner. In principle, project alerts will be used as an input to execute integrated engineering reviews which must be held prior to the GRR. In the case where the engineering health metrics reflect no improvement after follow up actions, this will be escalated to the Discipline Manager (and Manager, Engineering if required) as can be seen in figure 22.

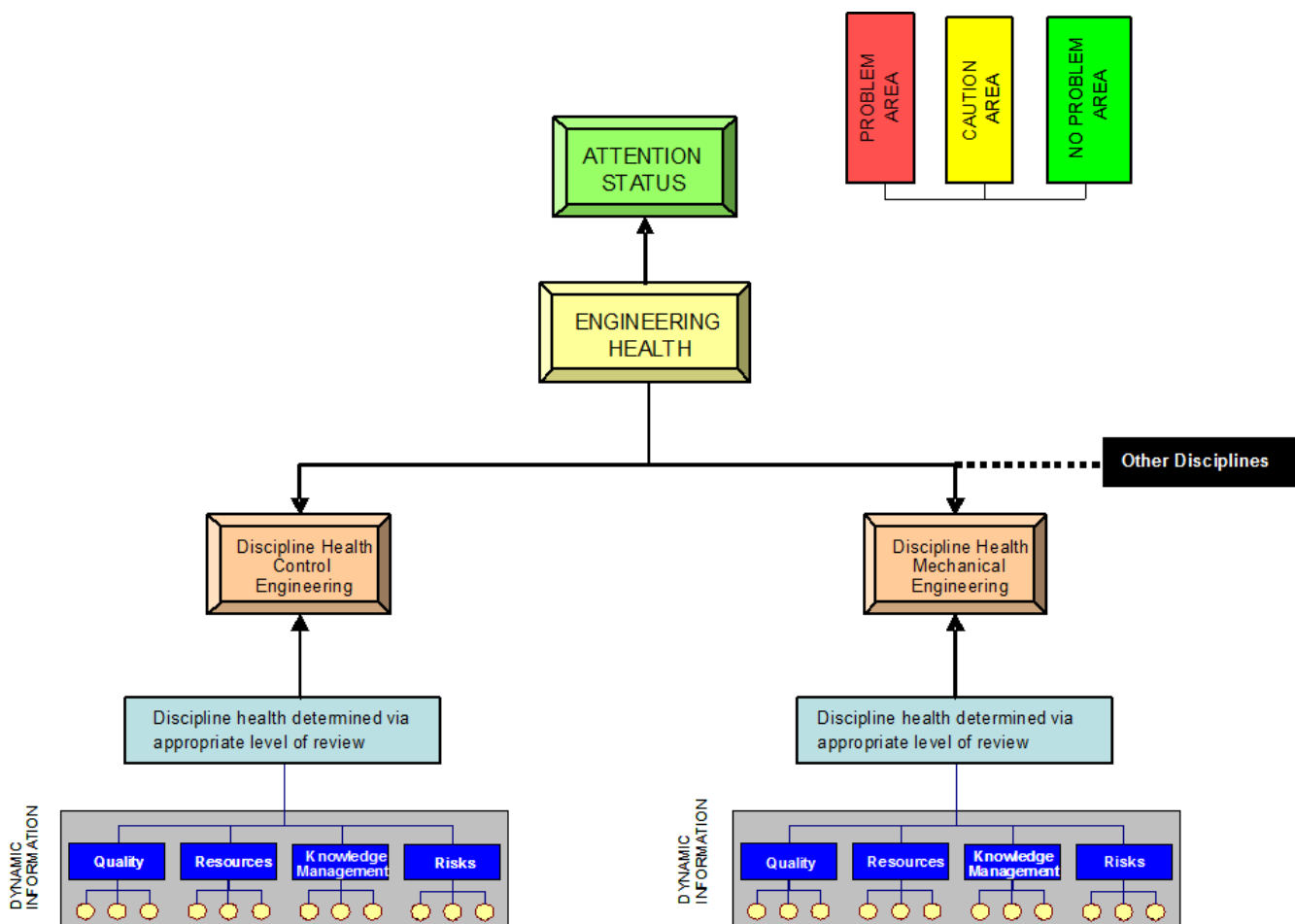


Figure 22: Engineering Health monitoring system

Phase Quality and Governance - Current Model

In order to understand and implement the philosophy proposed above it is important to briefly revisit the current model in terms of quality assurance and governance. The model below shows the current phase quality and governance approach.

Firstly, a GRR is done towards the end of the project phase and the GRR score is then used to indicate potential risk in a project. Note that this is a completeness check.

Secondly, ETQPs were introduced to address project engineering quality issues. ETQP audits are done at the end of a phase and focus more on plans rather than the implementation and content thereof as can be seen in figure 23.

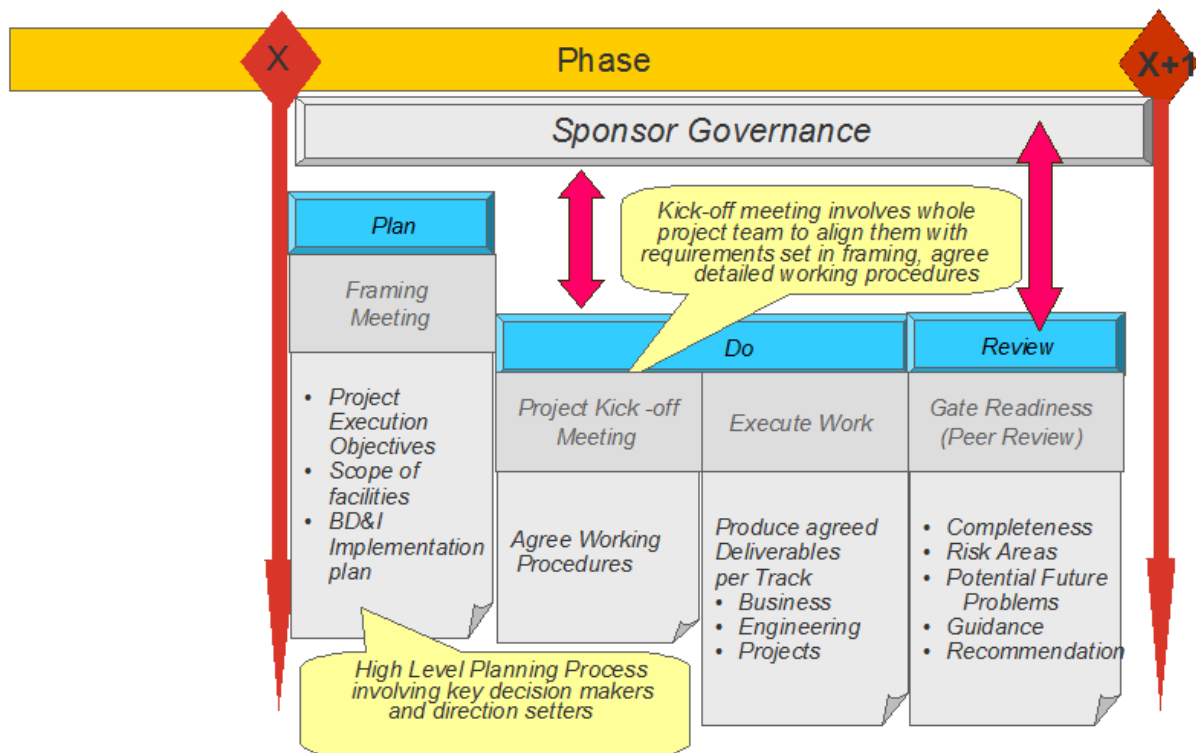


Figure 23: Project phase governance - Generic Process for each phase

2.3.3.2.3 Engineering Phase Quality Assurance Model – Revised Model

The model below indicates the formal engineering quality assurance process. In principle, the model depends on the Engineering discipline to assure the Project Team of the well-being of the project in terms of engineering quality. Focus is given to the actual content of the deliverables and activities. In addition, risks are highlighted, and appropriate mitigation plans put in place.

The objective of the reviews is to establish the status of project quality and to highlight technical risk/ problem areas. Several reviews are expected to be performed during a project phase in order to establish on-going project performance visualisation. The quality review frequency is once per month. A prerequisite for the start of the GRR is

Figure 25: Engineering phase governance model

Each discipline will independently evaluate the health of the discipline in four stipulated key performance areas, i.e. Quality, Knowledge Management, Resources and Risks. The discipline performance evaluation process will determine the status of the robot (health) resulting in overall project alerts. Feedback as a result of the evaluation process must also be used to formulate discipline specific next steps. In addition, the feedback and next steps must also form the basis for the updating of the ETQP.

2.3.3.2.5 Key Performance Indicators

Leading and lagging key performance indicators are utilised during the various phases of the project. Leading indicators will serve as an early warning system (proactive) for the particular phase and will ensure that the project starts off with the correct level of engineering input in terms of quality plans. Lagging indicators will typically measure the quality of the work done for the particular phase and will serve the purpose of checking on the quality of engineering executed for a particular phase of a project. This indicator will also provide a good indication of the completeness of the work during a particular phase of the project before the next phase is embarked on.

2.3.3.3 Engineering Metrics

Project reporting information is stored on the SAP database system. Metrics to monitor the project status in terms of cost and schedule have been implemented. SAP PS Remote is utilised for updating purposes while SAP PS Next is used for the generation of management reports. Engineering metrics, added to the current project reporting system, will ensure a single point of reference with respect to project status and health. It is vitally important that record is kept of all evaluations and outcomes thereof. Archiving is done as part of the SAP system.

2.3.3.3.1 KPIs Defined

Leading indicators are established during the planning of a particular project (phase start) and covers the drawing up and approval of the phase ETQP, Internal and external discipline resource plans and Knowledge re-use plans.

The lagging indicators are established typically during the execution and review of the project phase and measures quality and completeness of the content of engineering deliverables, thus giving a good indication of integrity.

2.3.3.3.2 Project Risk Categories

Project risk categories are defined as follows:

Category 1

A high priority (Super Critical) project is a Greenfield or Brownfield program (consisting of three or more interrelated projects) over two or more RSA sites or on sites outside RSA, involving five or more Sasol Business Units and/or a Joint Venture partner, with a capital cost in excess of R1 billion with execution times of more than 24 months, involving multi known and/or unknown technologies with hazardous materials.

Category 2

All medium and large-scale projects that are not part of Category 1 or Category 3 projects

Category 3

Projects referred to as Group Technology “small projects”, which conform to the following guidelines:

- Not new technology
- Not complex (not more than 2 process steps)
- No licensor or proprietary equipment involved
- Not Sasol core technology or process
- No in-depth or detail understanding of value chain (Low Technical Risk and Low Business Risk)
- Not a listed activity in terms of environmental legislation or requires limited EIA scoping and is likely to get exemption from involving external environmental consultants
- Projects identified by the Group technology / Owner Small Project Routing Forum suitable for this approach
- Typically, not an electrical or instrumentation single discipline project

2.3.3.3.3 Level of Checking

Within a particular phase of a project it is important to note that the level of quality checking must be commensurate with the level of risk and impact associated with the project.

Typically, a high risk, high impact project will demand more attention and more detailed checks than that of a low risk and low impact project. This is depicted in the diagram below.

In principle, the high priority projects (Category 1) will demand a very high level of quality checking and similarly the low risk projects (Category 3) will entail a low level of quality check, however the Discipline Manager is allowed to execute the performance evaluation as a typical Category 1 (high risk). This is allowed in order to

ensure that correlation between discipline complexity/risk and overall project risk is taken into account as can be seen in figure 26.

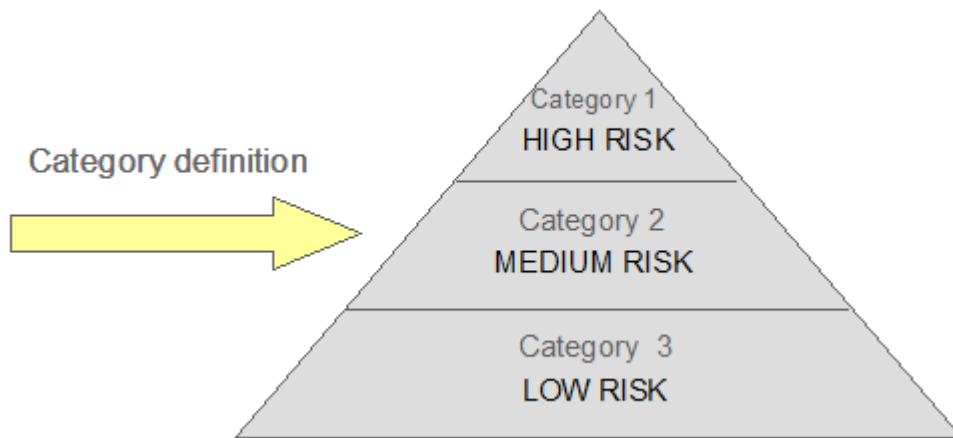


Figure 26: Level of quality checking

2.3.3.4 Overall Metric System

2.3.3.4.1 Engineering Metric Model

The engineering function comprises the following disciplines:

- Control Engineering
- Electrical Engineering including QA/QC and Plomic Centre
- Mechanical and Metallurgical Engineering (including Fabrication)
- Civil Engineering
- Environmental and Risk Engineering

Each discipline within Engineering will be accountable for the evaluation of the defined key performance areas and metrics in terms of resources, quality, knowledge management and risk. The individual discipline metrics will ultimately roll up into the overall engineering metric system as explained in the model rules below.

2.3.3.4.2 Model Rules

The Engineering KPAs are divided into four main categories:

- Resources (internal and external)
- Knowledge management (capturing and re-use)
- Technical quality status (generic to all disciplines and discipline specific)
- Technical risks (new and existing)

Each discipline defines its own specific technical quality KPIs (detailed questions). These questions have been developed with the intention to evaluate the health of

engineering deliverables. Discipline specific questions are extensive and are managed by each discipline on an on-going basis. These questions are available on request. It will be up to the combination of the lead discipline engineer and reviewer(s) (if required) to establish the actual quality status. Questions requiring simplistic yes/no answers must be substantiated in a manner that will allow the reviewer(s) to confidently rate a particular aspect of the project. Each discipline breaks down its KPA and KPI detail firstly into the specific phase of the BD&I model and secondly into logical sub-sections of the particular discipline e.g. Control Engineering broken down to process control systems, process safety, etc.

The questions are not merely aimed at Group Technology engineers only, but also covers the work performed by all the parties in executing the job i.e. Sasol Technology Lead Engineer, Engineering Contractor, Subcontractors, AIA, Manufacturers etc. The performance criteria required to reflect the state of a particular KPA / KPI (red, yellow and green) are defined and implemented individually by each discipline.

These performance criteria must be appropriate for the different project risk categories namely:

Category 1 = High Risk

Detailed and comprehensive criteria required to ensure that all possible areas of engineering are covered.

Category 2 = Medium Risk

Less extensive criteria required, but with sufficient detail to ensure that the most critical areas are covered.

Category 3 = Low Risk

Minimum criteria required, limited to one detailed question per KPA i.e. four questions.

Each discipline will evaluate each question per KPA (generic as well as discipline specific) and record the specific results according to the robot system as defined below:

- Green (1) = No problem - No action required.
- Yellow (2) = Caution - Potential problem area with identified actions and dates, highlighted by means of a management report.
- Red (3) = Problem area - Highlighted by means of a management report. Assistance / Action required by Discipline Manager and/or Manager, Engineering.

In addition, a free text area is available to describe any particular risk/problem and must be completed for all “yellow” and “red” status areas. The discipline metrics will roll up into the engineering metric display. In principle any “red” or “yellow,” recorded in any particular discipline will automatically roll up to the engineering metric for that

particular KPA. Final reporting is done on a percentage (red, yellow, green) basis. See concept below in table 5.

<i>Engineering Discipline</i>	<i>Resources</i>	<i>Quality</i>	<i>Knowledge</i>	<i>Risks</i>
	<i>Yellow</i>	<i>Red</i>	<i>Green</i>	<i>Yellow</i>
<i>Control</i>	<i>Green</i>	<i>Red</i>	<i>Green</i>	<i>Yellow</i>
<i>Electrical</i>	<i>Green</i>	<i>Green</i>	<i>Green</i>	<i>Green</i>
<i>Mechanical</i>	<i>Green</i>	<i>Green</i>	<i>Green</i>	<i>Green</i>
<i>Environmental</i>	<i>Green</i>	<i>Green</i>	<i>Green</i>	<i>Green</i>
<i>QA/Welding</i>	<i>Green</i>	<i>Green</i>	<i>Green</i>	<i>Green</i>
<i>Civil</i>	<i>Yellow</i>	<i>Green</i>	<i>Green</i>	<i>Green</i>

Table 5: Final reporting table

2.3.4 Peer Assist Procedure

The purpose of this procedure is to describe the steps involved to assist any employee within the organisation to conduct a Peer Assist. The Peer Assist is a process of knowledge exchange between two parties. The Peer Assist (exchange process) is triggered by one team facing a business challenge / decision and seeks the assistance of another team who has gained experience on the same subject.

