Critical Success Factors for Improving Quality Culture in A Coal Testing Division

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Abstract

For laboratories wishing to comply with the requirements of ISO 17025 quality management system, maintenance and improvement becomes two processes that are mutually inclusive. Like any other system, ISO 17025 system needs to be maintained through continual improvement. To effectively maintain ISO 17025 system through continual improvement in laboratories, certain critical success factors must be present. This study seeks to demonstrate the benefits for maintaining ISO 17025 system by identification of critical success factors for continual improvement of ISO 17025 system in a coal testing division. The study aims to highlight that through continual improvement of ISO 17025 system, organizations gain marketing edge and competitive advantage. The study process adopted a mixed method research by triangulation of quantitative and qualitative data. The research strategy used was a single case study by means of structured questionnaire. Convenience sampling method was adopted and 23 coal testing division employees participated in the study. The study highlighted that effective maintenance of ISO 17025 system through continual improvement may not necessarily guarantee error-free coal testing laboratories, but it will generate the needed confidence among coal end-users that the coal tested will satisfy coal quality requirements.

Key words:
Quality, management, system, maintenance and improvement

1. Introduction

Company X has provided testing services to the local and international mining industry since 1975. It is a key third party service provider to the global mining industry in sampling and analysis worldwide (Www.CompanyX.co.za Access date: 26/03/2018). Although the greater focus of testing service provided by company X to mining industry is in coal and iron ore, each of the tested commodities are used for different purpose(s) and the significance of their testing is as important as their daily use by mankind. This study will make reference to coal testing as the majority of testing laboratories of company X servicing mining industry are focused on coal testing. Been part of the commercial division of company X, the desirable end-result of coal testing division business strategy is to make as much reasonable profit as possible. This will result in stability within the business.

According to (Kaziliunas 2010), the application of international standards benefits manufacturers, service providers, users, consumers and regulators as well as supporting sustainable development. According to (Zhu 2014), the use of standards within organizations is a requirement for entry into the global trade. This study seeks to demonstrate to a greater extent the benefits for maintaining ISO 17025 quality management system through continual improvement. This will be achieved through identification of critical success factors for the maintenance of ISO 17025 quality management system in a coal testing division. The objectives of this study will be achieved by adoption of mixed methods research process through triangulation of quantitative and qualitative data by comparison of the literature review, company X commercial division quality management system case study and the structured questionnaire feedback. Twenty three relevant coal testing division employees participated in the study.

2. Literature Review

Central to every service provider's main objective is to know that business success depends upon customers' satisfaction with the service. This means that the quality of service meets the customers' expectations (Coombs et al. 1995). Any successful service provider will also agree that having the agility to meet customers ever changing needs is vital (Jacobsen 2011). According to (Kaziliunas 2010), quality may be considered a strategic competitive tool and organizations cannot afford to ignore the strategic implications of equality for their competitive position. It is therefore always important for organizations providing any form of service to ensure that their services or products comply with the relevant quality criteria. As an example, before sale or trade, coal used in the generation of electricity at the South African State owned company ESKOM must first be tested for quality compliance. Laboratories on which testing is conducted must be able to demonstrate competency to provide high quality and accurate service to their customers or end users of coal through implementation and maintenance of the relevant quality management system.

According to (ISO 9000 2015), quality management system is defined as a set of organized or interacting activities of an organization to establish policies and objectives and processes to achieve those objectives. It manages interacting processes and resources required to provide value and realize results for relevant interested parties. ISO 17025 is the widely acceptable standard used to assess the competency of different forms of testing laboratories (ISO 17025 2017). Implementation of ISO 17025 quality management system shall ensure that persons or organizations external to the testing laboratory cannot influence the results of tests carried out and therefore assure the customer of reliability of results (Balgobin and Khodabocus 2011). Once the quality management system has been implemented, it will, like any other system, require maintenance through continual improvement. In order to achieve this, certain critical success factors must be present (Joubert 2002).

Critical success factors are a handful of key areas where an organization must consistently perform well in order to achieve its mission. Critical success factors can be derived through a document review, analysis of goals and objectives of key management personnel as well as interviews with those individuals about their specific domain and the barriers they experience in achieving their goals and objectives, (Gates 2010). Through identification of critical success factors, an organization can create a common point of reference to help direct and measure its success. As a common point of reference, critical success factors help everyone in the team to know exactly what is most important. This help personnel perform their own activities in the right context and so pull together towards the same overall aims (Gates 2010). (Howell 2010) points out that critical success factors differ from laboratory to laboratory due to their location and testing service rendered. Table 2-1 list critical success factors common to the success of various improvement initiatives for organizations which are also applicable to testing laboratories together with their associated variable(s).

