Optimizing Vender Inspectors' Qualification Process Using Lean Six Sigma

Abdulaziz A. Bubshait, and Haitm A. Al-Hamdan

Abstract— **Inspection is one of the major activities that assure the quality of products and services. In the last few years, inspection jobs became highly demanded in the energy construction industry. However, finding qualified people to cover this demand is considered a difficult task. Assuring quality in the procurement phase in large construction project is essential. Inspection is required during the manufacturing of major equipment and materials in vendor premises. A process that test and qualify vendor inspectors and assure that they are competent to do their critical job is needed. Moreover, the process time cycle should be as short as possible, in order to match the construction phase requirements. The process of qualifying vendor inspectors was noticed to have long cycle time and variations in time starting from receiving the request until giving back the result. The process also is not giving consistent results. This paper reports on a study to improve and optimize vendor inspectors' qualification process. This was done using the lean six sigma methodology. The study findings proposed six recommendations: utilize an online exam system, fix exam date and location every year, establish a common procedure for the process, utilize standard CV templates and a rejection rate for CVs and establish a continuous process for developing exam questions.**

Index Terms— **inspection qualification; lean six sigma; procurement; quality improvement, Saudi Arabia**

I. Introduction

Six sigma technique represents a problem solving methodology to eliminate the root causes of defects in processes. In this way defects and variability and its associated costs can be reduced. It is considered as a customer focused approach, by which the emphasis is that defects are factors which increase costs and reduce customer satisfaction [1]. It is a combination of quality management methods, including statistical methods [2]. The sigma level indicates how frequently defects are occurring. Higher sigma level means that process would produce fewer defects. Another way of reading in six sigma language is through identifying the number of defects per millions opportunities. A six sigma level means that there are 3.4 defects per million opportunities (DPMO) [3]. Six sigma focuses is to improve the overall quality by making organizations produce their services and products better, faster and lower costs [1]. A six sigma process means that 99.99966% of the manufactured products are expected to be free of defects [2]. Different studies estimated that if six sigma is implemented, it could provide three or four times more gains than the cost of applications without six sigma. Firms that are at 3 or 4 sigma level spend 25 to 40% of their revenues to solve problems. On the other hand, six sigma level firms spend no more than 5% of their revenues to solve problems [1]. Six Sigma projects follow a standard methodology known as DMAIC. This five steps problem solving methodology is considered as the core of Six Sigma strategy [4]. DMAIC is an acronym for the 5 phases of Six Sigma projects: Define Measure, Analyze, Improve and Control. These phases help to move logically from defining the problem to implementing solutions, understanding causes and establishing best practices in order to assure that solutions stay in place [5].

The company understudy is an integrated global energy enterprise. The company is continuously executing a series of new mega projects that will help meet the worldwide energy demand. As quality is considered an important aspect in all the company's work and projects, there is a separate department called Inspection Department taking care of managing quality implementation during all phases of new projects. Under this department comes the vendor inspection division (VID), which focuses on managing the quality of procured materials and equipment. VID consist of three units: Quality Control Unit, Quality Assurance Unit and Quality Monitoring Unit. Moreover, there are Responsible Inspection Offices (RIO) in different locations worldwide that support the inspection department to perform mentioned functions. These RIOs are located in Tokyo, Shanghai, Singapore, New Delhi, Hague, Milan and New York. Vendor inspector is the main person who conducts inspection in vendor premises. His qualification and testing is an essential process in order to assure overall procured material quality at the end.

The objectives of this study are:

1. To streamline the process of vendor inspectors' qualification.
2. To reduce the time required for qualification to a target of 10 days maximum.