The main role players in this QMS document are:

- Home Team Leader (Peer Assist Owner)
- Peer Assist Facilitator
- Home Team (team seeking the knowledge)
- Away Team (team contributing the knowledge)
- Knowledge management Consultant
- Functional Knowledge management Coordinator

2.3.4.1 Responsibilities

Home Team Leader (Peer Assist Owner)

Defines the business challenge that the Home Team faces i.e. define the objective of the Peer Assist. Identifies and defines the required knowledge and experience to assist the home team in overcoming a challenge within a project or a business process e.g. new budget cycle. Involves either / or the KM Consultant and the Functional KM Coordinator to assist with the preparation and facilitation of the process and logistics (optional). Assists with the identification of where the knowledge and experience can be obtained from, i.e. internal and / or external to the organisation. Elicits support for the planned Peer Assist from the Home Team by communicating the Peer Assist objective, the potential value and the plan to solve the business challenge i.e. get assistance from another team to provide knowledge and experience to solve their

business challenge. Secures the willingness of the Away Team to provide the Home Team with the required knowledge and experience. Ensures all actions from the Peer Assist report are executed. During the session, ensures that the knowledge exchange between the Home Team and the Away Team is focussed on achieving the objective of the Peer Assist (addressing the defined business challenge). Ensures all actions from the Peer Assist report are executed.

Home Team

Collectively defines the requirements and desirable objectives from the Peer Assist session in more detail. Communicates their understanding of the business challenge to the Away Team (prior and during the session). Disseminates and make-sense of the knowledge and experience provided by the Away Team and formulate a solution for their unique situation. This is ideally done with the active participation of the Away Team.

Away Team

Agrees to participate and contribute their knowledge and experience. Makes the required time available to partake in the Peer Assist session. Ensures they understand the business challenge at hand. Participates and contributes their knowledge and experience (and ideally participate in developing a solution for the Home Team business challenge). Confirms the Home Teams' understanding of the advice.

Peer Assist Facilitator

If the KM Consultant is not the Peer Assist Facilitator, then notify the KM Consultant that a Peer Assist session is planned and provide the necessary details. Assists with the planning and preparation of the Peer Assist. Provides guidance and facilitates the process. Ensures that the objective of the Peer Assist is achieved. Ensures the Peer Assist Report is compiled and distributed. Ensures that the Peer Assist Report is published in Knowledge Online with assistance of the KM Consultant.

Functional KM Coordinator

On request of the Home Team Leader coordinate the entire Peer Assist process or request assistance from a KM Consultant. Informs and assists the KM Consultant with the planning, preparation and execution of the Peer Assist process as can be seen in figure 27.

2.3.4.2 Process Flow

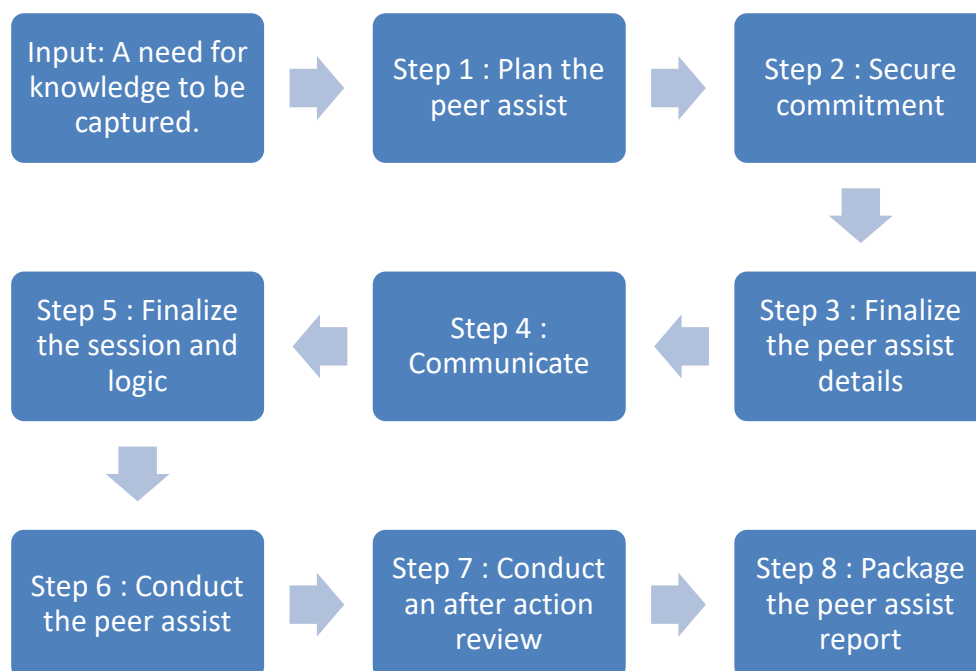


Figure 27: Knowledge process flow

2.3.4.2.1 Step 1: Plan the Peer Assist

Conduct a Planning Session with:

1. Home Team Leader
2. Peer Assist Facilitator (if already identified)
3. Functional KM Coordinator (optional)
4. KM Consultant (if no Peer Assist Facilitator)

Complete the Peer Assist Preparation Template stating the following:

1. Objectives (What is the business challenge that must be solved during this session?)
2. Key learning themes (What are the specific knowledge and experiences that are required to address the business challenge?)
3. Identify the parties who hold this knowledge and experience and will be willing to participate and share it.
4. Identify the Peer Assist Facilitator.

2.3.4.2.2 Step 2: Secure Commitment

Secure Commitment for the Home Team and the Away Team's participation in the Peer Assist.

2.3.4.2.3 Step 3: Finalize the Peer Assist details and Logistics

Determine the duration required to address the Peer Assist objective and learning themes. Finalise the Agenda and process of the session. Finalise the roles of the Facilitator, the Owner and the Away Team.

2.3.4.2.4 Step 4: Communicate

Communicate the following to all parties (details as defined in the preparation template):

1. Peer Assist objective
2. Key learning themes to be addressed during the Peer Assist session
3. Participants

2.3.4.2.5 Step 5: Finalize the Peer Assist session details and logistics

The Peer Assist Facilitator is responsible for executing the following:

1. Set up venue
2. Invite Participants
3. Send the preparation template and all other relevant documents (agenda, process etc.) with the meeting request.

2.3.4.2.6 Step 6: Conduct the Peer Assist

1. Follow the agreed agenda (Facilitator) as can be seen in appendix F.
2. The workshop could take a few hours or 1-2 days, depending on the depth or extent of the knowledge / challenge / need.
3. Commence the meeting with a welcome and introduction of all the team members.
4. State the reason for calling a Peer Assist and highlight the objectives and expected deliverables (The Home Team).
5. Share information about the context of the challenge facing them (The Home Team).
6. Encourage the Away Team to ask questions and to give feedback throughout the workshop (The Home Team).
7. Ensure that the Away Team develops a comprehensive understanding of the issues facing the Home Team.
8. Engage the Away Team in a face-to-face dialogue about experiences and learning to achieve the required understanding. This dialogue takes up 50% of the process (The Home Team).
9. Provide the Away Team with a feedback session where the outcome of the analysis is summarised, and the results are presented (Home Team).
10. Agree on proposed actions based on their learning (Home Team).

2.3.4.2.7 Step 7: Conduct an After-Action Review

Conduct an After-Action Review in order to:

1. Assess if the Peer Assist session objective has been achieved.
2. Identify possible improvements for the peer assist process.

2.3.4.2.8 Step 8: Package the Peer Assist Report

1. Compile the Peer Assist Report and distribute (Facilitator) as can be seen in appendix G.
2. Communicate the learning aspects to the wider Community of Practice (Interest Group) via the report (Facilitator).
3. Execute the actions as per the Peer Assist Report (Home Team) as can be seen in appendix G.

2.3.5 Case study literature conclusion

Sasol has a number of quality management systems currently in place that ensure that knowledge is transferred within the company. The engineering health of a project can be determined and evaluated to ensure that the quality at any given time is in a good state.

There are various companies within the Sasol organization, which range from Group Technology, South African Operations and Research and Development. Alignment between these entities regarding quality management is a complex task and proper communication of quality management exceptions should be done. Alignment within these departments regarding management, employee and human resources is also a complex task, but through the proper process, alignment, the proper knowledge transfer between companies and sub-divisions, continuous improvement and knowledge retention can be achieved.

Some of the shortcomings that I have encountered while doing research on the Sasol quality management systems is that it is not kept up to date to ensure that there is continuous improvement within the company. It was also very difficult to access the correct procedures during the study.

2.4 Final Conclusion

ISO standard, Lean manufacturing, TQM and Six Sigma implementation has been a norm as companies focus on becoming more efficient. The global market has become very competitive and inefficiencies can be the turning point between being profitable or not. Through implementation of all these quality management systems within the company, there can be a focus on various aspects that create inefficiencies and waste. These processes can then be addressed to ensure that the company stays competitive.

As can be seen in the literature study, not only one quality management system can be isolated as the best because each system focuses on a different aspect of the company. As can be seen in the literature and case study conclusions, section 2.3.5 and 2.2.11, it is important to do proper integration between the methodologies and the company itself as each company has different needs in the current environment that they are operating in.

Through proper knowledge retention and transfer between employees, a company can ensure that they do not have repeated past mistakes but there are lessons learned where culture and progress is made regarding the implementation of quality management systems.

This case and literature study examine the extent to which the implementation of integrated management systems impact business performance of the organizations. The quality management systems implementation within the organization will demonstrate that a commitment to quality, environment and health and safety according to international management standards, have a great effect on organization's performance. Closer examination of quality management systems shows that there is a correlation between standardization and effective risk management systems in organizations as Sasol takes a risk-based approach when making business decisions. If proper maintenance of quality management systems is done, the risk of lack of knowledge within the company can be mitigated.

Avoiding and mitigating risks in company's processes are directly linked to mitigation of nonconformities of all kinds. And through the proper implementation of quality management systems, nonconformities can be minimized. Therefore, the increased maturity of risk management systems through proper quality management systems, Sasol can generate better performance.

3. EXPERIMENTAL DESIGN

3.1 Introduction

The high-level aim of the research as described in chapter one “Establish the impact of restructuring and staff reduction on the quality management function and to identify the inhibiting factors that impact the successful implementation of quality management and recommend corrective measures so that the desired quality deliverables are achieved.”

The aim of this chapter is to give the details of the deployment and design of the research experiment. The experimental design will be used to conclude the relationship between dependant and independent quality management relationships within the organization. It will also explain the methods chosen for the experimental design and how the data was collected.

3.2 Experimental Method

There are three very widely used types of design, quantitative, qualitative and mixed methods. “Often the distinction between qualitative and quantitative research is framed in terms of using words (qualitative) rather than numbers (quantitative) or using closed-ended questions (quantitative hypotheses) rather than open-ended questions (qualitative interview questions).” (Creswell J. W., 2009). Either method can be used to collect data quantitatively through the utilization of instrumentation opposing qualitative data collection through observation.

Historically, there has been a progressive improvement in all three method studies. The quantitative method was most utilized during the 19th century up until the middle 20th century. During the second half of the 20th century, the use of qualitative methods became more popular that also resulted in the mix of the two methods that is known as the mixed method.

For this research the qualitative, quantitative methods and mixed method and can be defined as:

Qualitative Method: The explorations and understanding the human or social problems ascribed to groups or individuals. Questions and procedures are formulated to participants and used to collect data; this is then analysed through building themes and particular observations; this data is then interpreted to make a meaningful conclusion. This type of method is more flexible in nature. It is an inductive method, focusing on individual meanings and can make difficult and complex situations more tenderable (Creswell J. W., 2009).

Quantitative Method: Being objective in testing theories by examining relationships between different variables. Instrumentation is the main source of data collection that can be measured, through this numerical data collection, the variables can be measured and quantified. The method has a certain structured nature and comprises out of an introduction, literature study, theory, method, results, discussion and conclusion. One has to clearly define the assumptions in this type of method to guard

against biased conclusions, making alternative explanations possible that can be generalized and replicated (Creswell J. W., 2009).

Mixed Method: This type of method combines qualitative and quantitative methods. Assumptions are made and the combinations of the two methods comes to an observable but numerical quantitative result. This type of method has a greater impact as it can be related to both man and machine, which makes the conclusion much more powerful in meaning.

For this research the mixed was used, with more focus on the quantitative method through the design of a survey that aimed specific questions to collect meaningful data that could be interpreted. This method makes collecting data fast and effective as quality management is used in across the whole organization and between different business units. It makes for much better wide spread interpretation that can offer better understanding.

The aim of this data collection is to identify gaps in the quality management system and how these gaps influence the implementation of quality management in the organization. It is important to understand the views and opinions of the personnel and so using the human element of the qualitative method makes the understanding of the impact on current quality systems more recognizable. This was achieved by posing specific questions with open ended and opinionated design.

3.3 Survey Design

For the survey design it is very important to accurately get data from both quantitative and qualitative inputs. A questionnaire will be used to get data input. As can be seen in figure 28 it is a combination of method and methodology and the impact that they have on one another. As can be seen in appendix A, the survey design is shown. None of the participants could see the scoring of the questionnaire to not create any bias during conducting the survey.

Taking the literature and case study, as discussed in chapter two, material into account during the design of the survey it can be based on clear proven material.

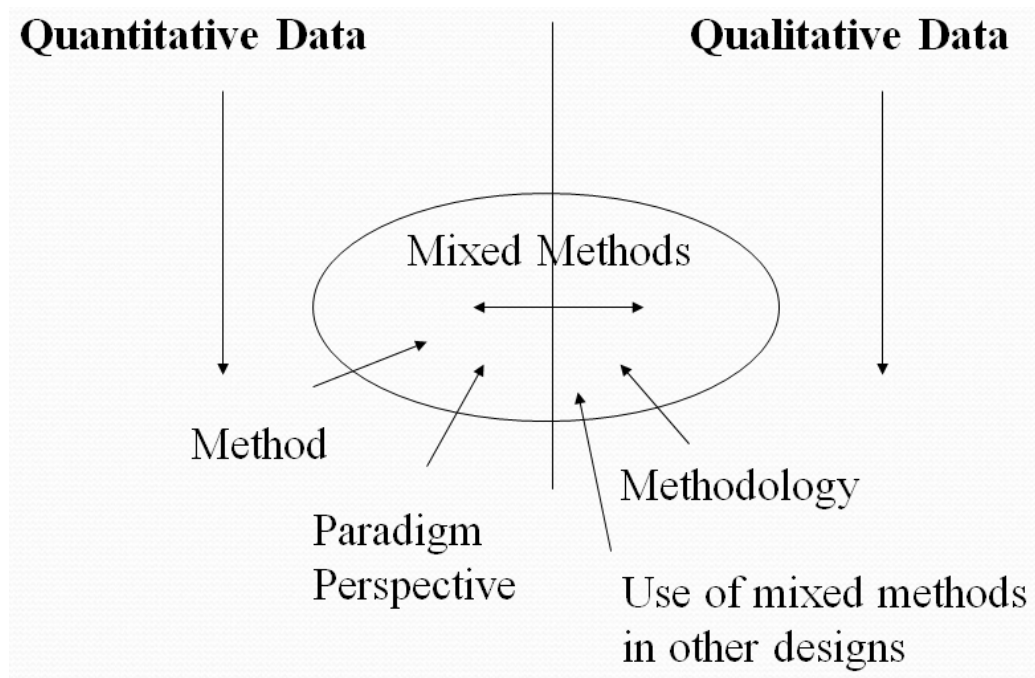


Figure 28: Mixed method design

- **Introductory Section:**

The structure of the survey is very important, so it can clearly define the required information from the participants. This will give a clear description and aim to the participants and an instruction of what information is needed.

- **Quantitative Section:**

The aim is to clearly define the methodology, the design will use a clear set of questions that will investigate the key areas of the impact of restructuring on the organization personnel in the area of quality management and what the current gaps are in the quality management within the organization.

During the identifying the research design the following areas were focussed on:

1. The investigation of how quality management is currently approached in the organization and what the degree of how quality management is perceived. It is important to identify how the current behaviour and culture of the organization is.
2. The investigation of what quality management gaps there are in the organization and what factors are present that could block the successful implementation of quality management.
3. The investigation of current knowledge transfer gaps and what factors are present that could cause information to not be transferred between individuals within the organization.

