

Dominant factors influencing project quality in the radioactive minerals processing pilot plant construction

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Abstract. Monitoring and supervision of factors that predominantly affect the successful implementation of quality management systems on the project will improve the quality of construction that provides a safety factor in the construction of a pilot plant nuclear fuel processing, to determine those factors is the aim of this research. The separation of Uranium, Thorium, and Rare Earth Metals Pilot Plant was used as a case of the research. Adopted descriptive research design were the primary data collected using questionnaires. Data collected analysed thought multiple linear regressions that only done on factors that have correlation strong – very strong. International Standard Organisation series 9001:2015 and International Atomic Energy Agency safety standards series No. GS-R3 were used as independent variables (X), contamination level was used as dependent variable (Y) that reflected project quality. The result is there are three factors that statistically significant influencing project quality: leadership and commitment, project planning, and safety culture. Those factors influencing the achievement of construction quality of the pilot plant uranium, thorium and rare earth element i.e. 92.3%, while the remaining 7.7% (100-92.3%) is determined by other variables.

1 Introduction

Indonesia's nuclear industry is currently facing an increasing need for nuclear fuel and require an increase in mineral separation technology, such minerals of the host rock. In response, the construction of nuclear facilities associated with the processing of nuclear material needs to be a concern. The realization of an effective and economical construction project can be applied in the development of nuclear mineral management technology to support the strategy of management and utilization of mineral resources in Indonesia optimally, integrated, sustainable, and environmentally friendly [1].

Construction is a project based industry with quality definition is meeting the customer's expectation [2]. Quality inspection, quality control, and quality assurance is the approach used to achieve sustainable quality improvement [3]. Quality performance is one

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of the three "iron triangles" in the Project management system [2]. Consumer satisfaction, better production quality, and higher market share [4], business benefits [5] could be achieved by applying a quality management system. The quality management system will affect the project quality that leads to superiority and reliability of the project [6].

The overall quality management system is to ensure continuous improvement in organizations related to human resources, systems, processes, and environments to improve customer service and increase profitability through efficiency and effectiveness across the organization [7]. The optimizations of intangible assets, such as in-house knowledge are the "why" and "how" the company makes progress towards high quality [8]. The nuclear organization in its implementation uses the applicable standards relating to the working relationship with external parties [9]. The best known Quality Management Systems (QMS) are those based on the ISO 9000 series of quality standards [10]. The use of ISO 9001 in the construction industry has been widely applied by many countries including Indonesia [11]. ISO 9001 can help the company's performance become more efficient and improve customer satisfaction [12]. To achieve this effectively and economically requires a series of actions throughout the project cycle from programming, planning, monitoring, checking, and quality control [11].

In order to address quality related issues, some studies have been conducted in different countries. Factors that have an effect on quality are client commitment, integration of quality plan, measurement of performance and improvement, training and education, cooperation and communication, usability of information and communication technology [13]. Employee engagement, management commitment, trained employee, good communication, training and education and guidelines for customer satisfaction [14]. Management of shareholders, support from top management, communication management in the form of interaction between stakeholders in the project, the competence of project manager and job owner, monitoring, and feedback from project participants contributes positively to the achievement of quality [2]. Top management commitment, Involvement and customer satisfaction, employee engagement and empowerment, customer-supplier relationships, process improvement, and management are factors that affect the quality of the project [15]. Top management commitment, staff training, communication, and organizational culture are factors that affect the quality of a project [7]. Leadership, commitment, responsibility, and authority for the management system, corporate policy, infrastructure, and environment work [16].

In management, the leadership quality of top management is an essential resource in making a possibility, accepting ideas from any employee, participating in all programs, and levels of quality management [7]. In addition to cutting costs of rework and corrective action requires the involvement of all personnel in all parts of the application of quality management systems at all stages of the construction project [7]. A project with poor performance quality has a higher likelihood of injury, and this means there is a relationship between the visible safety of the project and the quality of visible construction [17]. Basu said the quality of a project is influenced by the design quality, the quality of executions process and the quality of communication between stakeholders [6]. The goal is for all organizations to seek continuous performance improvement [10].