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II. The Case Study

A. Defining the problem (Define Phase)

The process of qualifying vendor inspectors was noticed to have long cycle time and variations (38 days in average, 19 days Standard Deviation) in time starting from receiving the request until giving back the result. The process also is not giving consistent results. The objective of the study is to streamline the process and reduce the time required for qualifying vendor inspectors to 10 days, which is less than the maximum number of days (14 days) specified for replying to contractors' transmittals in the company's contracts. Critical to quality (CTQ) is a tool used to focus on customer requirements and transfer it to easily quantified requirements. It is the key measurable characteristics of a process whose performance specification limits should be met to achieve customer satisfaction. It aligns improvement efforts with customer needs. In the process understudy the CTQ is the vendor inspector qualification cycle time. Cost of poor quality can be defined as the costs that will disappear if the process or the output was perfect. It is the potential costs that can be saved after improving the process. In this study the costs of poor quality are the delays in utilizing qualified inspectors and the costs associated with it. The defect definition is the specification limits of the outcomes. Any outcome out of specification limits is considered a defect and it is not acceptable. The defect definition is a qualification process taking more than 10 days. The measure of the current and goal performance are as follows:

Current average performance: 38 days
Target goal: 10 days

Benefits are the potential paybacks that will be gained after improving the process. The benefits are reduced cycle time and associated costs and customer satisfaction. Vendor inspector qualification process starting from Responsible Inspection Office (RIO) receives the request from inspection agency or SAIR (Single Agent Inspection Representative-the project single point of contact for inspection of procured material) until RIO sends the result to agency or SAIR. The current process map for the vendor inspector's qualification is as show in Figure 1. The voice of customer is what the customer point out as an issue in the process. Table I summarized the voice of the inspection agency or the contractor.

B. Data collection (Measure phase)

Data were collected from all inspection offices (RIOs) to measure the magnitude of the problem. RIOs were requested to provide: the dates of receiving the CV, conducting the exam and sending back the results for each inspector went through the qualification process from January to December. A total of 724 inspectors' data were received. However, only 192 inspectors were considered in this study because some of the RIOs did not have a history for the dates of receiving CVs and sending back results for the remaining inspectors.

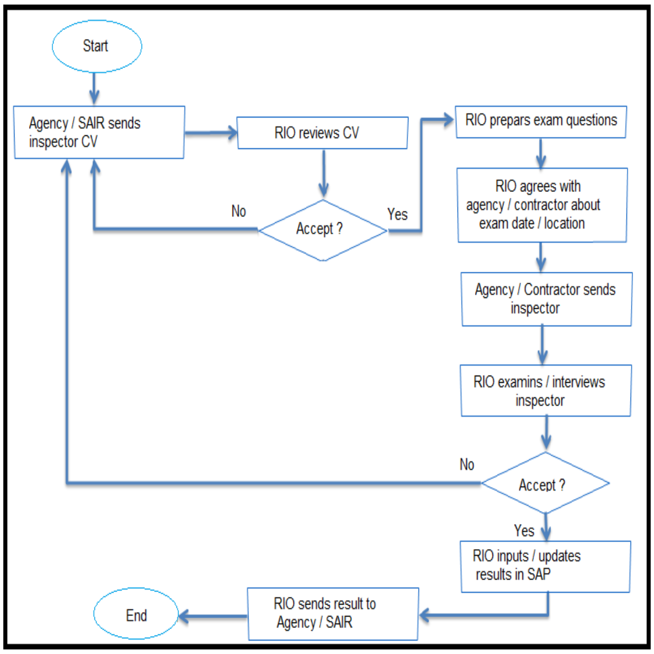

Fig.1. Current process map for vender inspectors' qualification

Table I. Voice of Customer

Customer	Voice of Customer	Key issue	CTQ
Agency/ Contractor	Approval process is long	Delays in the process	Approval process should be shorter
	Approval process is not streamlined	Not agreed upon procedure	One agreed upon procedure should be found
	Result are not consistent	Tests are not consistent	Tests should be consistent

The mean for the process is found to be 38 days and the standard deviation is 19 days (Figure 2). This is higher than the target (10 days) by about four times. Moreover, the P-value which is (<0.05) means that the data is not normal, which means that some statistical tools cannot be used, such as individuals control charts, process capability analysis, t-tests and the analysis of variance (ANOVA).