Table 2- 1 Critical success factors common to the success of various improvement initiatives (Source: Howell, 2010)

CSF	Variable (s)
QMS	✓ Documentation requirements
Management commitment	✓ Defined management responsibility
Customers focus	✓ Customer data analysis ✓ Assessment of customer needs
Quality policy	✓ Quality policy appropriateness ✓ Commitment towards continual improvement
Responsibilities, authorities and communication	✓ Roles and responsibilities communicated ✓ Effective communication system
Resource management	✓ Resources provision
Product realization	✓ Production and service provision ✓ Planning of product realization
Measurement, analysis and improvement	✓ Monitoring and measurement

	✓ Control of non-conforming products/services ✓ Analysis of data ✓ Improvement

3. Research Method

The research strategy adopted was a single case study. The research study adopted mixed methods research process. According to (Clark and Ivankova 2016), mixed methods research is a process of research in which researchers integrate quantitative and qualitative methods of data collection and analysis to best understand a research purpose. The way this process unfolds in a given study is shaped by mixed methods research content considerations and researchers' personal, interpersonal, and social contexts. The greatest advantage of this method is that it provides strengths that offset the weaknesses of both quantitative and qualitative research (Clark and Ivankova 2016).

Survey interviews by means of structured questionnaires were used to collect data for identification of critical success factors for improving ISO 17025 system. Survey interview is an important source of case study evidence (Yin 2014). Survey interviews with key personnel of an organization can result in accurate information generated (Howell 2010). This will result in gaining buy-in for stated study objectives since it will identify critical issues to achieve improvement initiatives.

Study participants were coal testing division BU Managers, Technical personnel and quality officer because they are involved in the daily operation, implementation and maintenance of ISO 17025 system and management of testing facilities. Technical personnel refer to SANAS technical signatories/test officers/analysts. The study questionnaires were sent to study participants via email and twenty-three set of questionnaires were sent to study participants. The sampled population of participants is enough for the study. According to (Cardon et al. 2013), 15-30 participants are required for participation in a single case study type. Questionnaire adopted from (Bireddy 2007) on Quality Management-Implementation of Quality Systems was used. A five-point lickert scale was used for each questionnaire variable. According to (Dale 2006), a five-point lickert scale works much better. A few three-point lickert scale may result in insufficient response for revelation of existing group differences. A many twelve-point lickert scale may result in unreliable responses due to many choices available.

Data analysis was performed by describing and analyzing the participants' case study results. This was done by coding study variables and lickert scale ratings on microsoft excel 2016. Statistical analysis of data was conducted by establishing correlations, descriptive statistics by calculation of mean and standard deviation of variables and plotting graphs for participants' feedback on questionnaire variables. According to (Rose 2015), excel is also an authenticated study data analysis tool due to convenience for use and less cost implications. Relevant literature review findings will be compared and contrasted with the case study results. This will avoid comments repeating with reference to the literature review results.

4. Results and Discussion

This section reveals the results of the study. Case study results will be compared by correlation of variables, mean and standard deviation calculation of variables and bar charts.

4.1 Analysis of the variables in the questionnaires

Table 4-1 list the significance of each questionnaire variable per critical success factor based on feedback of participants on study questionnaire variables.

