

Six Sigma Methodology as a Problem Solving Technique

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Abstract

Six Sigma Methodology (SSM) is a data driven problem solving technique which is very popular, reliable and result oriented (Pyzdek T., 2003). In this study SSM has been applied for saving financial loss in Sui Northern Gas Pipelines Limited (SNGPL). The technique has been applied to identify the most critical reasons for gas leakage in domestic connections above ground installations and have the solution to get rid of the leakage defect problem. The scope of study was restricted to Multan region only due to its atmospheric temperature.

This technique is highly effective and result oriented because whatever shortcomings appeared and found after applying the appropriate tool (method) in the processes, these are removed before moving to next phase.

In the study it has been found that on the average almost 2% of the joints in every domestic Customer Metering Station (CMS) are poor and cause the gas leakage. The main reasons for these poor leaking joints found in the study were due to expertise level of technician (fitter) and quality of tools (local and imported) used for pipe fittings and threading.

The solution obtained after the application of SSM can itself save a financial loss of Pak Rupees 2.1 million per annum approximately.

Key Words: *Customer Metering Station (CMS), Gas Leakage, Six Sigma and Soap Test*

Introduction

Sui Northern Gas Pipelines Limited (SNGPL) is the largest integrated gas transmission and distribution company in Pakistan but Unaccounted For Gas (UFG) is a major problem for SNGPL. Current UFG value of SNGPL is 07 % which costs approximately 07 billion rupees loss per annum and also causing customer dissatisfaction. The study has been restricted to Customer Metering Station (CMS) above ground installations of domestic users. As far as the coverage area of the study is concerned it has been restricted to only one city i.e. Multan. Multan is an important region and is in comparatively high average temperature zone. The data for the above study has been obtained from Quality Assurance department of SNGPL. As such the data is secondary and of discrete nature.

For the data analysis Six Sigma Methodology (SSM) is used as a problem solving technique to have an appropriate solution for CMS gas leakage. The SSM is a comprehensive and flexible system for achieving, sustaining and maximizing business success. Six Sigma is uniquely driven by close

understanding of customer needs, disciplined use of facts, data and statistical analysis, and diligent attention to managing, and reinventing business processes. This technique was first introduced by an American Company Motorola that was consistently beaten in the competitive market because the other foreign companies were producing high quality products at lower cost. After the Motorola, G.E and Allied Signals were the corporations those adopted and implemented SSM at a large scale (Pyzdek T., 2003).

The SSM was applied as a problem solving methodology in service quality to improve service processes. Many projects were completed for defect reduction like to reduce closed store passive suppression uncallables, the company reduced defect rate by 65% (Kim Sai, 2000). Similarly to reduce the defect rate with ongoing dollar saving, they reduced the defect rate by 44.5% (Bott Chris, 2000).

The SSM was applied in a manufacturing concern Tata Toyo Radiators (TTR), India to reduce the energy consumption. They recorded significant improvements in terms of energy saving and increase in productivity (Kapadia et al., 2005).

Methodology

SSM consists of five phases, in these five phases several techniques are applied for analysis. The application of these phases is systematic and objective oriented. Five phases of SSM and their respective objectives are as follows:

Define: Identify and state the practical problem.

Measure: Validate the practical problem by collecting data and by using Pareto chart, descriptive summary (Box-Cox Transformation of data), MSA and Process Capability.

Analyze: Convert the practical problem to a statistical one, define statistical goal and identify potential statistical solution by using Failure Mode and Effect Analysis (FMEA), regression analysis and diagnostic checks.

Improve: Confirm and test the statistical solution by using factorial models.

Control: Convert the statistical solution to a practical solution by using c-chart.

Each phase of SSM contains a set of different statistical and quality tools that leads the analyst towards the actual problematic area. The logic behind this methodology is that in the beginning all variables in the study that are pertaining to the product or a process giving problem are considered. In the next phases

these variables are reduced and at the end there remain only vital few variables. Then improving and controlling the possible variation in the finalized vital few variables, the problem is solved.

Research Findings

1. Define Phase

In the define phase the goal was clearly defined that gas leakage will be reduced in newly installed CMSs from the current value of 1.903 % to 1.400 % in Multan region because UFG is a major problem for SNGPL. Current UFG value of SNGPL is 07 % which costs approximately 07 billion rupees loss per annum. It was also concluded in the define phase that in the total process under consideration human resource, material & workmanship seem to be important inputs whereas the leaking threaded joints and gas leakage appear to be important outputs that cause heavy financial loss.

2. Measure Phase

On the basis Cause and Effect Matrix constructed after the brain storming of Six Sigma Team, the Pareto charts have been made in Fig. 1 and it is observed that the leakage (score 702) is a significant process output variable (Y). On the basis of Fig. 2, the potential input factors (X's) causing the process output variable are unsatisfactory pipe fitting connections (score 117), regulator connections (score 117), meter coupling connections (score 117) & service valve connections (score 117).