The Defect Per Million Opportunity (DPMO) was calculated by dividing the number of Defects (see Table II), where the process took more than 10 days (167 defects) by the total number of opportunities (192 opportunities) and multiplying by one million. The sigma level was calculated by using the equation:

$$\text{Sigma Level} = -\text{NORMSINV}(\text{DPMO}) + 1.5 = 0.37$$

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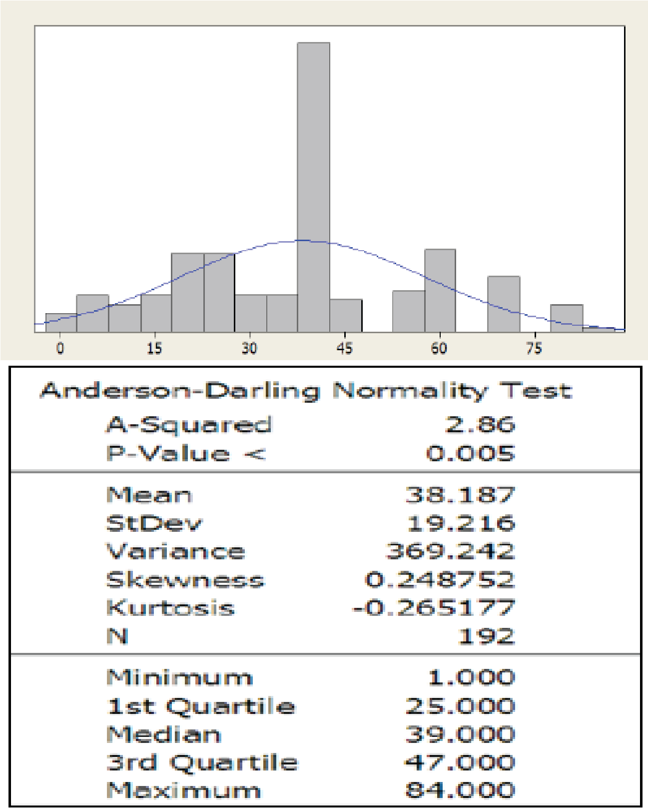

Fig. 2. Descriptive statistics for the process

In the equation, NORMSINV in excel returns the inverse of the standard normal cumulative distribution. The negative sign is to change result to positive value and 1.5 is the process natural shit, which is proven to exist when process operates for long periods by experiments.

Table II. Defect Per Million Opportunity and Sigma Level

Opportunities	192
Defects	167
DPMO	869,791.7
Yield	13.02%
Sigma Level	0.37

Failure mode and effect analysis (FMEA) is a risk assessment technique for systematically identifying potential failures and their effects in a system, process or product. FMEA consist of a group of activities intended to [6]:

- Identify actions which could eliminate or reduce the chance of the potential failures from occurring
- Institute a proactive approach to prevent defects
- Identify what can dissatisfy customers
- Document the process

FMEA focuses on the following [6]:

- Investigate causes that may result in failures of system, process or service to meet customer requirements
- Estimate risk of these causes
- Evaluate the current process control plan and suggest the solution
- Prioritize the actions to reduce the risk of failures and to avoid future defects
- Short-term as well as long-term focus
- Focuses on key process steps that may cause failures

Failure mode and effect analysis (FMEA) was conducted for the process to focus on the potential failure modes. A team meeting was held and all input for the FMEA was though that meeting. The result was as shown in Table III. It is clear that the focus was on four process steps: review of CVs, preparation for exam questions, informing agency/contractor about exam date and location and examine/interview inspectors. The key process inputs and potential failure modes and their effects for each step were identified. Then, a rating from 1 to 10 from the team for severity (SEV) was given to each effect, where (1) means no severity and (10) means hazardous severity. After that, potential causes for these failures were pointed out. They were given a rating from 1 to 10 for occurrence (OCC), where (1) means rarely and (10) means very frequent.