Table 4- 1 Critical success factors questionnaire variables significance

Critical Success Factor	Questionnaire variables	Total number of respondents	Mean	Standard deviation
Quality Management System	**V3:** Quality internal audits are performed on the ISO 17025 QMS	23	4.70	0.47
	V2: Document control systems are established tracking revision levels of all OD	23	4.52	0.51
	V1: There is an established and maintained ISO 17025 quality manual	23	4.48	0.51
Management commitment	**V4:** Top management ensures that quality policies and objectives are reviewed regularly	23	4.09	0.51
	V5: Top management behaviour is consistent with values relevant to quality and continuous quality improvement	23	3.91	0.73
	V6: Top management demonstrated an ability to manage the changes needed to improve the quality and services	23	3.87	0.76
	V7: Top management act on suggestions to improve the quality and services	23	3.65	0.65
Customer Focus	**V9:** Customer complaints are studied for identification of trend analysis and to prevent recurring of customer complaints	23	4.26	0.75
	V8: Current customer needs and expectations are assessed	23	4.13	1.06
	V10: Data from customers is used to improve services	23	4.13	1.06
Quality Policy	**V11:** Present Quality policy is appropriate	23	4.30	0.47
	V12: Quality policy commits to the continual improvement	23	4.30	0.47
	V13: Quality Policy is communicated and well understood	23	4.09	0.51
Responsibility, Authority & Communication	**V16:** A good communication system is established for an effective ISO 17025 QMS	23	4.09	0.51
	V14: Responsibilities and authorities are clearly defined and communicated	23	4.04	0.82
	V15: Key personnel responsible for establishment, implementation and maintenance of ISO 17025 QMS is appointed	23	3.78	0.85
Resource Management	**V18:** The required infrastructure for conformance with service requirements is provided and maintained	23	4.04	0.64
	V19: Resources required to establish and control working conditions are provided to ensure service quality	23	4.04	0.47
	V20: Education and training on how to identify and act on quality improvement opportunities are provided to staff	23	4.00	0.80
	V17: Sufficient resources are allocated to implement, maintain and improve ISO 17025 QMS	23	3.78	0.74
	V22: The require education and training to improve job skills and performance are provided to staff	23	3.65	1.11
	V21: Education and training in statistical and other quantitative methods supporting quality improvement are provided to staff	23	3.57	0.99
	V23: Quality objectives and requirements of the service are clearly defined	23	4.35	0.49

Product Realization	**V26:** Records are kept to confirm that the process and resulting service meet requirements	23	4.26	0.54
	V25: Reviews are done to ensure capability to provide requested service	23	4.17	0.65
	V24: Service specific processes are clearly established and documented	23	4.13	0.76
	V27: An effective customer communication is established for providing service information, handling enquiries, orders and customer feedback	23	3.96	0.88
Measurement, analysis and improvmenet	**V29:** A system is established to eliminate the causes of potential nonconformities to occur	23	4.22	0.52
	V30: An effective system established to ensure that non-conforming process is identified and controlled to prevent its unintended use	23	4.04	0.71
	V28: Service conformity is measured and monitored to ensure that all requirements are met	23	4.00	0.74

4.2 Linear correlation analysis of questionnaire variables

As part of quantitative data analysis, linear correlation of questionnaire variables was performed using Pearson. Pearson is used to establish the extent of relationship between variables in an interdependent relationship to measure relationship between variables, the correlation coefficient "r" ranging between -1 and +1 while determination coefficients ranges from 0 to 1, where 0 = no correlation and 1 = perfect correlation (Tamara 2016). This is achieved through the frequency table X and Y variables and the number of cases "n" as demonstrated by Table 4-2.

The other objective of performing Pearson correlation analysis was to establish the extent of influence of analyzed variables on each other in order to deepen meaningful relationship between the variables (Tamara 2016). Pearson correlation was performed between all variables. However, only those variables which strongly correlated or have no correlation will be reported as shown by table 4-2.

Table 4- 2 Pearson correlation between variables

	V4	V5	V6	V8	V10	V11	V12	V17	V18	V20	V21	V24	V27
V4	1												
V5	0.382	1											
V6	0.497	0.879	1										
V7	0.368	0.604	0.738										
V8	0.145	-0.102	-0.091	1									
V9	0.409	-0.039	-0.017	0.584									
V10	0.396	-0.278	-0.205	0.756	1								
V11	0.261	0.476	0.499	0.282	0.191	1							
V12	0.449	0.607	0.627	0.282	0.191	0.795	1						
V13	0.313	0.021	0.147	0.646	0.646	0.637	0.449						
V14	0.098	-0.294	-0.282	0.671	0.775	0.316	0.199						
V15	0.253	-0.105	-0.046	0.185	0.235	-0.054	0.173						
V16	-0.030	0.021	0.030	0.312	0.396	0.449	0.449						
V17	0.292	-0.037	0.028	0.681	0.564	0.462	0.462	1					
V18	0.403	0.300	0.389	0.530	0.261	0.408	0.560	0.699	1				