Key focus areas have been identified to assist in defining the analysis of the required data as per the three points earlier in the section. Using the literature study and organization structure the following sections have been identified.

1. Leadership commitment and accountability
2. Planning initiatives
3. Infrastructure availability
4. Focus & roll-out of procedures
5. Measurement of the
6. Training of personnel
7. Resources availability
8. Information and communication
9. Internal systems alignment
10. Client alignment

These points will serve as the ten variables that will be used during the analysis of the study. The points will be the high-level research measurement areas and the questions will be based on these headings. From these ten dimensions, statements will be made under each category considering the literature and case study.

A rating system will be used to get participant feedback for each statement that will serve as the implementation of the dimensions.

For the purpose of data analysis, the measurement of data can be defined in the following four areas: (Simon, 2013)

Normal scale: For this type of scale, discrete units or categories are used. This can be, for example, gender, ethnic groups, the colour of an object etc.

Ordinal scale: For this type of scale, values are evaluated from more or less, large or small. The sizes of the intervals are not specified. This can be, for example, ranking scales or rating scales. The Likert-type scale is an example of this type of data.

Interval scale: This type of scale measures the degree of difference but without a specified zero point. This can be, for example pressure or exam results. For this type of scale ratios are not applied.

Ratio scale: This type of scale a zero point is used and is measured in equal intervals. This can be, for example, the weight or height of an object.

It is important to remember that one level of measurement should not just be used for the lower level but also for the higher level.

For this research study, the use of Likert-type scales can give you a measurement of perception in different levels of measurement. Likert-type scales are designed with a range from agreement to disagreement. It is constructed in a way that the categories move through unit increments that are specified. Likert-type allows the evaluation and measurement of perception or attitudes toward a statement that quantifies the data.

Likert-type of scale measurement systems must accommodate at least a five to seven category intervals. Fewer numbered points in the Likert-type scale can result in the departure from the assumption of normal distribution. The Likert-type original design did not take into account the number of choices, an important focus point and he stated that “if five alternatives are used, it is necessary to assign values from one to five with the three assigned to the undecided position” (Likert, 1932).

For this study, it is important to remember that the degree of understanding between different respondents may differ and the statement/questions should be kept as simple and as short as possible. To ensure that there is no confusion during the interpretation of the question, it is important to not make the questions open ended or leading.

- **Qualitative Section:**

For the purpose of gathering additional data, the research has included a short section that assists in gathering opinions regarding quality views of the organization through open ended questions. This gives the respondent the platform to provide additional data that is not covered in the survey.

- **Biographic Information:**

Due the different seniority levels within the organization, it is important to collect data from different experience levels. The following categories of seniority levels were used in the collection of data:

1. **Junior Engineers / Engineers in training:** An employee who is qualified to become a registered, professional engineer in all respects but the necessary professional experience is required through training and mentoring.
2. **Intermediate engineers:** An employee that can work on their own but is not ready to lead, manage, mentor, or teach.
3. **Senior engineers:** An employee, who can lead small teams, knows what they (themselves) are doing and can act within a group or on their own with a bit of supervision.
4. **Middle management:** An employee of an organization or business who manages at least one subordinate level of managers, and reports to a higher level of managers within the organization. The duties of a middle manager typically include carrying out the strategic directives of upper-level managers at the operational level, supervising subordinate managers and employees to ensure smooth functioning of the enterprise (Dictionary, Business Dictionary, n.d.).
5. **Senior management:** A group of high-level executives who actively participate in the daily supervision, planning and administrative processes required by a business to help meet its objectives. The senior management of a company is often appointed by the corporation's board of directors and approved by stockholders (Dictionary, Business Dictionary, n.d.).
6. **Other:** These are any other personnel in the organization group. This was constructed to be able to get information from all sample sets in the bigger organization.

3.4 Survey Validity

“Validity is often defined as the extent to which an instrument measures what it purports to measure. Validity requires that an instrument is reliable, but an instrument can be reliable without being valid” (Winterstein, 2008).

It is very important that confidence in the survey be measured. This can be achieved by sending the survey to a test group that will be able to comment and give opinions about the structure of the survey.

For this study, the survey was sent to a controlled group to give input on the survey and ensure that the validity was achieved for the qualitative and quantitative constructs. The control group consisted out of an individual from each stated level of experience as discussed in the biographical information section. The comments that the controlled group issued were incorporated into the survey.

3.5 Study Population

The study population used for this research consisted of various departments within Sasol, Sasolburg region. It consisted out of Technical support (Group Technology), production and maintenance personnel (Operations). Operations personnel are more involved in the day-to-day running of the facilities, whereas the Group Technology personnel is involved in the Research and development and engineering. The study population consists out of approximately 290 individuals. The population information and details can be seen earlier in this chapter

The population consists out of junior, intermediate and senior engineers, middle management and senior management. The population information can be seen in table 6.

Table 6: population make-up

Population	Size	Departments
Junior engineers	75	52 – Group Technology/R&D 23 - Operations
Intermediate or Senior engineers	152	110 – Group Technology/R&D 42 - Operations
Middle management	37	21 – Group Technology/R&D 16 - Operations
Senior management	26	18 – Group Technology/R&D 8 - Operations
Total	290	---

Table 6 gives an indication of population size as well as size between different departments that includes Group Technology and Operations.

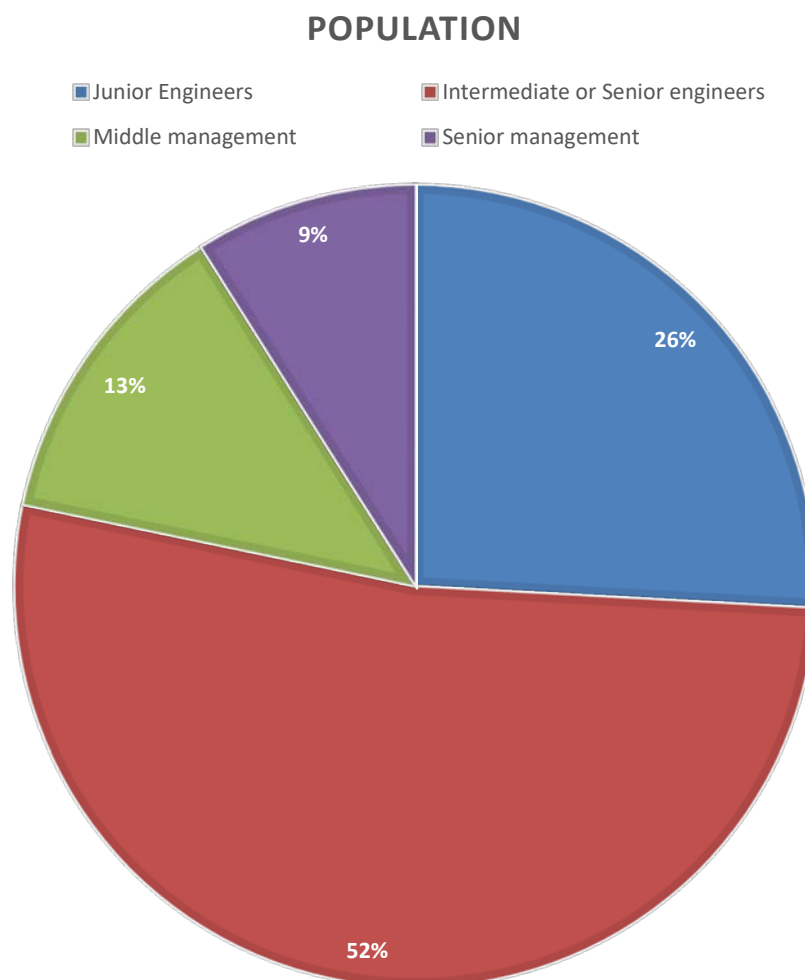


Figure 29: Population percentage

Figure 29 indicates the percentage split of the population. The selection was done in such a manner to give the most realistic indication of the total Sasol population. The total population size was selected in such a manner to take into consideration a low response rate and to ensure that the data will still be valid for a low response rate.

Figure 30 indicates the percentage split between the various departments that includes Group Technology and Operations. The Department selection was done in such a manner to give an analysis mainly of the technical department but also taking into account the operations department.

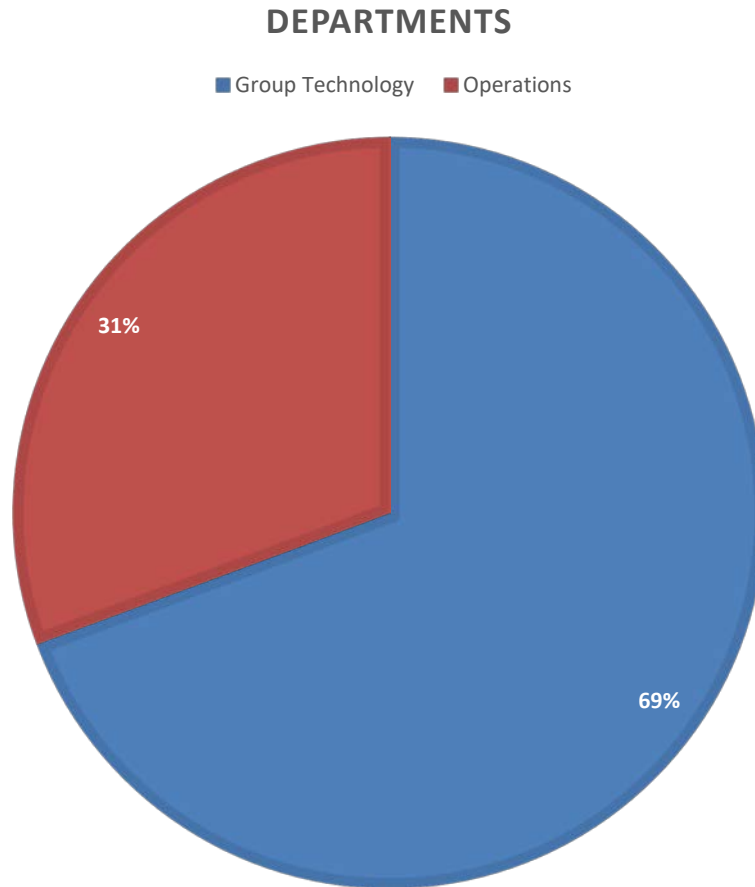


Figure 30: Department Percentage

3.6 Data Collection and Analysis

The data collection was done electronically by means of an online survey services company, Survey Monkey. The survey platform gives dynamic charts that can be visually analysed, giving statistical data.

Statistical software (MedCalc) was utilised to assist with the analysis of the quantitative data. The tests conducted included standard deviation, mean and Cronbach's alpha.

3.7 Summary and conclusion

Quantitative research methods are those methods in which numbers are used to explain findings. Quantitative research methods would be used in situations in which the researcher wants to study how a specified variable affects another, disregarding the effects of other variables. Such a method is suitable in the sciences, and quantitative methods have been used in the sciences for a really long time compared to the other research methods (Powoh, 2016).

Contrary to quantitative research methods, qualitative research methods have been in existence only for a few decades. Rather than using numbers, qualitative research methods use descriptive procedures to generate meaning and understanding of the phenomenon being studied. Open ended questions are used, rather than closed ended in quantitative methods. This method could be employed if the researcher is not certain of which variables to control (Powoh, 2016).

Through utilising the qualitative and quantitative methods a broad understanding of the required experiment can be achieved. The mixed method combines quantitative and qualitative methods in the same study in order to get a full understanding of the phenomenon under study. The main assumption is that when an inquirer combines both quantitative and qualitative methods, it provides a better understanding of the problem than using either method alone.

In conclusion, research methods can either be quantitative, qualitative or mixed. A mixed method combines both qualitative and quantitative elements to produce a better research quality by eliminating the biases inherent to either quantitative or qualitative methods alone. Should a researcher prefer to incline more on quantitative or qualitative methods, their choice should depend on the nature of the phenomenon being studied, what they want to know about the phenomenon, and their goals. It should, however, be noted that a research can neither be purely quantitative nor purely qualitative as there will always be some elements of both (Powoh, 2016).

For this study it is very important that both numerical and open-ended questions are utilised as it gives a better understanding of specific focus areas that need to be improved on. Through selection of a wide variety of population one can ensure that one specific target group is not isolated and that information is gathered from various experience and knowledge levels within the organization.

4. PRESENTATION AND DISCUSSION OF RESULTS

4.1 Introduction

The results of the survey data will be discussed in this chapter. It gives a detailed interpretation of all data collected through the participants. The constructs as discussed in chapter 3 were used as a measurement guideline to investigate the required problem statement.

For the interpretation of the results, the data was analysed and discussed in this chapter, verification of the results were also analysed to ensure that the experimental design requirements were satisfied.

As the survey was constructed out of a qualitative and quantitative, mixed method structure the first section of this chapter will focus on the quantitative results followed by the qualitative discussion. The recommendations that are devised from the survey

The survey was comprised out of 43 questions. Where 39 questions were quantitative and four were qualitative.

4.2 Participation Rate

The participation rate is as per table 8. A total number of 57 survey replies were received. Table 6 gives an outlay of the biographical population. A 19% response rate was achieved, a total of 290 surveys were sent out. A 19% response rate was acceptable as there was a good balance between the various populations and made an accurate interpretation of the results. As discussed in chapter one, due to various time constraints, a bigger population could not be approached to get a more refined analysis.

Table 7: Survey participation rate

	Number of Survey Replies	Percentage of Total Sample set
Junior Engineers / Engineers in training	14	24.56%
Senior or Intermediate engineers	23	40.35%
Middle management	8	14.04%
Senior management	6	10.53%
Other (please specify)	6	10.53%

4.3 Analysis of Results

The Likert-type scale was used to gather the data from participants as can be seen in table 8. Each question had a 5-point scale that can be interpreted as follow:

Table 8: Survey question scale

Description	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Weight	1	2	3	4	5

4.3.1 Overall Mean Data:

The survey was constructed out of 8 sections. Section 1 to 7 was quantitative sections and section 8 was for open ended questions that retrieved qualitative data.

As discussed, the data was interpreted around a neutral axis, with a mean value of 3, where the top section of the graph, mean value 3 to 5, shows agreement to the question and the bottom section of the axis, mean value 1 to 3 shows a disagreement to the question. The data was retrieved from the entire sample population. The mean data for each section of questions care given in the following figures:

1. Mean survey score values for all question:

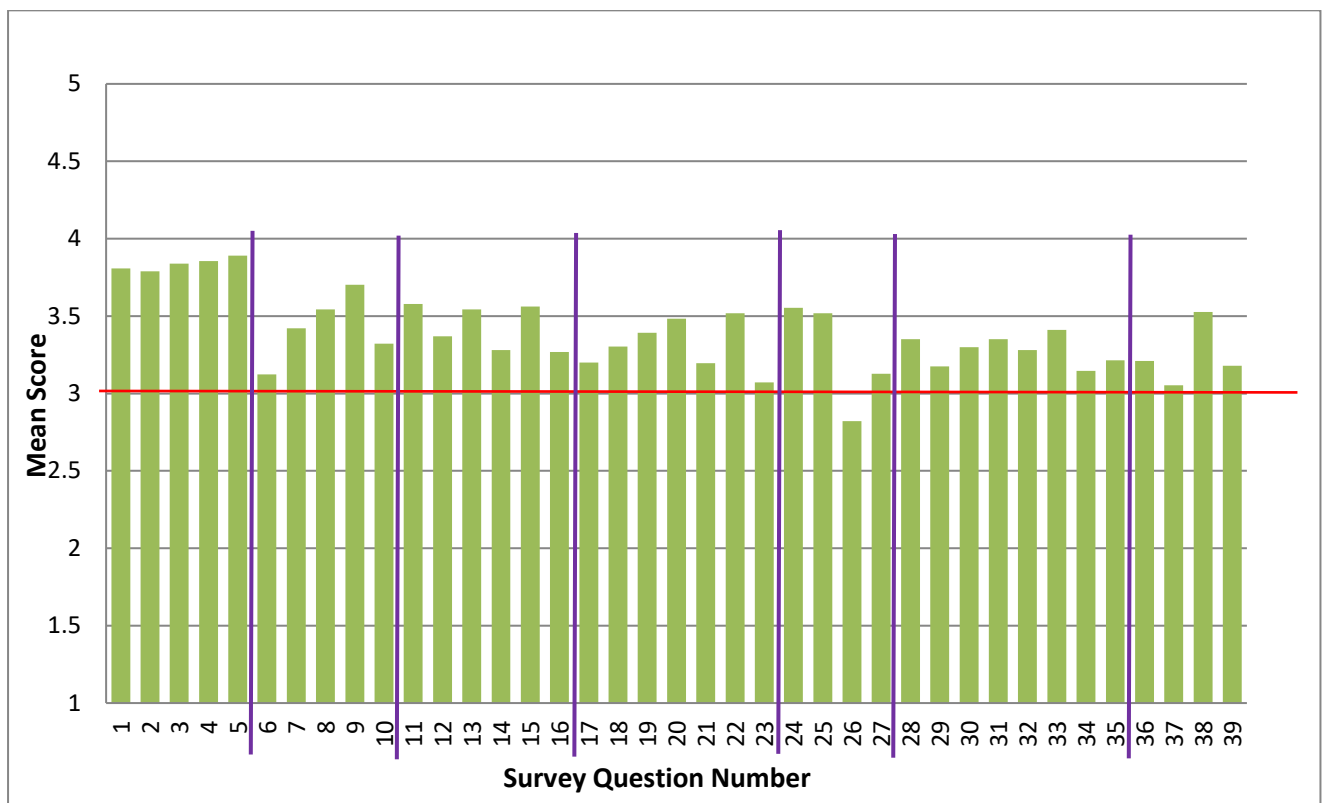


Figure 31: Mean survey scores per question

As can be seen in figure 31 there was an overall high score in the “leadership commitment and accountability” that included question 1 to 5. With the lowest average score construct “resource availability” question 28 to 35.