Moreover, controls to prevent each cause from happening (if any) were mentioned and another rating for detection (DET) from 1 to 10 was given to each failure. (1) Means very effective and (10) means absolute uncertainty.

Finally, the Risk Priority Number (RPN) was calculated for each cause by multiplying SEV by OCC by DET. The highest RPNs are for the following causes:

- Schedule changes
- No time for reviewing CVs
- Long preparation time for exams

These causes were taken into consideration in the following steps of the study.

A brainstorming session was conducted with VID supervisors to come up with all possible causes of the long cycle time for vendor inspector qualification and draw a fishbone diagram for them. A total of 15 causes were identified and classified into 5 main categories as shown in Figure 3.

C. Analysis Phase

The 15 identified causes were shared with all inspection offices (RIOs) and they were asked to classify all the defects they have according to these 15 root causes. Tokyo and Shanghai were the only RIOs gave feedback of 122 defects

Table III. Failure Mode and Effect Analysis

Process step	Key process function	Potential F. Mode	Potential F. effects	SEV	Potential causes	OCC	current control	DET	RPN
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
RIO reviews CV	Inspector's CV	CV isn't meeting requirements	Delay in qualifying the right inspector	8	Agency/ contractor not reviewing CV properly	7	RIO reviewing of CV	3	168
RIO reviews CV	Inspector's CV	No time for reviewing CV	Delay in qualifying the inspector	7	Not a priority	8	None	9	504
RIO prep. exam questions	Standard/ examiner	Long prep. time	Delay in setting exam date	6	No automation	8	None	9	432
RIO inform agency/ contractor about exam date/ location	Exam scheduling	Scheduling changes	Delay in qualifying the inspector	8	No fix schedule	8	None	8	512
RIO examines/ interview inspector	inspector	Not qualified inspector	Delay in qualifying the right inspector	2	Agency/ contractor not reviewing CV properly	8	Exam/ interview	3	48

(1) What is the process step? (2) What is the key process input? (3) In what ways does the key input goes wrong?
(4) What is the impact on the key output variables (customer requirements) or internal requirements?
(5) How severe the effect to the customer? (6) What causes the key input to go wrong?
(7) How often does cause or FM occur? (8) What are the existing controls and procedures (inspection and test) that prevent either cause of failure mode? Should include SOP number. (9) How well can you deduct cause or FM?

root causes. Other RIOs did not give feedback because the history for each defect was not available with them.

A Pareto chart of these causes was graphed and it is clear that 70% of the defects are caused by two reasons:

- Agency/contractor improper planning
- It is not a priority

Moreover, to include the input of other RIOs, all RIOs were asked to rate the 15 causes from 1 (lowest occurring) to 10 (highest occurring). All RIOs participated in this rating. From the rating results it is clear that 40% of the defects are caused by five reasons:

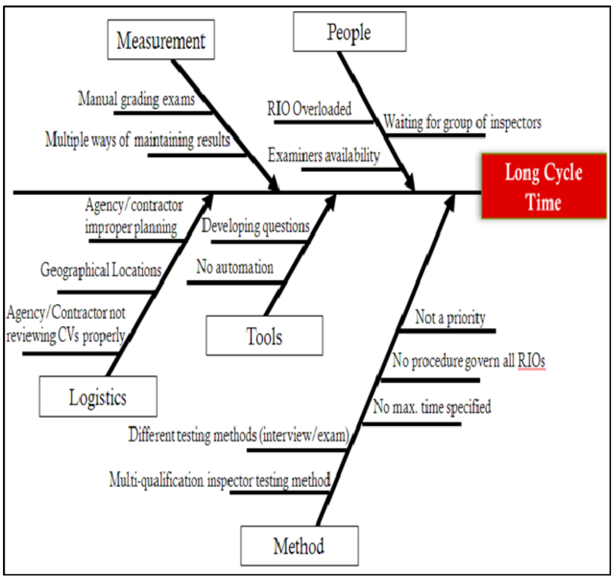

Fig. 3. Fishbone Diagram

- Agency/contractor not reviewing CVs properly
- Agency/contractor improper planning
- No automation
- Geographical locations
- Developing questions