V19	0.542	0.664	0.649	0.079	-0.102	0.345	0.549	0.289	0.444				
V20	0.443	-0.078	-0.075	0.593	0.700	0.242	0.242	0.542	0.179	1			
V21	0.434	0.071	0.163	0.750	0.663	0.199	0.296	0.550	0.462	0.459	1		
V22	0.611	0.017	0.106	0.736	0.736	0.298	0.298	0.625	0.471	0.768	0.845		
V23	0.237	0.598	0.499	0.261	0.173	0.707	0.707	0.347	0.388	0.351	0.139		
V24	0.203	0.021	-0.048	0.602	0.659	0.266	0.394	0.624	0.458	0.376	0.563	1	
V25	0.360	0.224	0.140	0.098	0.230	0.116	0.265	0.273	0.200	0.350	0.123	0.506	
V26	0.731	0.174	0.309	0.335	0.574	0.388	0.567	0.492	0.493	0.316	0.390	0.468	
V27	0.109	-0.006	-0.009	0.692	0.643	0.144	0.254	0.548	0.409	0.260	0.708	0.830	1
V28	0.359	0.000	0.000	0.466	0.698	0.131	0.262	0.335	0.096	0.463	0.620	0.650	0.701
V29	0.267	0.291	0.307	0.112	0.112	0.089	0.275	0.130	0.382	-0.110	0.192	0.388	0.421
V30	0.239	0.008	0.096	0.662	0.601	0.369	0.506	0.719	0.702	0.404	0.548	0.840	0.737

From table 4-2 above, there is a strong correlation between variable 4 and variable 26, variable 5 and variable 6, variable 6 and variable 7, variable 8 and variables 10, 21 and 22, variable 10 and variables 14, 20 and 22, variable 11 and variables 12 and 22, variable 17 and variable 20, variable 18 and variable 30, variable 20 and variable 22, variable 21 and variables 22 and 27, variable 24 and variables 27 and 30, variable 27 and variables 28 and 30. There is no correlation between variable 5 and variable 28 and variable 6 and variable 28.

4.3 Bar charts analysis of questionnaire variables

According to (Howell 2010), graphs (a bar/column chart or line) are used in order to get a clear picture of critical success factors performance. Bar charts were used to demonstrate the performance of each critical success factors variables as illustrated by figure 4-1 to 4-8.

4.3.1 Critical success factor 1: Quality Management System

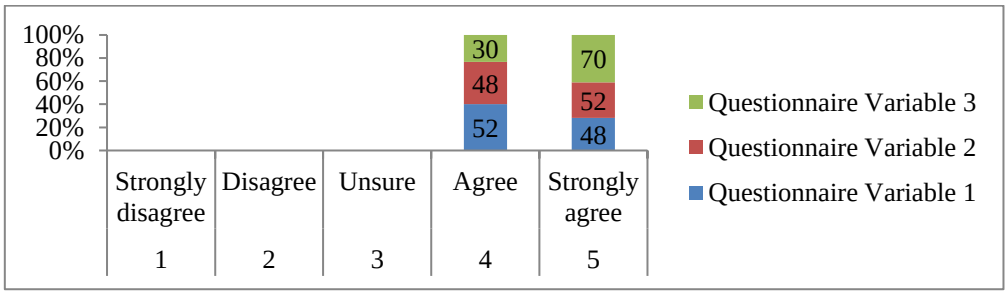

Figure 4-1 Critical success factor 1: Quality Management System

From figure 4-1 above, of the total respondents, 52% and 48% agree and strongly agree respectively that there is an established and maintained ISO 17025 quality manual. 48% and 52% agree and strongly agree respectively that document control systems are established tracking revision levels of all operational documents. 30% and 70% agree and strongly agree respectively that quality internal audits are performed on the ISO 17025 quality management system. Overall, the entire population of participants sampled all agrees and strongly agree that the entire coal testing division has a documented ISO 17025 QMS.

4.3.2 Critical success factor 2: Management commitment

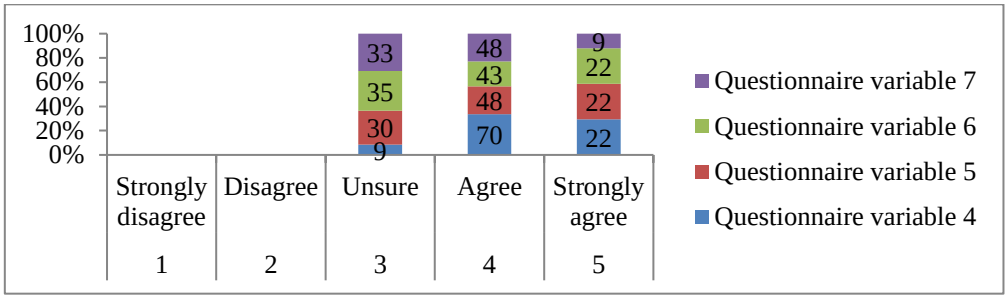

Figure 4-2 Critical success factor 2: Management commitment

From table 4-4 above, of the total respondents, 9% is unsure, 70% agree and 22% strongly agree that divisional management ensures that quality policies and objectives are reviewed regularly. 30% is unsure, 48% agree and 22% strongly agree that executive conduct is consistent with the values relevant to quality and continuous quality improvement. 35% is unsure, 43% agree and 22% strongly agree that executive showed ability in managing the changes needed to improve the quality and services. 33% is unsure, 48% agree and 9% strongly agree that executive take action on suggestions to improve the quality and services. For respondents under this critical success factor, it is worrisome to note that there is an uncertainty of 9%, 30%, 35% and 43% for questionnaire variables 4, 5, 6 and 7. This somehow does not provide a clear picture of top management commitment on the advancement of quality and continuous quality improvement.