Overall all the question scored a positive value higher than the mean of 3. Except for question 26, “I have been trained in how the quality management systems work at the company”. There were also three other questions that scored relatively close to the

mean and included question 6 “The Company gathers and reviews data effectively from its employees when developing quality management systems.”, 23 “Has the quality focus decreases since the implementation of the phoenix structure at the company” and 37 “The Company communicates quality management strategies to the client’s projects”

Interpretation:

The above information indicates that leadership does have commitment and accountability but overall there is a resource constraint within the company. It can be seen that there is lack of training of the personnel in quality management systems. There is also a noticeable indication that the quality perception has dropped since the implementation of the Phoenix structure and there is a lack of communication and data gathering during development of QMS’s.

2. leadership commitment and accountability

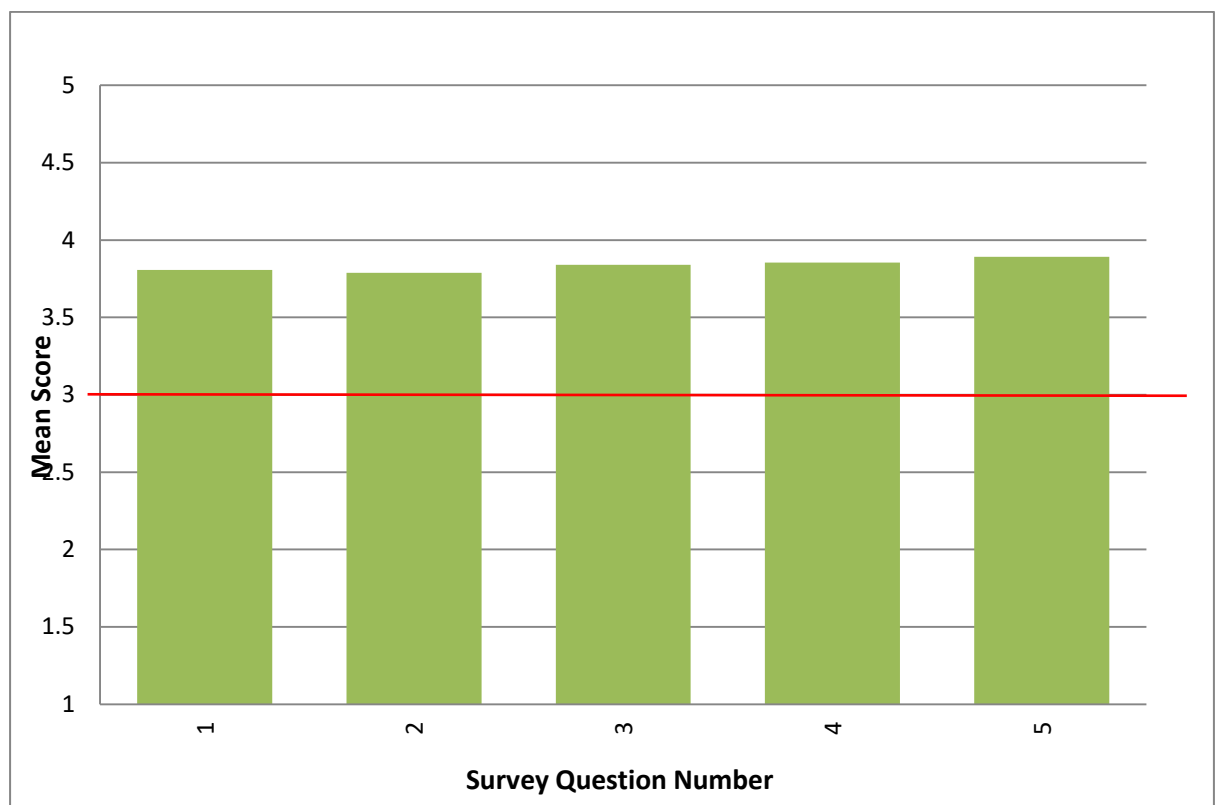


Figure 32: Mean data for leadership commitment and accountability

As can be seen in figure 32, the overall scoring of the leadership commitment and accountability section was highest of all the sections. Question 5 scored the highest “Leadership communicates expectation towards quality management at the company” and question 1 “Leadership demonstrates long term commitment to quality management at the Company” and 2 “Leadership demonstrates and lives commitment towards quality management at the company”.

Interpretation:

This indicates that leadership does communicate quality expectations but there is a lack of long-term commitment and living the quality expectations from leadership within the company.

3. Planning initiatives

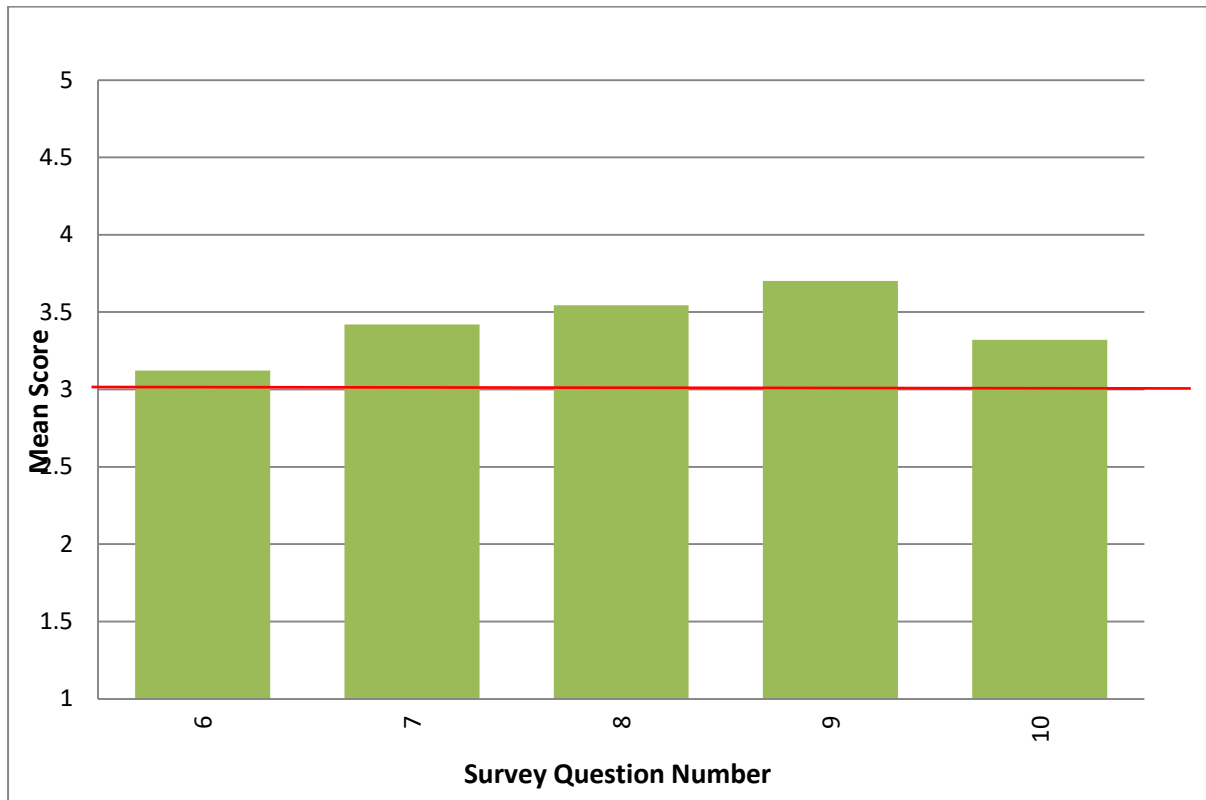


Figure 33: Mean data for planning initiatives

As can be seen in figure 33, question 9 scored the highest “The Company assigns accountability when implementing quality at the company”. Whereas question 6 scored the lowest “The Company gathers and reviews data effectively from its employees when developing quality management systems” for the planning initiative section.

Interpretation:

This indicates that the company does assign accountability when implementing quality but is not very effective at gathering and reviewing data during the development of these systems.

4. Infrastructure availability

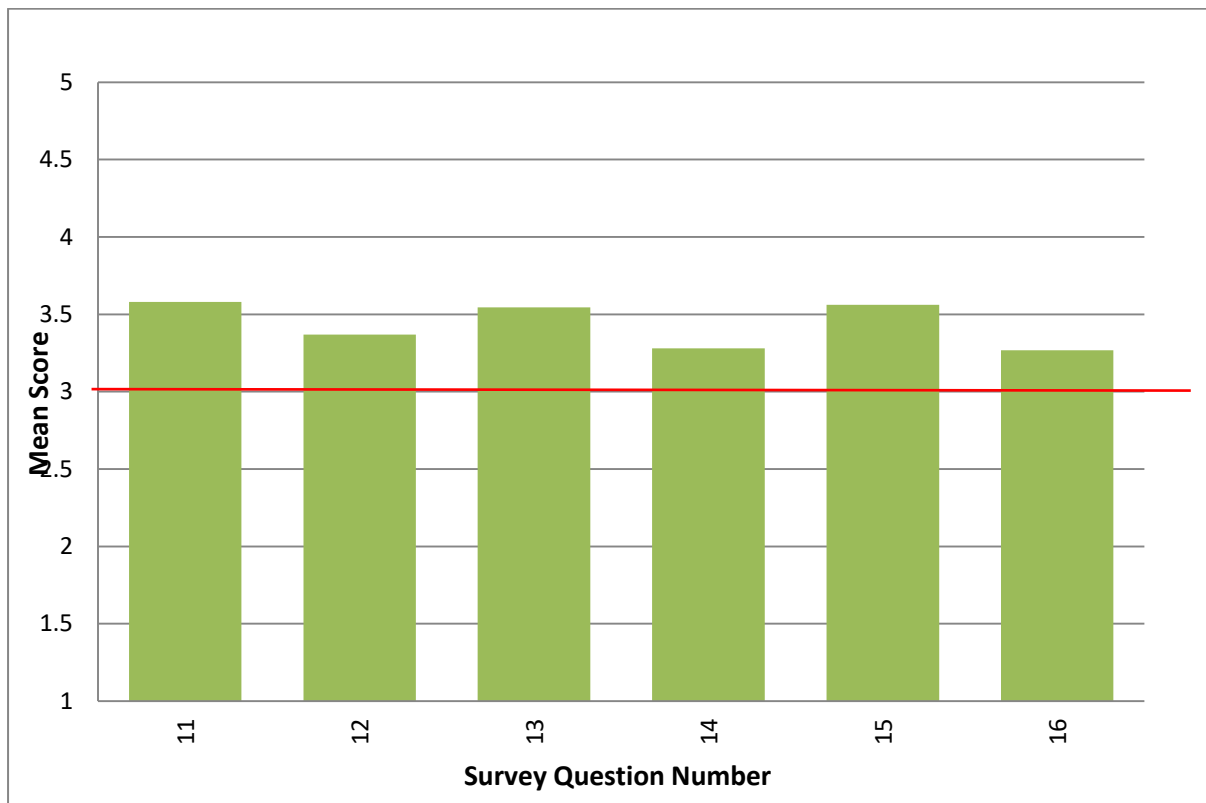


Figure 34: Mean data for infrastructure availability

As can be seen in figure 34, question 11 scored the highest “The Company develops quality management procedures effectively” with the lowest scoring question 14 “The Company creates functional quality management infrastructure effectively” and 16 “The Company develops processes to monitor quality management effectively” in the infrastructure availability section.

Interpretation:

This indicates that the company develops quality management procedures effectively but there is a lack of functional quality management structures and monitoring of these systems within the company.

5. Focus and roll-out of procedures

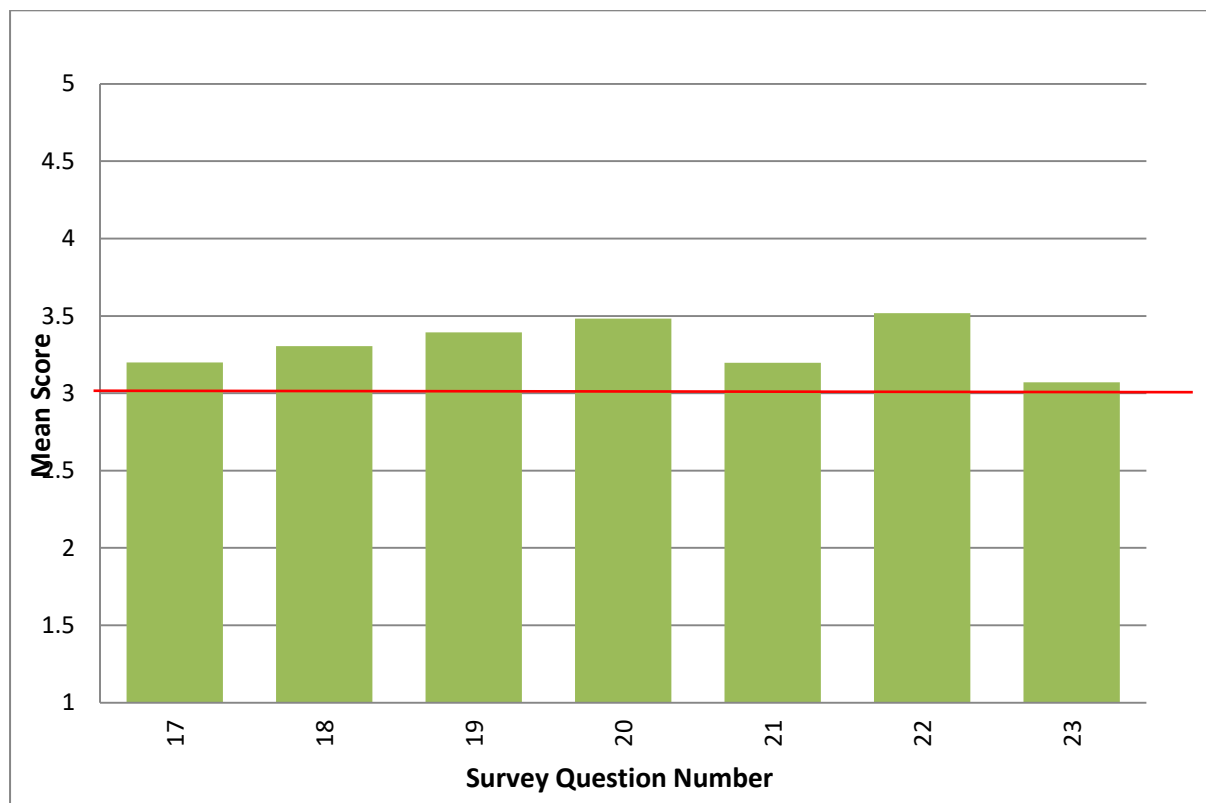


Figure 35: Mean data for focus & roll-out of procedures

As can be seen in figure 35, question 22 scored the highest “The Company sets stretched objectives for focusing on cost versus quality during execution of quality management”. With the lowest scoring question being 23 “Has the quality focus decreases since the implementation of the phoenix structure at the company” in the focus and roll-out of procedures section.