The previous study mostly focuses on factors that affect quality, thus reflecting the successful implementation of the project's quality management system. Therefore, elements that give effect to the quality of the previous study can be used as a reference to determine the factors that affect the achievement of excellence in the construction of the pilot plan. The Factors are grouped into 6 (six) areas of the quality system as in Table 1.

The body of literature provides support for critical success factors implementation base on ISO 9001. However, the previous study has not involved another standard used for nuclear facilities. This research addresses the gap by dominant factor analysis that

influences the achievement of the construction quality of nuclear facilities by adding the management system of activities and nuclear facilities, case study on separation of Uranium, Thorium and Rare Earth Metals Pilot Plant Construction at Centre for Nuclear Minerals Technology – BATAN. Based on the previous research that has been presented gives a preliminary hypothesis of research that if the factors that predominantly influence the successful implementation of the quality management system on the project determined, it will improve the quality of construction that provides the safety factor in the construction of a pilot plant of nuclear fuel processing.

Table 1. Success factors for QMS implementation.

Success areas	Previous study
Policy and commitment	[13], [2], [7], [6], [3], [15], [18], [4], [17], [14], [10], [19], [16]
Strategic quality planning	[4], [17], [13], [19], [18].
Monitoring, measurement and improvement	[2], [6], [13], [14], [15], [10], [20], [18].
Education and training	[7], [2], [13], [14], [3], [18].
Communication	[7], [3],[10],[13], [18],[14],[2],[15].
Documentation	[6], [13].

2 Methodology

Questionnaire as a form of quantitative approach [21] was designed and administered to 36 respondents are those involved in the construction work of the pilot plan. They are the owner of the pilot plant, contractor, and supervisor with more than 2 (two) years experiences. The survey was designed to collect specific information about the level of influence of factors that give effect to the construction quality and contamination level of the pilot plant as a reflection of the quality project. The result of this questionnaire is the primary data, while the secondary data using literature review and standard. Secondary data used to build the independent variables (variable X) of questionnaire base on ISO 9001: 2015 and IAEA GS-R3 with guidance Table 1.

To determine the factors of each area based on ISO 9001: 2015, use the correlation matrix between ISO 9001: 2008 and ISO 9001: 2015 [22]. Meanwhile, to determine factors affecting the implementation of a quality system in nuclear activity and management system, the correlation matrix between ISO 9001: 2008 and IAEA GS-R3 contained in IAEA safety reports No. 69 was used.

The 29 variables were used to answer research question on what factors affect the achievement of the quality predominantly in the construction of the pilot plan, based on the implementation of ISO 9001:2015 quality management system and IAEA GS-R3. The variable Y or dependent variable is a project quality indicated by contamination. The scale and criteria of contamination in the construction of a pilot plant are shown in Table 2 [23].

Also, this research uses a descriptive design. The methods of utilized descriptive research survey method of all kinds including comparative and correlational method [24]. The descriptive analysis using the Statistical Package for Social Sciences (SPSS) program with correlation and multiple regression analysis is used to obtain the coefficients of the independent variables influence magnitude on the dependent variable. Spearman rank

correlation is appropriate when one or both variables are skewed or ordinal [25]. Correlation analysis measures the relationship between two things. The correlation coefficient (resulting value) was utilized in this research to measure the relationship amongst the quality management factors and project quality that indicated by contamination. Within the statistical analysis, produce statistical significance testing (p-value) which as important as the coefficient correlation value [16]. Statistical significance testing (p-value) is The P value or calculated probability, is the probability of finding the observed or more extreme, results when the null hypothesis (H0) of a study question is true [26]. This research use the p-value at 0.05 as used in previous studies [16, 17, 27, 28]. The interpreting size of correlation coefficient shown in Table 3 [25].

Table 2. Dependent variables in research.