4.3.3 Critical success factor 3: Customer Focus

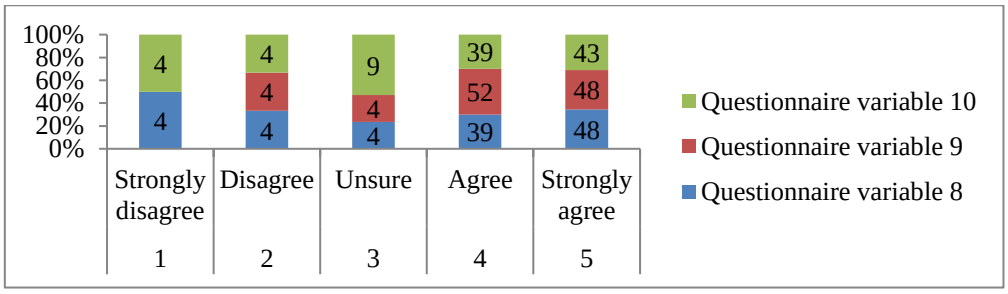

Figure 4 -3 Critical success factor 3: Customer Focus

From figure 4-3 above, of the total respondents, 4% strongly disagree, disagree and are unsure while 39% and 48% agree and strongly agree respectively that the current customer needs and expectations are assessed. 4% disagree and are unsure respectively while 52% and 48% agree and strongly agree respectively that customer complaints are studied for identification of trend analysis and to prevent recurring of customer complaints. 4% strongly disagree and disagree respectively while 8% is unsure, 39% agree and 43% strongly agree that data from customers is used to improve services. On average, about 4% strongly disagree, agree and is unsure that there is a clear customer focus by coal testing division.

4.3.4 Critical success factor 4: Quality Policy

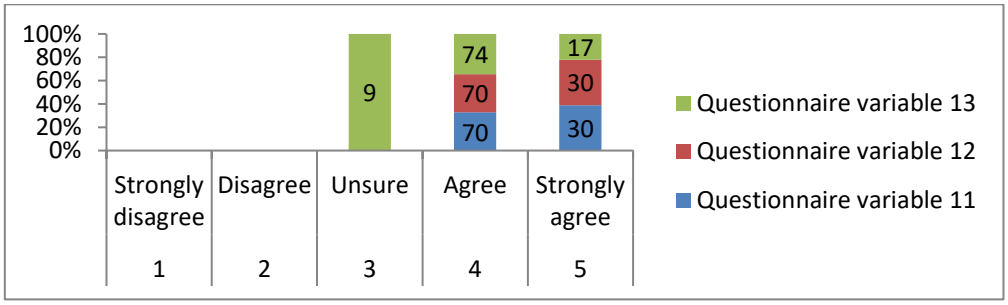

Figure 4-4 Critical success factor 4: Quality Policy

From figure 4-4 above, of the total respondents, 70% agree and 30% strongly agree respectively that the present coal testing division quality policy is appropriate. 70% agree and 30% strongly agree respectively that coal testing division quality policy commits to the continual improvement. 9% is unsure, 74% agree and 17% strongly agree that quality policy is communicated and well understood. Overall, except for small percentage for questionnaire variable 13, a higher percentage of respondents in this critical success factor agree and strongly agree that quality policy is appropriate, commits to continual improvement and is communicated and well understood.