Interpretation:

This indicates that the company sets stretched objectives regarding taking quality and cost into consideration during quality management and that the focus on quality has decreased after the implementation of the phoenix restructuring process. Taking question 21 and 17 into account there is an indication that the company struggles to roll out complex quality management systems and that there is a lack of a roll out plan.

6. Training of personnel

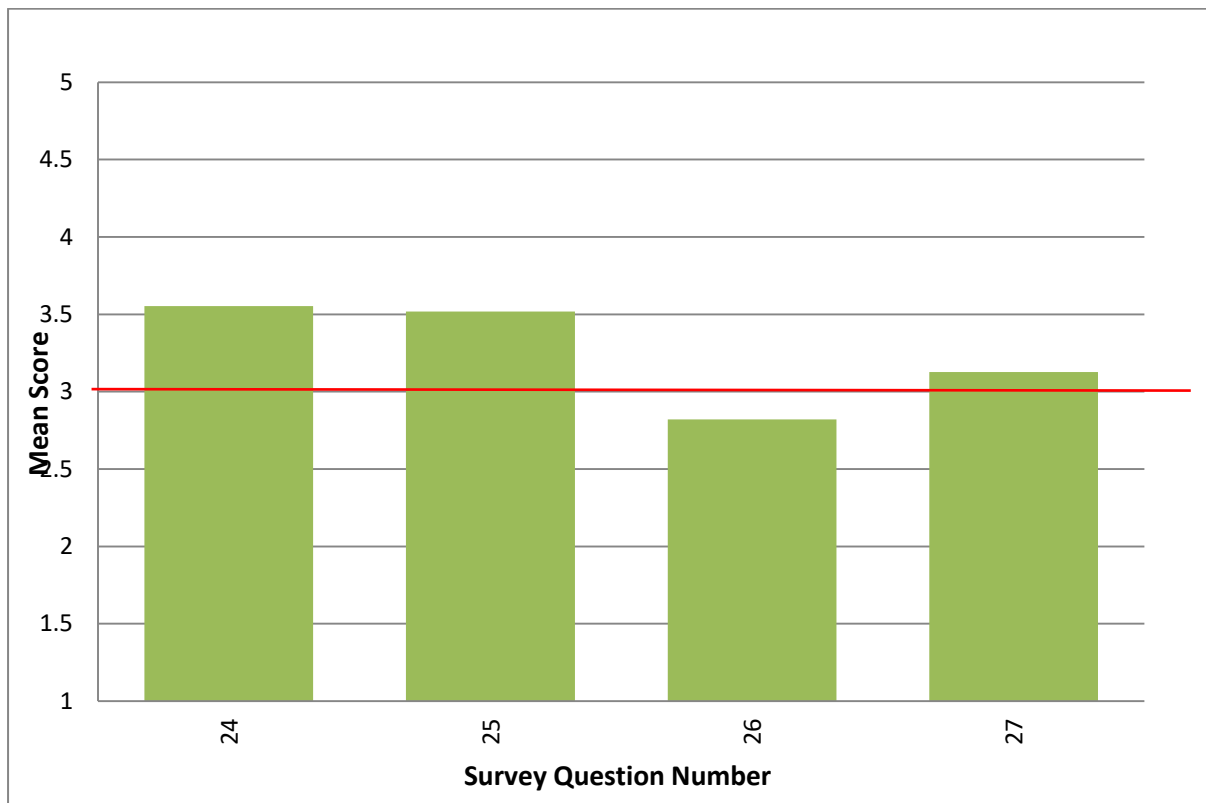


Figure 36: Mean data for Training of personnel

As can be seen in figure 36, question 24 scored the highest “I am aware of how the quality management system works at the company”. The lowest scoring question was 26 “I have been trained in how the quality management systems work at the company” in the training of personnel section.

Interpretation:

This indicates that there is an awareness of how the quality management systems work within the company but that there is a lack of training of the personnel within the company. Taking question 27 that also scored very close to the mean there seems to be a lack of mentorship for quality management systems within the company.

7. Resources availability

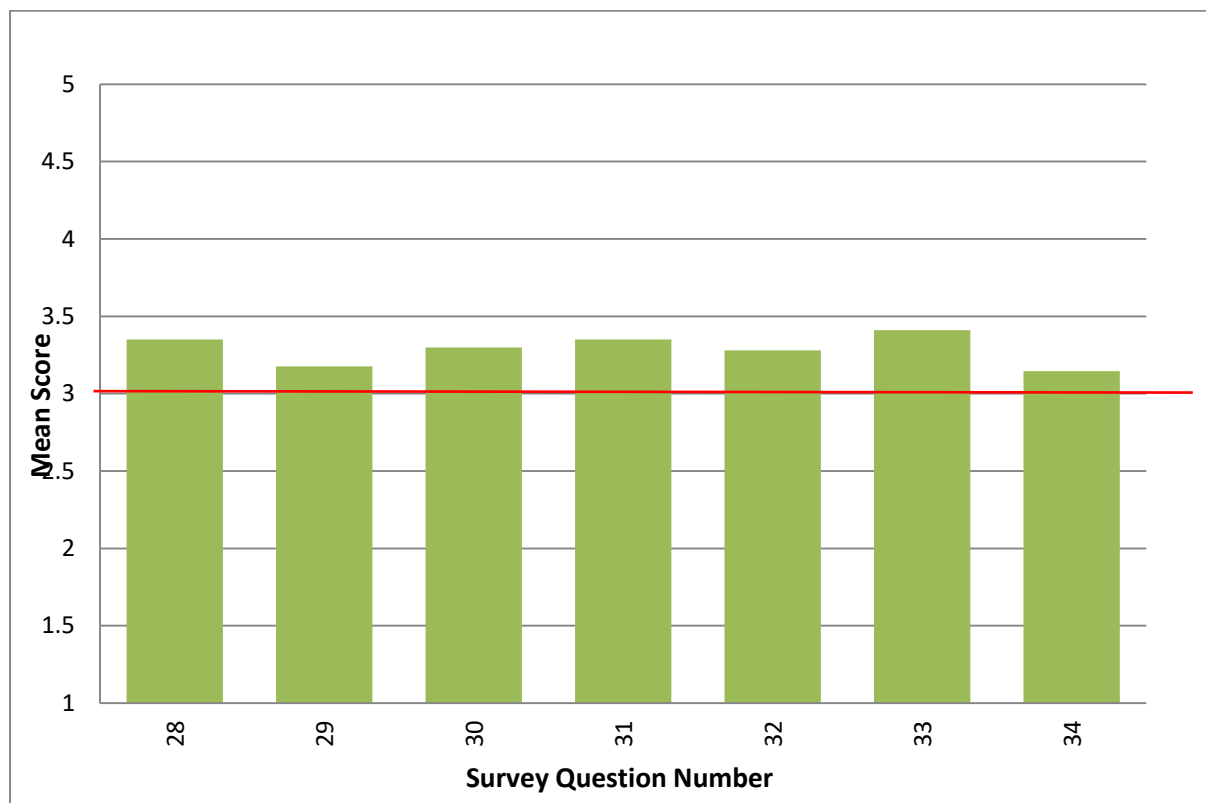


Figure 37: Mean data for Resources availability

As can be seen in figure 37, question 33 scored the highest “The Company considers the needs of clients when allocating resources for projects effectively”. The lowest scoring questions were 29 and 34 “The Company provides required personnel to implement quality management” and “The Company benchmarks its quality systems against other companies’ effectively” in the resources availability section.

Interpretation:

This indicates that the company does focus on the client’s needs when allocating resources but that there is a lack of personnel that can implement the quality management systems. The company also seems to be lacking in benchmarking itself against other companies effectively.

8. information and communication

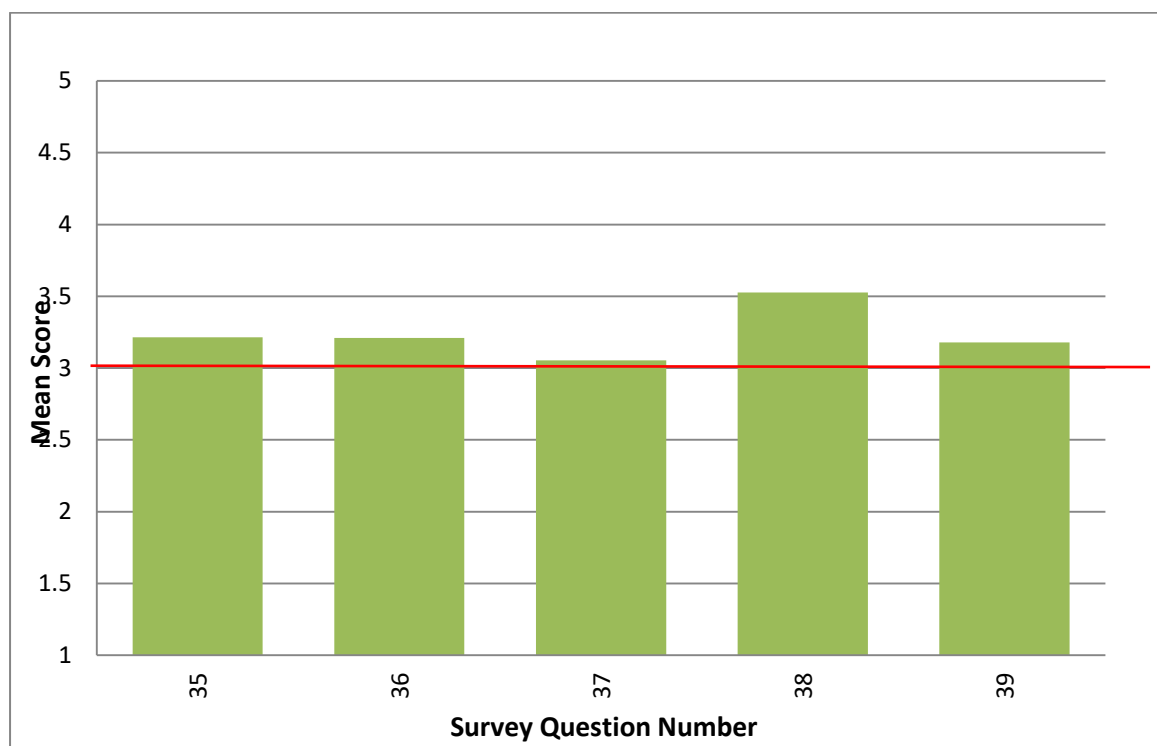


Figure 38: Mean data for information and communication

As can be seen in figure 38, question 38 scored the highest “The Company communicates a statement from senior management regarding commitment to quality management”. With the lowest scoring question being 37 “The Company communicates quality management strategies to the client’s projects” in the information and communication section.

Interpretation:

This indicates that the company does communicate from senior management the commitment regarding quality but that there is a lack of communication of quality management strategies within the organization.

The top 10 positively scored questions are summarized in a descending order in table 9, from “Strongly Agree” to “Agree” order. These questions are shown with the mean data as well as the standard deviation. It is important to be able recognise the positive questions as it gives you a good indication of areas where the company is performing well and should be maintained.

Table 9: Positively scored questions

	Question:	Mean Score	Standard deviation
5	Leadership communicates expectation towards quality management at the company?	3.89	0.81
4	Leadership enforces quality management at the company?	3.85	0.83
3	Leadership focuses on quality management at the company?	3.84	0.73
1	Leadership demonstrates long term commitment to quality management at the Company?	3.81	0.81
2	Leadership demonstrates and lives commitment towards quality management at the company?	3.79	0.67
9	The Company assigns accountability when implementing quality at the company ?	3.70	0.91
11	The Company develops quality management procedures effectively?	3.58	0.73
15	The Company develops processes to monitor quality management effectively?	3.56	0.85
24	I am aware of how the quality management system works at the company	3.55	0.83
8	The Company develops a plan to achieve long term goals effectively?	3.54	0.93

The top two positive areas were in sections:

1. Leadership commitment and accountability
2. Planning initiatives

There was only one negatively scored question as can be seen in table 10. This question is shown with the mean data as well as the standard deviation. It is important to be able recognise the negative questions as it indicates development areas where improvements can be made. This negative rated question was in section “Training of personnel”

Table 10: Negatively scored questions

	Question:	Mean Score	Standard deviation
26	I have been trained in how the quality management systems work at the company	2.82	1.01

The top five lowest positively scored questions are summarized in a descending order in table 11 from “Strongly disagree” to “disagree” order. These questions are shown with the mean data as well as the standard deviation and are located very close to the mean - mean score difference < 0.15. It is important to note that these questions show a very close “Neutral” sentiment towards question.

Table 11: Close to neutral scored questions

	Question:	Mean Score	Standard deviation
34	The Company benchmarks its quality systems against other companies' effectively?	3.15	0.83
27	I have mentorship available to me to guide me on how quality management is executed at the company	3.13	1.11
6	The Company gathers and reviews data effectively from its employees when developing quality management systems?	3.12	0.83
23	Has the quality focus decreases since the implementation of the phoenix structure at the company?	3.07	0.99
37	The Company communicates quality management strategies to the client's projects?	3.05	0.75

The top two close to neutral were in sections:

1. Focus & roll-out of procedures
2. Information and communication

4.3.2 Results According to Constructs:

For each of the seven constructs the mean data was calculated. The mean data for all the constructs were analysed for the total sample set and population. It was also split up into each geographical population to ensure that the differences between each population can also be analysed.

Figure 39 indicates the mean data for each construct for the entire population. This data is analysed through the mean data and standard deviation per construct.

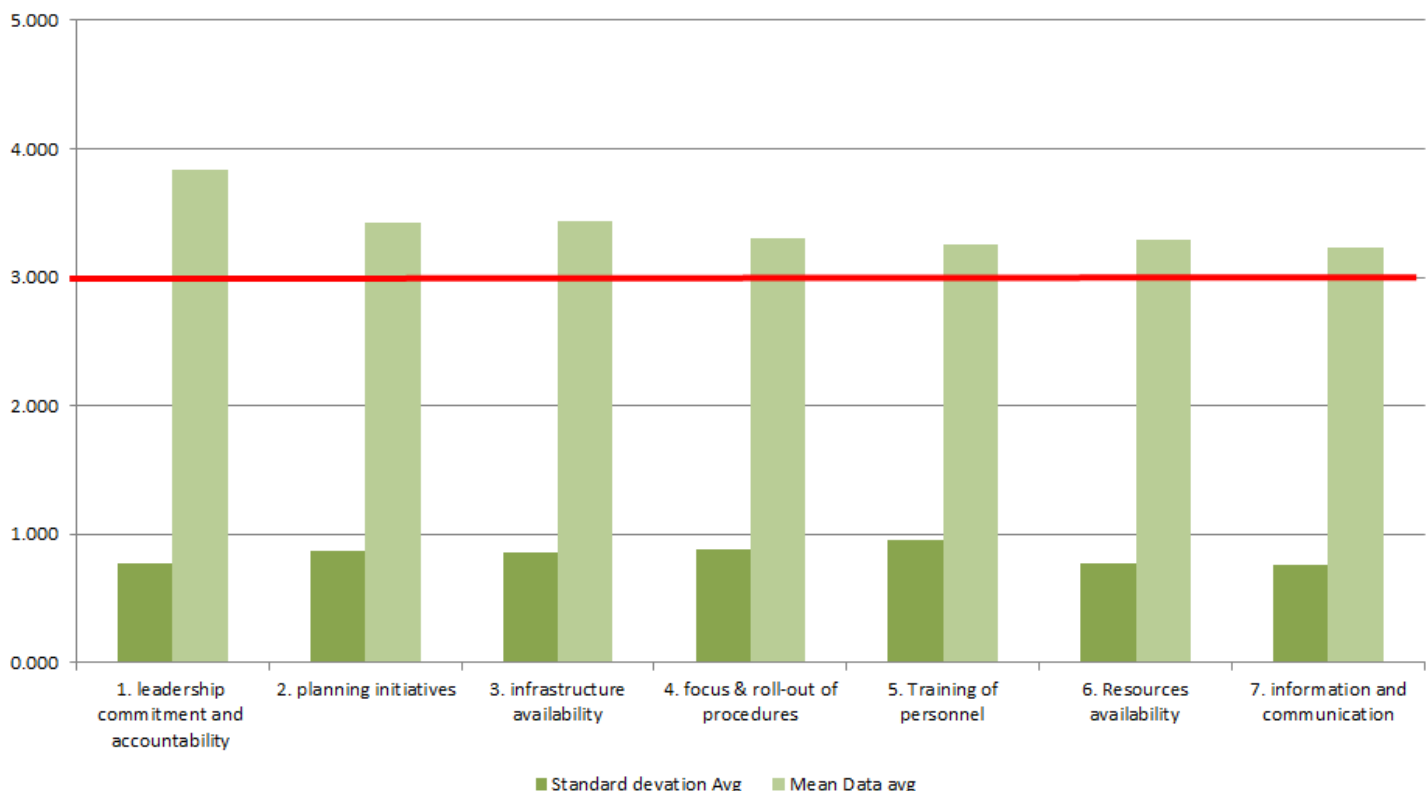


Figure 39: Mean data per construct for entire population

As can be seen from figure 39 there are no constructs that score negatively, this means that it is a construct with a weight less than 3. All the constructs scored positively, with a weight of 3 or more. As can be seen the “training and personnel” construct had the highest standard deviation of all the constructs.