Criteria	Contamination level (Bq cm ⁻²)	
	α	B
Low	< 0.37	< 37
Moderate	$0.37 \leq x < 3.7$	$3.7 \leq x < 37$
High	> 3.7	> 37

Table 3. The interpretation of correlation size for the research.

Size of correlation	Interpretation
.90 to 1.00 (-.09 to -1.00)	Very high positive, (negative) correlation
.70 to .90 (-.70 to -.90)	High positive, (negative) correlation
.50 to .70 (-.50 to -.70)	Moderate positive, (negative) correlation
.30 to .50 (-.30 to -.50)	Low positive, (negative) correlation
.00 to .30 (.00 to -.30)	Negligible correlation

Regression analysis is one of the analytical tools that describe the consequences and magnitude of the effect caused by one or more independent variables on a dependent variable [11]. Stepwise method was used which will automatically eliminate independent variables (predictors) that are not significant so that the resulting regression model that is not biased and only performed on variables that correlate of strong to very strong.

3 Results and discussion

The questionnaire is intended to derive factors from quality management factors that influence the project quality of the pilot plant construction. The scale of this questionnaire using ordinal from 1 to 5. Scale 1 indicates that the factor does not give any influence, continue to be tiered to scale 5 which means that factor is very influential to the project quality of pilot plant construction. Summary of the questionnaire results of all variables x has a maximum value of 5, four variables with a minimum value of 4, 21 variables with a minimum value of 3 and four variables with a minimum value of 2. Mean value of the questionnaire in the range of 3.772 and 4.806.

Strength and direction of the relationship will be valued if the correlation between these variables were significant. The significance level of the influence of X variables can be

seen from the value of Sig. (2-tailed) from the calculation using SPSS program with the following criteria: If the value of Sig. (2-tailed) calculation results <0.05 , then the relationship between these two variables is significant. If the value of Sig. (2-tailed) calculation results >0.05 , then the relationship between these two variables is not significant. Based on these provisions, independent variables that have strong correlations to very strong and significant are summarized in Table 4.

Table 4. Summary of correlation analysis.

No.	Factors	Correlation coefficient (r)	p-value	Result
1.	The influence of leadership factors and commitment to achieving the quality of pilot plant construction	- .866	0.000	very strong
2.	The influence of operational planning and control to achieving the quality of pilot plant construction	- .696	0.000	strong
3.	The influence of project planning to achieving the quality of pilot plant construction	- .876	0.000	very strong
4.	The influence of safety culture to achieving the quality of pilot plant construction	- .802	0.000	very strong
5.	The influence of human resources to achieving the quality of pilot plant construction	- .600	0.000	strong
6.	The influence of monitoring, measurement, analysis, and evaluation to achieving the quality of pilot plant construction	- .632	0.000	strong
7.	The influence of action to address risks and opportunities to achieving the quality of pilot plant construction	- .847	0.000	very strong
8.	The influence of purchasing to achieving the quality of pilot plant construction	- .829	0.000	very strong

Correlation analysis results mentioned factors were used as a predictor of regression analysis. In multiple linear regression analysis, the variables that influence the dependent variable (Y) is a variable that has a significant number smaller than the significance value (.sig 0:05) [11]. From the eight independent variables only three variables have a significant number smaller than the value of significance (Table 5). The three independent variables are leadership and commitment, project planning, and safety culture. The above three variables are also called dominant factors. The other five factors have a significant number higher than 0.05, so it does not affect the Y variable. After obtaining the dominant factor on achieving the quality of pilot plant construction, further analysis was carried out of the magnitude of leadership and commitment, project planning, and safety culture on the level of contamination on the pilot plant. Multiple linear regression analysis using SPSS ver. 24 got the coefficient of determination in the form of R square and adjusted R square. In multiple linear regression analysis with independent variable (variable X) more than two, the coefficient of determination used is adjusted R square [29].