4.3.5 Critical success factor 5: Responsibility, Authority & Communication

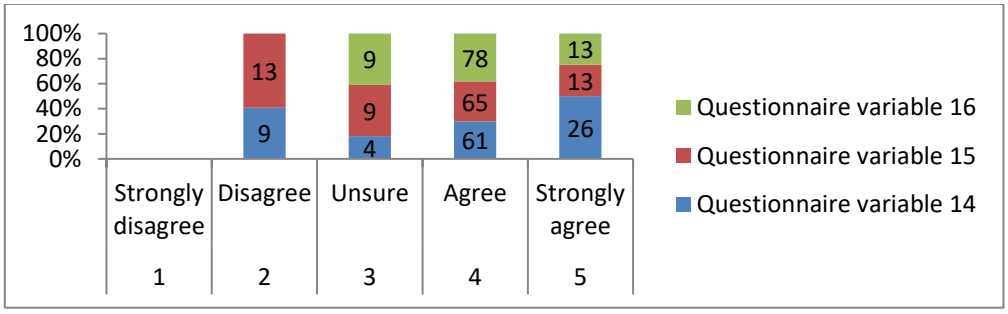

Figure 4-5 Critical success factor 5: Responsibility, Authority & Communication

From Figure 4-5 above, of the total respondents, 9% disagree, 4% is unsure, 61% agree and 26% strongly agree that personnel responsibilities and authorities are clearly defined and communicated within coal testing division. 13% disagree, 9% is unsure, 65% agree and 13% strongly agree that key personnel responsible for establishment and maintenance of ISO 17025 quality management system are appointed at coal testing division individual business units. 9% is unsure, 78% agree and 13% strongly agree that there is a good communication system in place for an effective ISO 17025 quality management system. Respondents under this critical success factor expressed mixed feelings in terms of defining and communicating to personnel their responsibilities and authorities in terms of establishment and effective maintenance of ISO 17025 quality management system.

4.3.6 Critical success factor 6: Resource Management

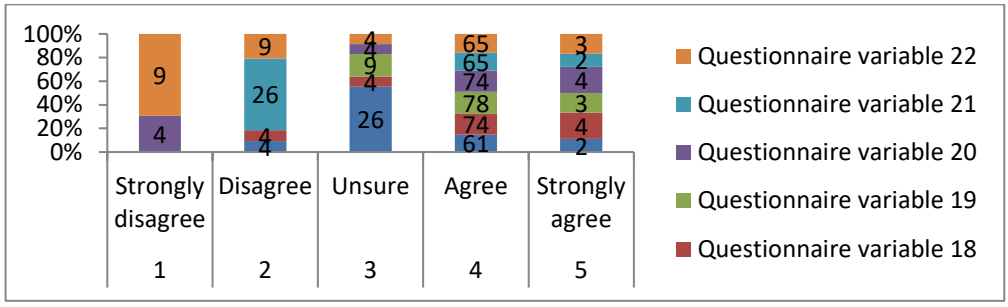

Figure 4-6 Critical success factor 6: Resource Management

From figure 4-6 above, of the total respondents, 4% disagree, 26% is unsure, 61% agree and 9% strongly agree that sufficient resources are provided to implement, maintain and improve ISO 17025 quality management system. 4% disagree and is unsure respectively while 74% agree and 17% strongly agree that the required infrastructure for conformance with service requirements is provided and maintained. 9% is unsure, 78% agree and 13% strongly agree that the resources required to establish and control working conditions are provided to ensure service quality. 4% is unsure, 74% agree and 17% strongly agree that education and training on how to identify and act on quality improvement opportunities are provided to staff. 26% disagree, 65% agree and 9% strongly agree that education and training in statistical and other quantitative methods supporting quality improvement are provided to staff. 9% strongly disagree, 4% disagree, 4% is unsure, 65% agree and 13% strongly agree that the required education and training to improve job skills and performance are provided to staff. The general feeling is that not all respondents are fully satisfied about resource availability on quality improvement.