For the investigation of the hypothetical differences in the population the analysis of the construct was extended between the different population sample sets. These population sample sets were broken down into four categories as per the geographical population as discussed on chapter 3:

1. Junior Engineers / Engineers in training
2. Intermediate and Senior engineers
3. Middle management
4. Senior management
5. Other

The mean data was calculated for each population group and is represented in figure 40 together with the total population sample set.

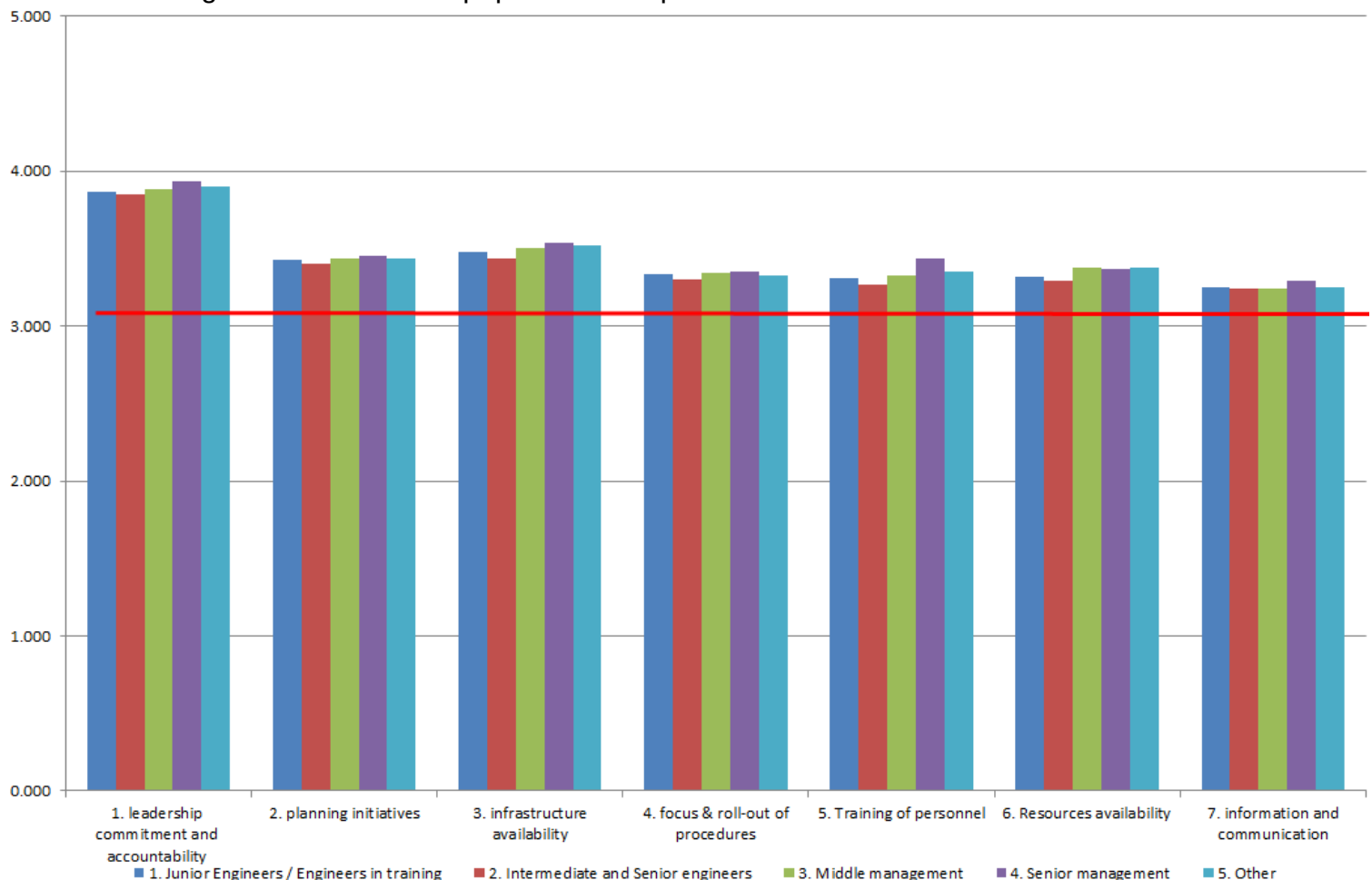


Figure 40: Mean score per population group.

Table 12: Mean data for population and constructs

	1. leadership commitment and accountability	2. planning initiatives	3. infrastructure availability	4. focus & roll- out of procedures	5. Training of personnel	6. Resources availability	7. information and communication
1. Junior Engineers / Engineers in training	3.868	3.424	3.482	3.331	3.310	3.318	3.252
2. Intermediate and Senior engineers	3.849	3.405	3.434	3.302	3.265	3.290	3.242
3. Middle management	3.884	3.440	3.501	3.341	3.329	3.374	3.244
4. Senior management	3.933	3.455	3.535	3.348	3.439	3.371	3.290
5. Other	3.896	3.439	3.525	3.330	3.350	3.379	3.253

As can be seen in figure 40 there is a distinctive difference in the mean values per population group with the “senior management” population group scoring the highest and the “intermediate and senior engineer” population group scoring the lowest.

As can be seen in table 12 and figure 40, the “intermediate and senior engineer” population scored in “information and communication” constructs the lowest to the mean with a score of 3.242. The “leadership commitment and accountability” constructs measured the highest for the “senior management” population with a score of 3.933. As can be seen the “information and communication” construct measured the lowest to the mean for all populations, with the second lowest construct “training of personnel”. The highest scored construct in relation to the mean was the “leadership commitment and accountability” over all populations.

For the second demographical investigation, the population was split up into two population groups, “Management” and “Non-management” The mean data for these two populations can be seen in Figure 41.

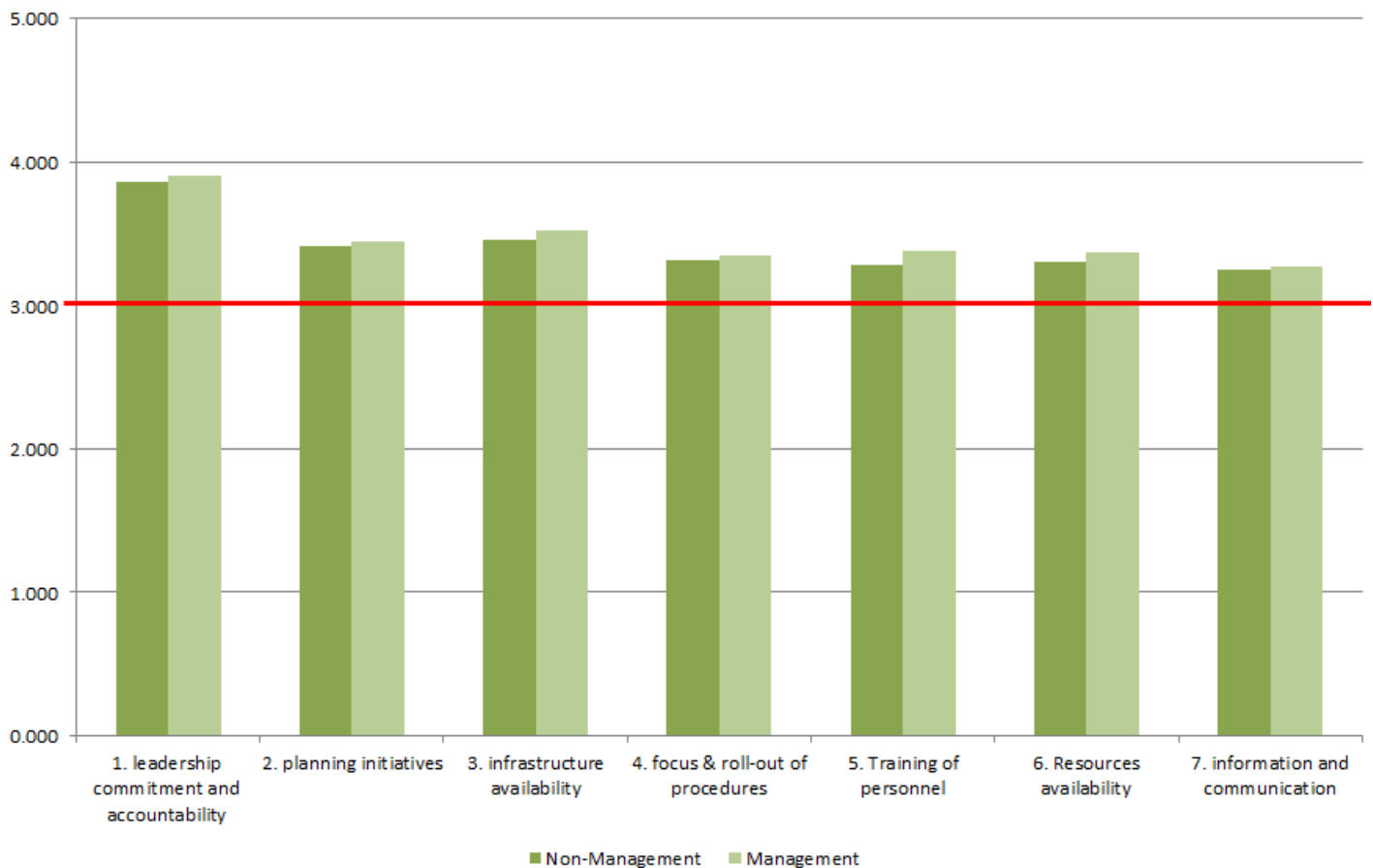


Figure 41: Mean data for "Management" and "Non-Management" populations.

Table 13: Mean data for management and non-management over all constructs

	1. leadership commitment and accountability	2. planning initiatives	3. infrastructure availability	4. focus & roll-out of procedures	5. Training of personnel	6. Resources availability	7. information and communication
Non-Management	3.858	3.415	3.458	3.317	3.287	3.304	3.247
Management	3.908	3.448	3.518	3.345	3.384	3.372	3.267

As can be seen in figure 41 and table 13, there is a distinctive difference in the mean values for the “Management” and “Non-management” population group with the “Management” population group scoring the highest in the “leadership commitment and accountability” constructs and the “Non-management” population group scoring the lowest in the “information and communication” constructs.

As can be observed over all constructs, the “Management” population scored better than the “non-management” population with the biggest standard deviation in the “training of personnel” construct.

4.3.3 Results of the Qualitative Investigation:

From section 8 of the survey, the four qualitative questions were used to gather data. This was done in the form of open-ended question to gather opinions on the various specified question. These questions were as follow:

1. In your opinion how has the restructuring impacted quality management at the company?
2. In your opinion has Company shown a commitment towards quality and communicated the goals of quality management?
3. In your opinion what are the main barriers that prevent you from implementing quality management at the company?
4. Are there any improvement suggestions that you have to better implement quality management?

For each of the sections the following answers were gathered:

Note that these answers have not been altered in any way and that it was not corrected for any spelling or grammar to ensure that the integrity of the data was kept intact.

In your opinion how has the restructuring impacted quality management at the company?

- The focus has now moved from doing a quality job to getting the job done
- We have lost a number of quality management
- Don't know, employment started after the restructuring
- I was not here before the restructure
- Some of the key positions e.g. plant mechanical trainers have been removed. This resulted in the decline in the quality of work performed by our artisans and reliance on service providers.
- It has not as we are still producing the product we did before restructuring
- Yes, it did but now there are too many extra layers of governance put in place
- Resources are stretched. There is a greater emphasis on the QA role of others (e.g. contractors) that needs to be played.
- Bad
- No Major impact
- There is actually more focus on Quality Management since the restructuring
- Very little
- Only part of the company after phoenix
- I have no point of reference as I was not around pre-restructuring of the company.
- The restructuring has improved quality management.
- I would say it stayed the same maybe improved a little bit restructuring divested other aspects like retention of key personnel in key positions
- Much greater focus with establishment of COE

- The initial phases led to a loss of focus due to the combination of various quality functions. There is now a consolidated quality function that is effective.
- Very negatively
- Depends what department or are you looking at. At GT for example quality management on projects and the focus on measuring quality outputs increased substantially. For example, the ECOE structures looking after quality deliverables specifically. Then zero-defect engineering is another example of this.
- I have only been employed since Jan 2017
- Inconsistencies in personnel together with new procedures did harm to quality management
- The focus has been on cost, thus less focus on the quality management at the company
- Was not aware of any impact
- Available resources are working much harder to maintain quality standards
- Negatively. When cutting costs, quality frequently suffers.
- Perhaps a period of uncertainty, no long run impact
- Very negative impact on the people
- No comment
- Limited human resources available to manage quality
- Increased control and micromanagement. This has lowered employee engagement
- Negatively; no specific and accountable drivers
- I was not employed at the company prior to the restructuring and hence do not possess proper insight to recent changes in quality management systems.
- Yes
- It had impacted the competency and the right resources to do quality management. Due to the fact individuals did not understand technical content the quality management was high level and superficial
- Less understanding of Quality in different areas.
- At first there was expectations that accountability will be clearly allocated. However, the reality is different. Many of those who got positions are not competent enough in their positions, thus decision making is passed on, creating delays, committee decisions or otherwise rushed decisions on the 11th hour which have negative impact on quality management.
- Poorly
- Not very positive.
- YES, lack of continuity and experience
- Negatively
- I came to the company after the restructuring, so I cannot give an accurate opinion to how it has impacted quality management
- No not directly
- Negatively - we just have the minimum restructures in place and when someone falls ill, or other initiatives needed; then there may be items that are not covered
- Improved it.
- I cannot say as I did not experience quality management prior to the restructuring.

- Put quality management under pressure as structures to support quality management were rationalised.
- Significantly. We have less people to do the same work
- No impact

In your opinion has Company shown a commitment towards quality and communicated the goals of quality management?

- There are some areas where the company and those responsible act, and other areas where there needs to be greater focus
- I don't think so,
- Not to the full potential
- yes
- Company has but in some instances employees struggle to locate the documents on the system.
- yes
- The company is definitely committed towards Quality.
- Goals have been communicated.
- To a degree
- Yes
- Yes
- Yes
- No, it does not seem to be a key focus
- Yes
- Yes
- Yes, even more so now
- yes
- Yes
- No
- Yes
- Yes
- New initiatives have been launched so there is a focus on quality management. It was communicated with roadshows by senior management.
- There is a fair level of commitment, however there is little to no communication regarding the goals
- Yes
- Yes
- Yes, the intent is shown but the execution thereof is the problem.
- Regular updates
- When it suits them, yes
- Yes - partially (less consideration for resource requirement)
- Yes
- No
- I believe the company values quality and has a strong commitment towards implementing quality management.
- Yes
- They have shown a commitment and working towards getting this embedded
- Not in all areas

- To some extent management is dealing with a great deal of stuffs resulting from the restructuring. Quality management is surely on the list but not top priority.
- Yes
- To a certain extent
- Yes
- No
- Yes
- Yes
- Yes - in words but not always in actions
- Yes.
- Yes
- No, not the same level of commitment and communication as in the past.
- Yes
- No. There hasn't changed much on the quality front. Everything is back to normal
- Cost has taken precedence over quality. There are not enough hours allowed to ensure quality. More resources will be required.
- Yes

In your opinion what are the main barriers that prevent you from implementing quality management at the company?