Further examination was conducted using why-why analysis tool. At the end of the analyze phase, the following root causes were identified:

- No fixed schedule for exams
- No fixed locations for exams
- No clear measure for CVs rejection rate
- No governing procedure, especially for developing questions

III. Findings

A. Improve Phases

The goal of the improvement phase is to develop solutions for the root causes, prioritize these solutions, develop implementation plan and start implementing of solutions. Brainstorming was used to achieve this goal. A session was conducted with VID supervisors to brainstorm all possible solutions. The outcomes of the session were as follows:

- No computer based exams (until now)
- Fixed date/location Exams per quarter
- Utilize web based exams requests, online CV validation and exams
- Establish a common procedure governing all RIOs
- Share the procedure with agencies/contractor
- Rely on international certificate
- Standardized interview checklist
- Deal with specialized company for qualification

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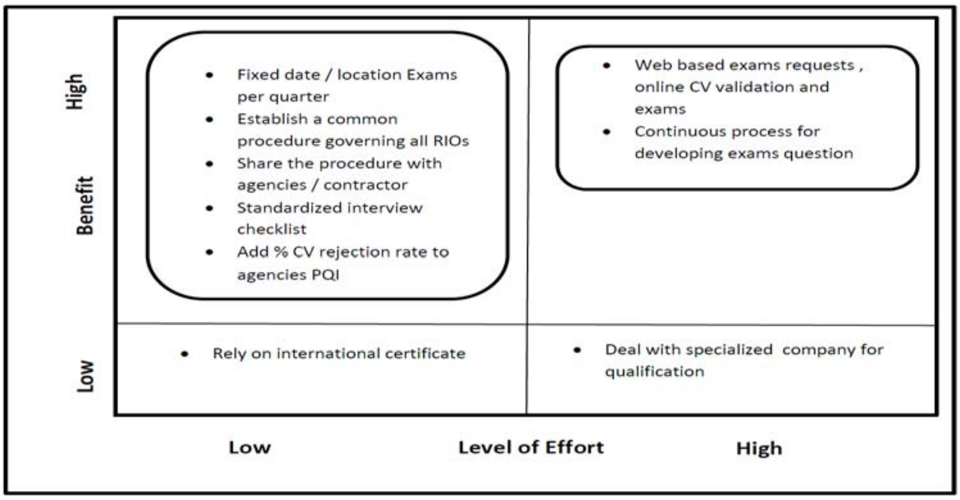

Fig.4. Prioritizing Solutions with Payoff Matrix

- Continuous process for developing exams questions
- Add % CV rejection rate to agencies performance quality index (PQI)

Payoff matrix was used to prioritize the solutions. Each solution was given a rated factor based on the effort for solution implementation and benefit from the solution. Solutions are mapped on high and low quadrants of these factors.

Then, solutions in high benefits and low effort quadrant are prioritized. This exercise was done and the result is shown in Figure 4.