4.3.7 Critical success factor 7: Product Realization

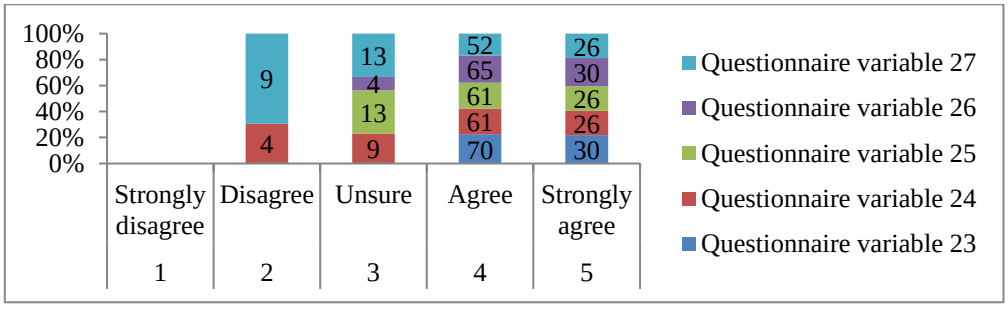

Figure 4-7 Critical success factor 7: Product Realization

From figure 4-7 above, of the total respondents, 70% and 30% agree and strongly respectively, that quality objectives and requirements of the service are clearly defined. 4% disagree, 9% is unsure, 61% agree and 26% strongly agree that service specific processes are clearly established and documented. 13% is unsure, 61% agree and 26% strongly agree that reviews are done to ensure capability to provide requested service. 4% is unsure, 65% agree and 30% strongly that records are kept to confirm that the process and service rendered meet requirements. 9% disagree, 13% is unsure, 52% agree and 26% strongly agree that an effective customer communication is established for providing service information, handling enquiries, orders and customer feedback. Overall there are respondents disagreeing about service specification processes been established and effective customer communication.

4.3.8 Critical success factor 8: Measurement, analysis and improvement

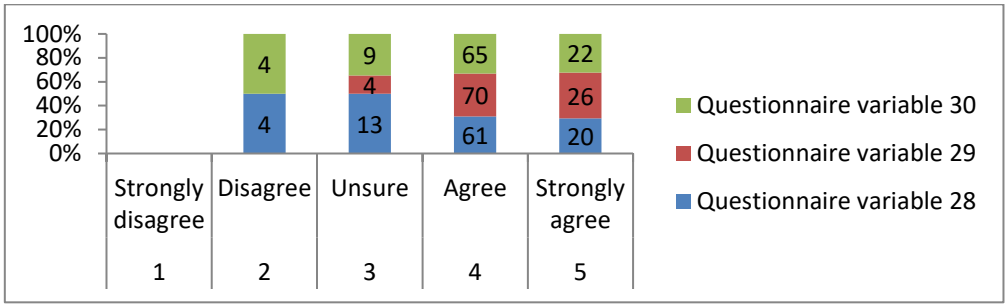

Figure 4-8 Critical success factor 8: Measurement, analysis and improvement

From figure 4-8 above, of the total respondents, 4% disagree, 13% is unsure, 61% agree and 22% strongly agree that conformance to service is measured and monitored to ensure that all requirements are met. 4% is unsure, 70% agree and 26% strongly agree that a system is established to eliminate the causes of potential non-conformances to occur. 4% disagree, 9% is unsure, 65% agree and 21% strongly agree that an effective system is established to ensure that non-conforming process is identified and controlled to prevent its unwanted use. Respondents under this critical success factor expressed regarding conformance to service been measured and monitored, establishment of system to eliminate cause of potential non-conformances and that an effective system is established to ensure non-conforming process is identified and controlled.

5. Conclusion

From the literature review, the benefits for maintaining ISO 17025 quality management system revealed include improved customer satisfaction, greater market share (Competitive advantage), operational credibility with government and customers, international recognition and stronger risk management. With regard to answering the question on, how to improve ISO 17025 quality management system within coal testing division? there must be an enforcement of customer requirements awareness to ensure everyone within coal testing division is familiar with customer requirements. Creation of an effective and open communication system on quality policy and objectives for all coal testing division personnel is vital. There must be an empowerment managed by designated personnel stationed in each laboratory to ensure an ongoing improvement of ISO 17025 quality management system which will result in the reduction of reaction time to quality related issues. Coal testing division staff at all levels must be provided with education and training providing to equip them with the necessary knowledge to allow them to continuously improve ISO 17025 quality management system. An effective customer communication system must be established within coal testing division for providing customer service information, handling of enquiries, orders and customer feedback. Measuring and monitoring system must be established for service conformity to ensure all customer needs are met. There must be a creation of a system for identification and control of non-conformances and to prevent their unwanted use.

Table 4-1 in section 4 is a summary of the identified critical success factors and their associated questionnaire variables scores. Each questionnaire variable rank represents the influential level of the questionnaire variable per critical success factor. The higher the rank, the higher the influence of the critical success factor questionnaire variable. Table 4-2 in section 4 is a summary of the correlation between questionnaire variables. Correlations represent the relationship between questionnaire variables with one where values closer to one represent perfect correlation and zero represents no correlation between questionnaire variables.

References

Balgobin, K., & Khodabocus, F., 2011. *Implementation and Practical Benefits of ISO/IEC17025:2005 in a Testing Laboratory*. UNIVERSITY OF MAURITIUS RESEARCH JOURNAL., Vol. 17.

Bireddy, R.V., 2007. *Quality Management: Implementation of Quality Systems a Perspective of Developing Countries-India*. Technical University of Berlin. Berlin.