- Lack of resources and Silo mentality
- I think our managers themselves don't fully understand the management quality plans, so they are unable to implement them
- resources
- Shortage of key personnel to ensure implementation.
- Quality is a key focus area daily - it forms part of daily assurance
- I think people needs to be trained on QMS to have a proper understanding of the quality management system
- Limited resources -time and personnel.
- bureaucracy
- Few resources that is all very busy with their own projects and tasks.
- Lack of clear definition
- Project timeline constraints
- I do not think there are barriers, others can have different opinions
- Shortage of resources and skills
- Challenging trading conditions is impacting on profitability and consequently access to resources - people and capital
- Company structure, bureaucracy, ill-defined roles & responsibilities
- In my environment not many barriers
- Lack of specific knowledge
- There are too many initiatives and they are not streamlined and easy to follow.
- Cost reduction exercise
- To little Resources
- Adequate resources (time)

- Clear communication of specific goals, not "let's do quality work" statements or vague directions.
- Knowledge of existing procedures
- When integrity gets downgraded due to costs
- No comment
- Human resources. Inter-departmental and inter-company networking and sharing of experiences and lessons learned
- So many processes and procedures and double check systems. I am disempowered
- Expertise and resources
- Lack of resources
- Communication/budget
- right competency and understanding of what the role entails
- Outsourced projects and quality management
- Structures
- Experience workforce
- Still new to the process and how the company works as a whole
- Cost reduction and resource constraints
- Time constraints
- Availability of resources (people, money, commitment vs other priorities)
- Financial constraints
- Knowledge and time
- Not enough time.
- authority

Are there any improvement suggestions that you have to better implement quality management?

- Quality management should be treated in the same light as how Sasol Treats Safety. It should be part of our corporate culture as we have made Safety our culture.
- Ensure that the managers understand fully the management quality plans
- Use all the data which is currently available to implement engineering solutions
- N/A
- Introduce quality control department in the maintenance and production environment.
- I think people needs to be trained on QMS
- Review the role of company specifications. They are world class but require significant manpower to enforce.
- Rather communicate it as webinars
- Increased focus by managers
- empowerment of people would be my main focus, you need to listen to your team if you want to implement effectively
- All projects to be adequately staffed
- More effective general training in the philosophy and principles of quality to all employees
- Clear Roles & Responsibilities and Accountabilities

- Training of young engineers specifically on ISO 9000 quality management systems
- Commit to fewer aspects at a time and create more focus and better training on those few items. Rather than focusing on so many things and it is a diluted effort.
- Communicate the goal and the plan to affected employees
- Internal forums and work groups working closely with the different areas in an OE.
- Focus on communicating, implementing & tracking specific quality goals.
- More visible roll out to lower levels
- Adhere to the current set requirements and don't change them when cost become an issue
- Yes. Additional human capital. More networking opportunities
- In a high variety, low volume environment, there should be more autonomy and less fixed rigid processes. The employees are disengaged and don't feel accountable.
- Training
- Stronger focus on quality management training
- Need to have a plan, do, check and sign-off. Ensure that roles and responsibilities are fully understood and what deliverables are expected.
- Keep quality management during execution in-house
- Right people in the right positions will help. People who can appreciate the need for a quality management system rather than what comes out of their own head. As clever as people can be, a large company can't rely on the intelligence of individuals; work must be governed by standards, procedures and specifications that are developed by competent people with experience of past "failures".
- Communication
- One system
- Better communication. Implement strategies that are easy to understand and make sure people know where they belong within the system.
- Streamline processes
- investment in future technological developments
- Elevation & support of quality management systems by top management.
- Going back to basics.
- Engineering quality expectations need to match the allowed hours/resources

4.4 Discussion and Interpretation:

4.4.1 Introduction

The experimental work carried out in this chapter had specific research objectives that included the study of current organization the current quality management system and compare to requirements identified in literature and investigate similar quality management models and evaluate against the current quality management practise at the company.

The results during the interpretation of this analysis helped to investigate the above-mentioned research objectives.

When taking all the results into account, it can be seen that the overall interpretation of the questions that the results show a positive sentiment from the respondents. Thirty-eight of the questions scored very positively that were higher than the mean of three. On the other hand, there was one question that showed a negative feedback with a mean score of less than three.

4.4.2 Quantitative Summary

According to the analysis of data, the areas of “information and communication” and “Training of Personnel” showed the lowest scoring of all the constructs. As can be seen in the literature study, training of personnel is a key area of quality management and is very important to ensure the successful implementation of a quality management system. In addition, communication in an organization is important; there should be well established communication procedures for an organization. As the company has a very extensive quality management system, it is important to remember that not all personnel can use it immediately, there should be awareness and usage training conducted to ensure that personnel can use the management systems to their full potential.

As can be seen in figure 37 the “leadership and commitment” construct scored much higher in relation to the other construct. This shows that there is a general perception over all populations that there is a focus on quality management systems from leadership in the organization. Taking the literature study into account, leadership commitment towards quality management is very important to the successful implementation of quality management.

As can be seen in figure 41 and table 14, there seems to be a difference in scoring between “management” and “non-management” populations over all constructs, with the “management” population scoring higher. This can be due the “non-management” population that uses the quality management more extensively than the “management” population and observe the barriers and constraints more because it is used more than the “management” population.

The “intermediate and senior engineer” population over all the constructs scored the lowest. It can be interpreted as this population has been in the organization longer than the other populations and use the quality management system more than the other populations and can identify the barriers more extensively.

4.4.3 Qualitative Summary

Through the analysis of the qualitative data, there seems to be barriers in the form of resources, time and knowledge that was highlighted on multiple occasions. As discussed in chapter 1, this is understandable as through restructuring and global

economic constraints there will be some form of time and resource constraint as there is less people to perform the work. Knowledge and experience are also a big factor of restructuring as personnel with knowledge is lost and if the knowledge is not transferred it will create gaps in the quality management systems.

During the analysis of the qualitative data, there is an opinion that the company is showing a very strong commitment towards quality and there was a majority of positive responses towards commitment from the organization.

During the analysis of the barriers that the company is experiencing there was a majority opinion in the areas of “resources” in the form of time and financial support as well as “knowledge of procedures”. This shows that there is high pressure on existing resources to effectively implement quality management within the organization.

During the analysis of the improvement suggestions “training of personnel” was identified as a very important aspect to ensure improvement. “Communication” was also identified as an improvement suggestion. Both these areas also showed the lowest scored areas during the quantitative analysis.

4.4.4 Critical assessment and interpretation

A total of 290 surveys were sent to various departments within Sasol, Sasolburg region. It consisted out of Technical support (Group technology), production and maintenance personnel (Operations). This included Junior, Senior and intermediate engineers as well as middle and senior management. A total of 57 replies were received that resulted in a 19% response rate. The replies that were received were sufficient to do the analysis as it has the correct population spread as discussed in chapter 3.

4.4.4.1 Barriers and proposal for correction

Following the interpretation of leadership commitment and accountability, it indicated that leadership does communicate quality expectations but there is a lack of long-term commitment and living the quality expectations from leadership within the company.

Barriers identified:

- There is an indication of no long term commitment and living the quality expectations from management.

Proposed correction:

- Management should re-commit long term commitment regarding quality management and set up a communication plan to roll out to the whole company.

Following the interpretation of planning initiatives, it indicated that the company does assign accountability when implementing quality but is not very effective at gathering and reviewing data during the development of these systems.

Barriers identified:

- There is an ineffective gathering of information when developing quality management systems.

Proposed correction:

- Management should set up a quality management task team that gets functional input from the company employees when reviewing and creating quality management systems.

Following the interpretation of infrastructure availability, it indicated that the company develops quality management procedures effectively but there is a lack of functional quality management structures and monitoring of these systems within the company.

Barriers identified:

- There is a lack of functional quality management systems and monitoring of these systems within the company.

Proposed correction:

- Quality management system should be reviewed in regards to complexity and functionality in the current business environment, together with a task team that monitors if the quality management system is functional and update where needed.

Following the interpretation of focus and roll-out of procedures, it indicated that the company sets stretched objectives regarding taking quality and cost into consideration during quality management and that the focus on quality has decreased after the implementation of the phoenix restructuring process. Taking question 21 and 17 into account there is an indication that the company struggles to roll out complex quality management systems and that there is a lack of a roll out plan.

Barriers identified:

- The company sets stretched objectives regarding quality management expectation whilst regards to cost versus quality.

Proposed correction:

- The company should do a cost analysis in regards to the impact of rework because of lack of quality management on projects and systems. This will serve as a motivation to appoint extra personnel for quality management monitoring and implementation.

Following the interpretation concerning the training of personnel, it indicated that there is an awareness of how the quality management systems work within the company but that there is a lack of training of the personnel within the company. Taking question

27 that also scored very close to the mean there seems to be a lack of mentorship for quality management systems within the company.

Barriers identified:

- There is a lack of training and mentorship regarding quality management systems within the company.

Proposed correction:

- Simple and effective training programs should be put in place to introduce new employees to the quality management systems. There should be refresher courses put in place to update employees on changes and help the personnel to better understand technical content.

Following the interpretation of resource availability, it indicated that the company does focus on the client's needs when allocating resources but that there is a lack of personnel that can implement the quality management systems. The company also seems to be lacking in benchmarking itself against other companies effectively.

Barriers identified:

- There is a lack of personnel that can implement and enforce quality management systems. There is also not a benchmark of their own QMS's against other companies.

Proposed correction:

- Quality management task team should be put in place to benchmark current quality management systems against industry norm. As disalced earlier the cost analysis will help motivate additional, personnel to enforce quality management systems.

Following the interpretation of information and communication, it indicated that the company does communicate from senior management the commitment regarding quality but that there is a lack of communication of quality management strategies within the organization.

Barriers identified:

- There is a lack of communication of quality management strategies within the company.

Proposed correction:

- Communication plan should be set up to help focus on critical quality management system strategies and help roll out to employees.

Taking the qualitative questions into account the following barriers and proposals are suggested.

Barriers identified:

- There is an lack of training and mentorship within the organization.
- Too many layers of governance regarding implementation of QMS's.
- Inconsistency of personnel together with new personnel.
- Available personnel are under more pressure because of smaller structure.
- Personnel does not understand the technical content of the quality management systems.
- Managers do not fully understand the quality management systems.
- No clearly defined rolls and responsibilities.
- There was a lot of continuous emphasis put on time, financial and knowledge constraints.

Proposed correction:

- Management training on quality management systems should be implemented.
- Roles and responsibility matrix's have to be developed to clearly define responsibilities during implementation of quality management systems.
- *Other barriers have been addressed earlier in this chapter.*

4.5 Verification of Results:

The verification of the results was conducted using two methods:

- Comparing the data results to the literature study
- Using MedCalc software for statistical analysis.

To establish the reliability of the survey responses, an analysis was performed by testing the responses against the intended constructs and testing the consistency of the responses. Using the Cronbach's Alpha coefficient, the expected correlation of two tests that measure the same construct could be evaluated. If the Cronbach's Alpha coefficient measured a value greater than 0.7 the results can be evaluated as reliable. Table 15 gives the resulting Cronbach's Alpha coefficient for all the constructs:

Table 14: Cronbach's Alpha coefficient for all constructs

	Standard deviation	Mean Data	Cronbach's Alpha coefficient
1. leadership commitment and accountability	0.771	3.836	0.8905
2. planning initiatives	0.875	3.422	0.8669
3. infrastructure availability	0.857	3.434	0.8674
4. focus & roll-out of procedures	0.883	3.309	0.8773
5. Training of personnel	0.955	3.255	0.899
6. Resources availability	0.774	3.287	0.8718
7. information and communication	0.758	3.237	0.8721

As per table 15 one can observe that all the Cronbach's Alpha coefficients have a value greater than 0.7 and can be taken as reliable.

4.6 Discussion of quality improvement plan

Appendix B contains the quality improvement plan that would help address the barriers as discussed earlier in this chapter. The proposed corrects were incorporated into the setting up of the quality improvement plan.

The main proposals in the improvement plans were as follows:

- Communication strategy development.
- Training and mentorship strategy development.
- Recommitment from management towards quality management systems.
- Gathering of information when setting up QMS systems.
- Functional quality management system development.
- Continuous monitoring of quality management systems.
- Setting up a task team to benchmark, enforce and review current systems.
- Development of roles and responsibility matrix to better define responsibilities.

During the development of the quality improvement plan, these suggestions were taken into account. The quality improvement plan does not give direct solutions towards the barriers but gives suggestions to the company to narrow down focus points to address these issues. Because of the complexity of the organization systems it is recommended that a task team be assigned to develop these suggested focus points because due to lack of resources and complexity the author of the plan could not develop the full strategies.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

Through the discussion of the literature study and the analysis of the data as in chapter 4, this chapter will discuss the barriers that have been identified as well as the recommendation that can be observed as defined in the problem statement. The concluding recommendations and statements that have been reported will be elaborated in this chapter.

5.2 Research aim conclusions

As discussed in chapter 1, due to the current economic climate, a lot of companies have introduced restructuring programmes to optimize and streamline business processes. The effects of such restructuring programmes on quality management in companies cannot be predicted as there are a lot of variables that cannot forecast the final outcome of such a programme. The purpose of the research in this study was to identify the barriers and recommend a quality improvement plan to mitigate and improve the barriers that could be identified.

Through further investigation, there is an overall opinion within the organization that the focus on quality has improved after the phoenix restructuring program with leadership showing dedication towards quality. This is important because if there is a devotion to quality from leadership the personnel will follow their example towards quality.

There are certain areas that can be improved within the organization, but through proper guidance and removal of barriers that are blocking the implementation of quality management the organization can improve on the quality focus.

5.2.1 Research Objectives

The aim of the research is to establish the impact of restructuring and staff reduction on the quality management function and to identify the inhibiting factors that impact the successful implementation of quality management and recommend corrective measures so that the desired quality deliverables are achieved. Through the conclusion of these factors and barriers a quality improvement plan will be presented.

Through the analysis of the data and literature study the specific research objectives were fulfilled:

1. Objective 1: *Study the current quality management system and compare to requirements identified in literature.*

Through the review of the Sasol quality management systems and investigation of the current organizational input the study was conducted through the literature study. The literature study provided an input to create seven constructs that could be used during the case study to evaluate the quality management systems within the organization.

This literature study provided a valuable baseline to be able to create the various constructs.

2. Objective 2: *Study the current organization culture towards quality management systems and compare against quality management system requirements as provided in the literature study.*

As can be observed in chapter 4, there are various barriers that were identified that are inhibiting proper quality management practices within the organization. The overall scoring of the constructs showed that there was leadership and commitment towards quality management, but there are barriers like communication and training that is inhibiting adequate implementation of quality management within the organization.

3. Objective 3: *Compile a quality improvement plan proposal to assist in closing quality management gaps.*

Through the evaluation of the current quality management culture within the organization and using the literature study as a foundation for evaluating best practices, a study could be made to give recommendations to improvement suggestions within the organization.

As can be studied in chapter 4, there is a commitment from leadership towards quality management within the organization. It can, however, be observed that there are certain barriers that are preventing the proper implementation of quality within the organization. There is a noticeable difference of the perception of quality management between management and non-management, it is important for management to understand these gaps and address them to ensure proper implementation of quality management.

Through the analysis of the qualitative section there was a high response in terms of lack of resources and knowledge within the organization towards quality management. This is understandable given the current economic environment and constraints towards financial pressure for ensuring organization health. It can be observed that there is a lack of training in quality management systems within the organization. It is critical that training is conducted within an organization regarding systems to ensure that there is a proper understanding of the organizational requirements.

Through the study of the qualitative and quantitative data as well as using the literature study as a foundation, a quality improvement plan was compiled as proposed in appendix B addressing the barriers as discussed and Chapter 4.

5.3 Recommendations

The recommendations that follow out of this study are as follows:

1. The organization must ensure that there are proper communication structures established for communicating quality management strategies within the organization. There should be clearly stated expectations for the objectives that the organization wants to achieve regarding quality management.

2. The organization should ensure that there are mentorship programmes developed to ensure that there is proper transfer of knowledge between senior and junior personnel. Mentorship is very important within an organization as there is a lot of knowledge gained in lessons learned with practical implementation of projects and initiatives.
3. The organization should ensure that training is available for quality management systems. It is important that the systems are well understood and that the personnel are aligned with the requirements and expectation in regards to quality management systems.
4. The organization should ensure that the required resources are allocated to implement quality management within the organization. There are various constraints that the company will experience due to the economic environment, but leadership should understand that the downstream effect of putting constraints on quality will have a long-term effect on the company as a whole.
5. The organization should ensure that training in quality management systems is mandatory for any new personnel. There should be periodical refresher training for personnel to ensure that they are updated with any new requirements in the system.
6. During the examination of the current organization's quality management systems, there were a lot of quality management systems that are outdated and have not been reviewed as stipulated review periods. Critical quality management procedures should be identified and benchmarked to ensure that the procedures are in line with current requirements. This is in line with the continuous improvement principles.
7. The organization should ensure that experienced personnel are involved during the development and review of quality management system procedures. These documents should be sent out to control groups of quality management experts within the organization to ensure that the gaps are addressed and updated to best practices.
8. Leadership should keep enforcing its commitment towards quality management and should keep communicating long- and short-term strategy expectations within the organization. Accountability should be clearly defined and communicated.
9. Awareness initiatives should be established within the organization and continuous communication should be established. This can be in the form of continuous updates of requirements.