There are three regression models with different predictor composition obtained from linear regression analysis in Table 6. The regression models resulted in a larger adjusted R square value if all dominant factors were predictors so that the model used to determine the

magnitude of influence was three models with adjusted R square 0.923. This shows the percentage of influence leadership and commitment, project planning, and safety culture of construction quality of 92.3%.

Table 5. Analysis process.

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	
	B	Std. Error	Beta			
1	(Constant)	9.493	0.447		21.257	0.000
	Leadership and commitment	-0.608	0.151	-0.354	-4.019	0.000
	Project planning	-0.627	0.154	-0.366	-4.079	0.000
	Safety culture	-0.271	0.096	-0.270	-2.811	0.009
	Action to address risks and opportunities	0.100	0.180	0.097	0.558	0.582
	Purchasing	-0.060	0.181	-0.054	-0.329	0.745
	Operational planning and control	-0.075	0.077	-0.071	-0.979	0.336
	Human resources	-0.073	0.064	-0.070	-1.151	0.260
	Monitoring, measurement, analysis, and evaluation	-0.077	0.076	-0.069	-1.019	0.317

Table 6. Model summary.

Model summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change statistics				
					R Square change	F Change	df1	df2	Sig. F change
1	.870 ^a	.756	.749	.43415	.756	105.559	1	34	.000
2	.935 ^b	.874	.866	.31735	.117	30.635	1	33	.000
3	.964 ^c	.930	.923	.24014	.056	25.631	1	32	.000
a. Predictors: (Constant), Project planning									
b. Predictors: (Constant), Project planning, Leadership and commitment									
c. Predictors: (Constant), Project planning, Leadership and commitment, Safety culture									

In addition to the magnitude of the influence of the three dominant factors together, it can also be known the magnitude of the influence of each dominant factor on the achievement of the quality of pilot plant construction through the regression model. Based on the selected regression factor model can be calculated constants and regression coefficients value of each dominant factor. The calculation (Table 7) yields the regression model:

$$Y = 9.358 - 0.713X_1 - 0.616X_7 - 0.324X_{10} \tag{1}$$

where Y = Contamination level, X_1 = Leadership and commitment, X_7 = Project planning, X_{10} = Safety culture.

Based on the above regression model shows the variable Y is proportional to the constant value and influenced by the three dominant factors with the amount of regression coefficient for each factor. The Y variable is the level of contamination occurring in the pilot plant of Uranium, Thorium, and Rare Earth Element Processing at present.

Table 7. Coefficients^a.

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.799	0.652		13.490	0.000
	Project planning	-1.489	0.145	-0.870	-10.274	0.000
2	(Constant)	9.847	0.513		19.195	0.000
	Project planning	-0.878	0.153	-0.513	-5.737	0.000
	Leadership and commitment	-0.851	0.154	-0.495	-5.535	0.000
3	(Constant)	9.358	0.400		23.392	0.000
	Project planning	-0.616	0.127	-0.360	-4.857	0.000
	Leadership and commitment	-0.713	0.120	-0.414	-5.964	0.000
	Safety culture	-0.324	0.064	-0.322	-5.063	0.000

a. Dependent Variable: contamination

4 Conclusions

The dominant factor analysis on the achievement of construction quality of Pilot Plant of Uranium, Thorium, and Rare Earth Element Separation, resulted in three dominant factors with significant influence (<0.05). The dominant factor and the magnitude of its influence were obtained based on the results of correlation analysis and multiple linear regressions. These factors are leadership and commitment with value -0.713, project planning with value -0.616, and safety culture with value -0.324. The value of the multiple linear regression coefficient (R) of the three dominant factors is 0.930, and this indicates $r > r$ table ($0.930 > 0.329$) a significant relation of factors influencing the achievement of construction quality of the project. The coefficient of determination (adjusted R square) is 0.923. This means that 92.3% of the factors affecting the achievement of the construction quality of the pilot plants are rarely determined by leadership and commitment, project planning, and safety culture. Monitoring and supervision of those factors ensure successful implementation of quality management systems on the project construction of a pilot plant nuclear fuel processing.

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