Cardon , P., Fontenot, R., Marshall, B., & Poddar, A., 2013. Does Sample Size Matter in a Qualitative research?: A Review of Qualitative Interviews in IS. *Journal of Computer Information Systems. pp 11-22.*

Clark, L. P. V., & Ivankova, N. V., 2016. *Mixed methods research: A guide to the field*. Sage publications

Coombs, C. F., Ireson, W. G., & Moss, R. Y., 1995. *Handbook of Reliability Engineering and Management*. McGraw-Hill.

Dale, A.S., 2006. *Research methods: Planning, conducting and presenting research*. Belmont. Thomson Wadsworth.

Gates, L.P., 2010. *Strategic Planning with Critical Success Factors and Future Scenarios: An Integrated Strategic Planning Framework*. Carnegie Mellon University.

Howell, M.T., 2010. *Critical Success Factors Simplified: Implementing the Powerful Drivers of Dramatic Business Improvement*. New York. Taylor & Francis Group, LLC.

ISO 9000., 2015. Quality Management Systems – Fundamentals and vocabulary

ISO 17025., 2017. General requirements for the competence of testing and calibration laboratories

Jacobsen, J., 2011. Supporting Customers and Driving Excellence Through Quality. ASQ

Joubert, W., 2002. *Defining the Critical Success Factors for the implementation and miantenance of Total Quality Management System in South African construction companies involved in building*. University of Pretoria. South Africa

Kaziliunas, A., 2010. *Success factors for quality management systems*: Certification benefits. University of Wroclaw

Rose, S., 2015. *Management Research: Applying the Principles*. Nigel Spinks & Ana Isabel Canhoto.

Tamara, P., 2016. *Critical success factors for project management support information systems: SEBRAE/RN Case*. Federal University of Rio Grande do Norte.

Www.CompanyX.co.ZA. Accessed date: 26/03/2018

Yin, K. R., 2014. *Case study research: Design and methods (Fifth edition).* Sage Publications Asia-Pacific Pte. Ltd.

Zhu, Q., 2014. *Coal sampling and analysis standards*. IEA Clean Coal Centre, London, United Kingdom

Biography / Biographies

Jonas Rasethe is a Principal Internal Auditor for laboratory systems accreditation responsible for conducting ISO 17025 internal audits in laboratories at the South African Bureau of Standards (SABS) in Pretoria, South Africa. A position he has held from March 2014 up to date. Jonas Rasethe is a graduate of the University of Johannesburg, where he received National Diploma and BTECH Degree in Extraction Metallurgy. Jonas completed one year of experiential learning Part one and two at Nkomati Nickel Mine in Machadodorp, Mpumalanga Province of South Africa in partial fulfilment for the requirements of National Diploma in Extraction Metallurgy. After completing his BTECH Degree, Jonas launched his career as a Graduate Process Metallurgist at then Goldfields Mine (now Sibanye Stillwater) in Westonaria, Gauteng Province of South Africa for one year from December 2011 to December 2012. He later worked at SNC Lavalin in Morningside, Sandton, Gauteng Province of South Africa as a Junior Process Engineer for one year from February 2013 to February 2014.

Arie Wessels obtained the following degrees: B.Sc. (Eng) (Elect), 1968, University of the Witwatersrand, M.Ing. (Eng Management), 1997 Cum Laude, Rand Afrikaans University, PhD (Eng Management), 2013, University of Pretoria. He worked at Telkom for 25 years and at Denel Aerospace Systems for 16 years. He is also part time lecturer and supervisor in Engineering Management at the University of Johannesburg.

Jan Harm C Pretorius obtained his BSc Hons (Electrotechnics) (1980), MIng (1982) and DIng (1997) degrees in Electrical and Electronic Engineering at the Rand Afrikaans University and an MSc (Pulse Power and Laser Physics) at the University of St Andrews in Scotland (1989), the latter cum laude. He worked at the South

African Atomic Energy Corporation (AEC) as a Senior Consulting Engineer for fifteen years. He also worked as the Technology Manager at the Satellite Applications Centre (SAC) of the Council for Scientific and Industrial Research (CSIR). He is currently a Professor and Head of School: Postgraduate School of Engineering Management in the Faculty of Engineering and the Built Environment. He has co-authored more than 200 research papers and supervised over 39 PhD and 220 Master's students in Electrical Engineering and Engineering Management. He is a registered professional engineer, professional Measurement and Verification (M&V) practitioner, senior member of the Institute of Electrical and Electronic Engineering (IEEE), fellow of the South African Institute of Electrical Engineers (SAIEE) and a fellow of the South African Academy of Engineering.