5.4 Limitations and Future Work

The analysis that was conducted was on a high level due to time constraints to be able to do an in depth evaluation of the quality management systems within the

organization. Thus, a detailed analysis could not be conducted and an in depth review was not possible.

The population group that was selected was a very small representation of the entire company. The Sasol organization has 31000 employees who are globally based; only the Sasolburg geographical area was used as an evaluation population so the views cannot represent the whole organization.

Because of the time and demographical constraints, the low level analysis could not be established and further investigations should be conducted to implement in depth corrective measures.

The analysis that will be conducted will be at a high level due to continuous changes to the quality management systems within the organization and set time frame for the analysis of the research problem. Thus, a detailed analysis will not be conducted and an in depth review not possible.

Because of the complexity of the organization systems it is recommended that a task team be assigned to develop suggested focus points in the quality improvement plan proposal. Due to lack of resources and complexity the author of the plan could not develop the full strategies but rather the give guidance to the company.

5.5 Concluding Thoughts

During this research, it was observed that restructuring initiatives should take into account the impact of these initiatives on quality management within the organization. When developing restructuring program, there should be a focus on retaining key knowledgeable personnel and mentorship and training programmes should be established so that there is a proper understanding of the expectations towards quality within the organization. Resource constraints should be evaluated and corrective measures should be put in place to address the barriers that inhibit the implementation of quality requirements. The current systems should be benchmarked against current industry standards to ensure that the systems are relevant in the current economic environment. Due to businesses that have to be competitive there is an understanding that the business should optimize resource utilization; the company should just take into account that if resources are minimized that the current structures should not be neglected and it should look into still clearly defining roles and responsibilities to remaining personnel to ensure that there are no gaps created due to the restricting initiatives.

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APPENDIX A: RESEARCH QUESTIONNAIRE

Quality Management Study

Background information to goals and objectives of this survey

In light of the current global economic constraints, Sasol along with many other role players in the South African industrial sector recently embarked on a restructuring program that aimed to streamline business principles and make Sasol business easier to operate. This would have enabled the Sasol business to achieve the main objective of sustainable profitability in an increasingly global market and due to current depressed global economy.

The high level aim of the research is to establish the impact of restructuring and staff reduction on the quality management function and to identify the inhibiting factors that impact the successful implementation of quality management and recommend corrective measures so that the desired quality deliverables are achieved.

Thank you for taking the time to complete this survey!

1. Please indicate what role category you are.

- ☐ Junior Engineers / Engineers in training
- ☐ Senior or Intermediate engineers
- ☐ Middle management
- ☐ Senior management
- ☐ Other (please specify)

leadership commitment and accountability

2. Leadership demonstrates long term commitment to quality management at the Company?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
				

3. Leadership demonstrates and lives commitment towards quality management at the company?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
				

4. Leadership focuses on quality management at the company?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
				

5. Leadership enforces quality management at the company?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
				

6. Leadership communicates expectation towards quality management at the company?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
				

Planning initiatives

7. The Company gathers and reviews data effectively from its employees when developing quality management systems?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

8. The Company develops a plan to achieve short term goals effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

9. The Company develops a plan to achieve long term goals effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

10. The Company assigns accountability when implementing quality at the company ?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

11. The Company plans effectively when identifying need changes for quality management systems?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

Infrastructure availability

12. The Company develops quality management procedures effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
				

13. The Company creates the means to manage quality management effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
				

14. The Company assigns accountability for executing quality management effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
				

15. The Company creates functional quality management infrastructure effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
				

16. The Company develops processes to monitor quality management effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
				

17. The Company trains and identifies key personnel to ensure that quality management infrastructure is implemented effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
				

Focus & roll-out of procedures

18. The Company develops a roll out plan for quality management effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

19. The Company gives short and long term objectives of rolling out quality management procedures ?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

20. The Company identifies key managers who will implement quality management effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

21. The Company focuses on the client's priorities while implementing quality management systems?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

22. The Company focuses on effective roll-out of more complex quality management systems effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

23. The Company sets stretched objectives for focusing on cost versus quality during execution of quality management?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

24. Has the quality focus decreases since the implementation of the phoenix structure at the company?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

Training of personnel

25. I am aware of how the quality management system works at the company

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

26. I know where to access the quality management systems at the company

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

27. I have been trained in how the quality management systems work at the company

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

28. I have mentorship available to me to guide me on how quality management is executed at the company

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

Resources availability

29. The Company provides financial support to implement quality management?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

30. The Company provides required personnel to implement quality management?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

31. The Company provides equipment and facilities to implement quality management?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

32. The Company considers the needs of clients when allocating resources for projects effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

33. The Company considers quality when doing annual budgeting for projects?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

34. The Company considers client requirements when allocating resources effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

35. The Company benchmarks its quality systems against other companies' effectively?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

Information and communication

36. The Company uses client feedback when changing quality management systems?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

37. The Company communicates quality management strategies to employees?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

38. The Company communicates quality management strategies to the client's projects?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

39. The Company communicates a statement from senior management regarding commitment to quality management?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

40. The Company provides periodical updates on quality management status to the clients?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
☐	☐	☐	☐	☐

Open ended questions

41. In your opinion how has the restructuring impacted quality management at the company

42. In your opinion has Company shown a commitment towards quality and communicated the goals of quality management.

43. In your opinion what are the main barriers that prevent you from implementing quality management at the company

44. Are there any improvement suggestions that you have to better implement quality management?

APPENDIX B: Proposal for Sasol case study

PROPOSAL



QUALITY IMPROVEMENT PLAN

ABBREVIATIONS

BD&I	Business development and implementation
PFD	Process flow diagrams
MFD	Mechanical flow diagrams
3D	three dimensional
ETQP	Engineering track quality plan
QA	Quality assurance
FOAK	First of a kind
ECoE	Engineering centre of expertise
QMS	Quality management systems
LDC	Learning and development
PDP	Personal development plan

INTRODUCTION

There was a quality management system study conducted that identified certain barriers that are prohibiting proper implementation of quality management within the organization. Through this study of a sample of Sasol's personnel that was based in the Sasolburg region there are certain proposals that have been suggested to improve on the current quality management system. These proposals include on a high level the following focus areas:

1. Management
2. Communication
3. Training and mentorship
4. Defining roles and responsibilities

OBJECTIVE OF THE QUALITY IMPROVEMENT PLAN

The objective of the quality improvement plan is to suggest focus areas that are currently posing challenges for personnel executing projects and maintenance.

While there is currently a range of documentation within Sasol describing high level quality objectives and workflows, there is an absence of training and mentorship within the organization's detailed requirements which spell out the exact review and checking activities needing to be undertaken by the employees. Due to the complex nature of the system more experienced employees understand what checks and process to have in place to ensure the best outcome in a quality context.

This leads to situations where project and maintenance quality is too heavily dependent on the experienced engineers, their experience and interpretation of how and what activities should be performed. This puts time and resource constraints on a selected few individuals that have to ensure that quality is enforced.

Small project execution is particularly vulnerable to this situation due to the relative inexperience of the engineering resources often allocated. This causes variability in project results and success.

The emphasis on project execution **predictability** within Sasol drives the need for a set of quality controls available to engineers appointed which can be employed in both the small and large capital project environments.

These quality management systems should meet critical criteria:

1. Should be available to all
2. Should be simple and easy to use
3. Should find general applicability across all projects
4. Should be customizable, to address the risk profile of each project
5. Should strive for consistency in engineering and company specification application
6. Should be aligned with existing quality frameworks (e.g. QMS, workflows, etc.) and applicable to both the BD&I and the Small project execution methodology
7. Should incorporate lessons learnt from previous projects
8. Should be kept brief due to time constraints– ideally one-pagers.
9. Training and mentorship programs between junior and senior personnel.

Communication within the organization is complex and communication is not always filtered down to the employees executing projects and maintenance. This creates a misalignment between quality expectations of the company and actual quality that is enforced by the personnel. The objective should be to ensure that communications channels are established between personnel developing QMS systems and personnel that use the QMS systems. Leadership commitment is critical to QMS success, the focus that leadership should give and reassurance and communication is critical to ensure quality is enforced.

PROPOSED FOCUS AREAS AND CORRECTIONS TO ENSURE QUALITY

Triggered by and aligned with the requirements of the workflows and QMS's, it is proposed that a series of "worksheets" or "checklists" be created **specifically for engineers** which drive the consistent review of engineering quality deliverables and engineering quality behaviour. Simplicity is the key and it should be kept simple to accommodate all levels of experience in the company.

With development of these check sheets there should be proper review protocol and should not be reviewed in isolation. It is recommended that a selected group of experienced engineers be selected from Group Technology as well as operations to review these QMS systems to ensure that they are practical and relevant to the current business needs

These checklists could have considerable scope, spanning the following non-exhaustive list of typical engineering activities/ deliverables:

- PFD reviews
- MFD reviews
- Plot plan reviews
- Isometric reviews
- Datasheet reviews:
 - o Typical vessel
 - o Typical heat exchanger

- Typical tank
 - o Typical pumps
 - o Typical compressors
 - o Typical packaged equipment
- 3D model reviews
- Detailed engineering scope reviews
- Requisition reviews
- Construction scope reviews
- Audits of fabrication facilities
- Audits of equipment and component preservation facilities

A clear disclaimer will be made on every checklist that the appointed engineers should still apply their mind to technical and other risks present on the project and should adapt the system to address these risks accordingly.

While the ETQP will provide the overarching quality intervention plan and framework, the expectation would be that the ETQP would call-up the applicable checklists as required by the lead engineer, based on the experience levels and composition of the project team and the performance of the contracted engineering design house.

Training and mentorship programs should be established through LDC. These courses should be kept short and easy to understand. When new engineers are appointed it should be a mandatory PDP requirements to ensure that the engineers are properly introduced to the QMS requirements and expectations. Junior engineers should also be allocated senior engineers that can mentor them in the QMS systems.

Roles and responsibility matrix's are important to ensure that certain level of engineers with the right experience level can approve critical quality hold points. This will ensure that less experienced engineers must consult with experienced engineers in certain quality decisions to ensure that all levels of detail is addressed.

Leadership should also recommit to the focus on quality. There is a general feeling that management does prioritize quality but continuous communications and high quality expectations should be reemphasised by leadership through constant communication.

ROLE PLAYERS

Several role players participate in the total quality chain in the development of engineering deliverables on QMS systems. Typical role players likely to be exposed to the checklists or be asked to contribute thereto would be:

- Sasol project management teams:
 - o Lead engineers
 - o QA inspection specialist
 - o Welding engineer
 - o Metallurgical specialist
 - o Project Manager

SECONDARY BENEFITS

- o The system will be developed in *Excel*. No costs for additional/special software platforms required
- o The establishment of this system would, to a certain extent, take the guess work out of the lead engineer's domain, who on account of their own project workload, does not know the exact daily checking and quality interventions being performed by other (generally junior) staff.
- o FOAK Checklists (especially those customized for a project) populated by the lead engineers could be used as concrete *go-bys* or training material for junior engineers or simply those joining the project late.
- o The implementation of the system would lend itself to a possible future objective where Sasol aims for ISO 9001 accreditation, as it reinforces the objective of repeatability of results.
- o Any omissions recorded in the evaluation of the engineering documentation could be used to identify developmental/ training areas for the engineer involved

SASOL SPECIFICATIONS AND PROCEDURES

The development of the system would require an over-arching view of the majority of the mechanical/ piping/ fabrication Sasol specifications, standards, procedures, workflows and QMS documentation addressing the standard of engineering deliverables.

RESOURCE AND ADMINISTRATIVE REQUIREMENTS

It is proposed that the development of the system adopt a process similar to a QMS, in the sense that the following role players are required:

- 1) An author
- 2) A reviewer – a second engineer with 'generalist' lead engineering experience or a specialist in specific equipment type, depending on the checklist type

3) An approver – representative of the ECoE

IMPLEMENTATION OF ENGINEERING QUALITY CONTROL SYSTEMS

The checklists could be made available on the intranet for immediate on any project. Appropriate communication would be required to create awareness around the existence and benefits of the system

CONCLUSION

Sasol has the potential to derive great benefit from the development of a set of engineering quality control checklists, aimed at engineers, which aim to produce repeatability in engineering quality.

The **SASOL LEADERSHIP** is requested to:

- **Approve** the development of checklists for use by the engineering functions in the execution of project work, as well as the hours required by the necessary resources.
- **Specify** the number and type of checklists to be developed.
- **Specify** the timeframe for development of the checklist systems to ensure that proper implementation

APPENDIX C: Knowledge transfer plan

Knowledge Transfer Plan

Purpose

This template serves as a Knowledge Transfer Plan for line managers when an individual leaves his/her current position, to ensure all explicit and tacit knowledge is captured, retained and transferred within the organisation.

KM Coordinator : _____

Line Manager : _____

Employee : _____

Function : _____

Date : _____

SECTION A

Documented Knowledge

This refers to knowledge that is captured already or must still be documented or reviewed (e.g. specifications, guidelines etc):

What?	Where is it located?	Purpose of Document/s	Action (i.e. publish to KOL, update, review)	Target date
Hardcopy:				
Electronic:				
To be documented:				
Outputs / Deliverables:				

SECTION B

Know - How

Things you do intuitively / subconsciously

What? (Topics, areas of responsibilities)	Provide Detail	Transfer
Business Processes		
Discipline / Competency		
Feedstock, Intermediate, Final Product		

Geographical Area		
Industry / Sector		
Projects (list relevant project/s)		
Stakeholders		
Technology		

SECTION C:

List of possible Knowledge Transfer Interventions

Intervention	Provide Detail	Transfer to	Target date
KM Tools			
• After Action Review			
• Peer Assist			
• Knowledge Interview (panel)			
• Knowledge Questionnaire			
• Informal Discussions			
HR Tools			
• Coaching Guidelines			
• Mentoring Guidelines			
• Shadowing Guidelines			
• Formal Training			

SECTION D:

Final sign off:

Employee

Date :

Line Manager

Date :

KM Consultant

Date :

APPENDIX D: Peer Assist Preparation

Peer Assist Title	
Peer Assist Coordinator	
Knowledge Owner	
Facilitator	
Note Taker/s	
Date Scheduled	
Duration	
Venue	

“The Peer Assist is a process/workshop for bringing knowledge into a project, or piece of work, at the outset. It is a meeting, where a project team (the Home Team) invite a number of people (the Away team) with relevant knowledge and experience, which they bring to bear on the issues of the project.”

Context

State the background and objectives to the project/process as well as the full context within which you intend having this Peer Assist. [Delete]

Desired outcomes and objectives

What would you like to achieve from this Peer Assist workshop? [Delete]

Key Stakeholders/Teams (proposed date)

Identify who the key participants should be. Also identify who from the Home Team will give the introductory presentation of the issue/project at hand. [Delete]

- **Host Team (name + role)**
- **Visiting Team (name + role)**

Key Learning Issues

List the key learning issues/themes you would like both teams to prepare for and cover in the Peer Assist. [Delete]

Host Team

With regards to each of these issues listed, please spend some time prior to the workshop, preparing your thinking around what critical learning you require and possible questions you could ask of the Away Team. [Delete]

Visiting Team

With regards to each of these issues listed, please spend some time prior to the workshop, preparing your thinking around what critical lessons learnt and advice you can offer the Home Team. [Delete]

APPENDIX E: Peer Assistant agenda

- 1. Welcome and Introduction to Peer Assist Process**
- 2. Ground Rules**
- 3. Introduction of Participants and their Involvement**
- 4. Host Team Learning Objectives**
- 5. Agree on Learning Themes**
- 6. Q&A Session (Host and Visiting Teams)**
- 7. Capture Key Advice / Learning**
- 8. Host Team Validates Advice / Learning**
- 9. Host Team Prioritizes Actions / Way Forward**
- 10. After Action Review**

APPENDIX F: Peer Assist Report

Title of Peer Assist]
[Date i.e 13 March 2017]

INDEX	
Background and Context	
Participants	
Key advice from Visiting Team	
Key learnings from Host Team	
Learning Issues	
Actions	

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BACKGROUND AND OBJECTIVES OF THE PRAGMA AUDIT PEER ASSIST

PARTICIPANTS

HOME TEAM	AWAY TEAM
Name Designation/Involvement e-mail address	

Key advice from Away Team

Key advice from Away Team

Learning Issues

Learnings -

Learnings –

Learnings –

VIDEO TRANSCRIPTIONS