From the payoff matrix, two solutions were disregarded due to their low benefit. Five solutions were pursued because of their high benefit and low efforts. Moreover, two solutions were also considered because of their high benefit, even though the effort to implement them is high. Based on the results of brainstorming and prioritizing the following recommendations were proposed to the champion of the study (unit head):

- Establish a web based exams requests, online CV validation and exams system.
- Adopt a fixed schedule for exams for all RIOs every year:
  - o Select dates/locations from the beginning of the year
  - o RIOs to review online accepted CVs
  - o RIOs to send confirmation e-mails to agency/SAIR
  - o Conduct the exam/interview on the schedule date/location
  - o Send results after 2 days of the exam
- Establish a common procedure for vendor qualification governing all RIOs and share it with agencies/contractors
- Develop standard templates for CVs to be utilized by agencies and Contractors
- Add % CV rejection rate to agencies PQI
- Establish a continuous process for developing exams questions (include it in the procedure)

A new process map (proposed) for the vendor inspector's qualification was developed as show in Figure 5. The next

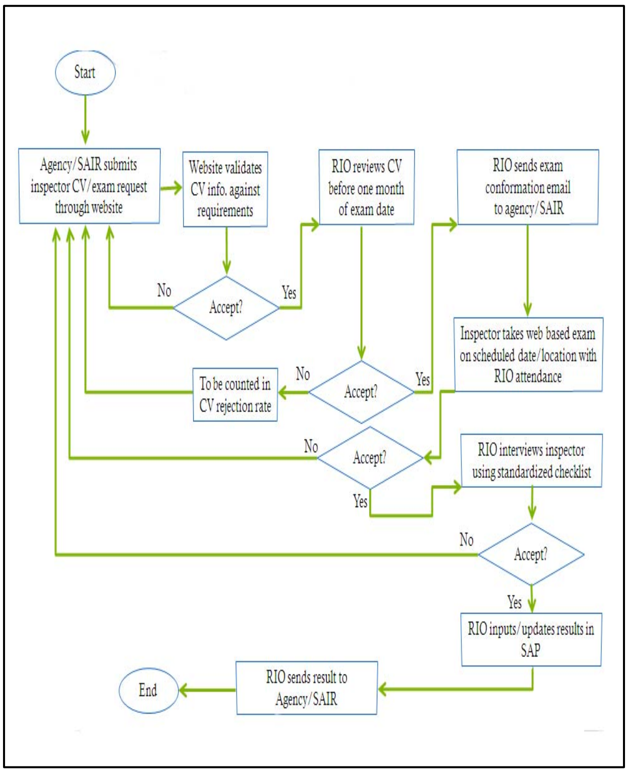

Fig.5. Proposed Process Map for Vendor Inspectors' Qualification

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step in the study is to put the recommendations into actions. This is done through agreeing on an implementation plan. Process map was developed and a measure of current performance was done base on a data taken from all inspection offices during one year.

B. Control Phase

In the control phase emphasize is to sustain and institutionalize the improvements mad, so that the process does not slip back to the original performance. Process control is a crucial tool in ensuring that lean six sigma project delivers lasting benefits.

IV. Conclusion

In the company understudy, the process of vendor inspector qualification in its current situation is causing frustration and concerns to all stakeholders of the process because of its long average cycle time and variations. Throughout the study, DMAIC methodology was followed to improve the process. The problem was defined exactly and the objective was set to improve the time for qualifying vendor inspectors to 10 days and streamline the process. Moreover, critical to quality (CTQ), cost of poor quality, defect and benefits of the study were specified. The current process map was developed and a measure of current performance was done base on a data taken from all inspection offices during one year.

Utilizing a team from the company, Failure Mode and Effect Analysis (FMEA) was done and areas to focus on were identified to be schedule changes, no time for reviewing CVs and long preparation time for exams. Then, a fishbone diagram was developed to find 15 causes of the problem and Pareto chart was used to see the highest probable cause. Forty percent of the defects were because of not reviewing CVs properly, improper planning, no automation, geographical locations and developing exam question. Why-why analysis was use and the results shows that there is no fixed schedule or location for exams, no measure for CVs rejection rate, no governing procedure for the process and no computer based exams until now.

Finally, recommendations were made to utilize an online exam system, fix exam date and location every year, establish a common procedure for the process, utilize standard CV templates and a rejection rate for CVs and to establish a continuous process for developing exam questions.

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