Figure 1: Pareto Chart of Y's (Effects) – C & E Matrix

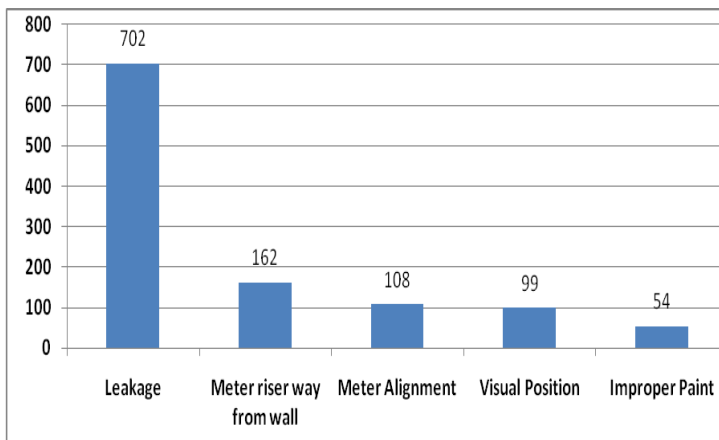
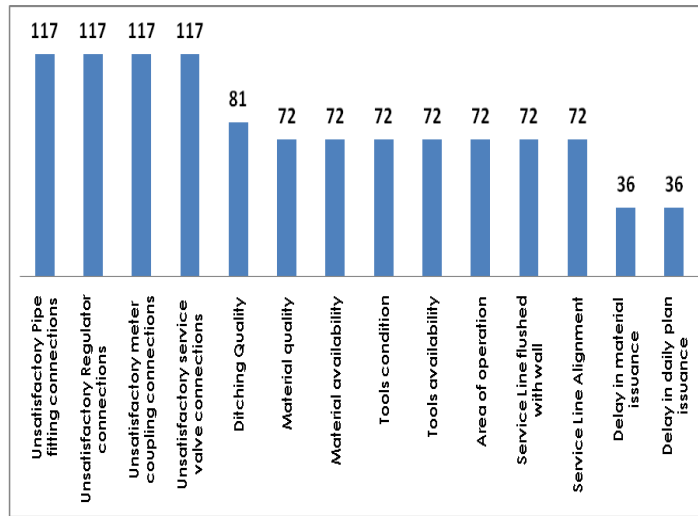


Figure 2: Pareto Chart of X's(Causes) – C & E Matrix



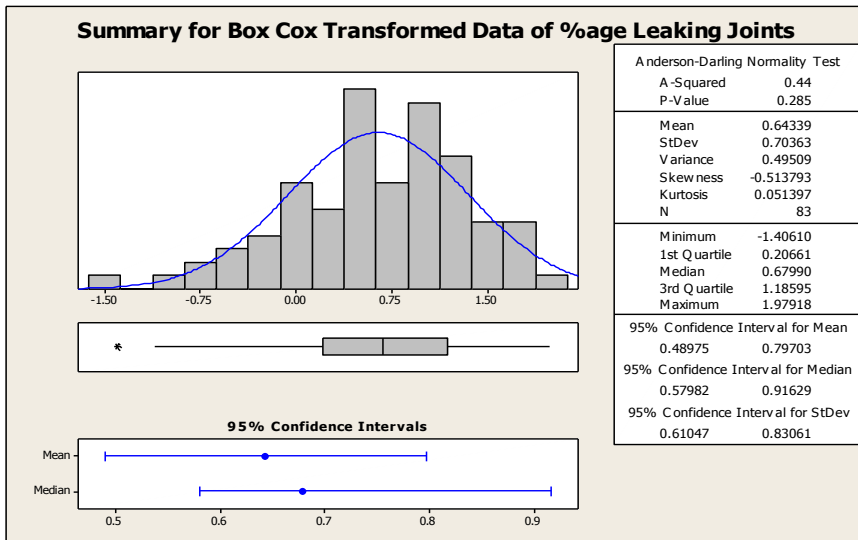
The data used for analysis were historical. It was obtained from the newly installed CMSs in Multan region during the period July 2006 to April 2008. It consists of inspected CMSs and their joints checked for the leaking opportunities. Since the data for the %leakage joints were not distributed normally but Box Cox transformation normalized it by using natural log of %leakage data. So finally, normality was achieved (Fig.3).

Further more histogram with normal curve shows the shape of normal data. The values of mean and median come out to be close i.e. 0.6434 and 0.6799, respectively with 95 % confidence interval. The value of mean transformed data is 0.6434. The actual mean of the non transformed data can be calculated as

$$e^{0.6434} = 1.903$$

The actual percentage of leaking joints is 1.903 % because data of %leakage joints was taken for the purpose. This value will be used in further calculations.

Figure 3: Descriptive Summary of Transformed data



By using 1.903% leakage joints, the corresponding value of sigma is 3.55σ at which average cost of leakage per year is Pak Rupees 8,792,181. The goal is to achieve the defect percentage 1.4% at which the corresponding value of sigma is expected to be 3.70σ which will save Pak Rupees 2,323,945.

Moreover, the CMSs installation process was also evaluated for process performance or Process Capability Index (PCI). The process capability C_p value comes out to be 0.42 that is far below than the international benchmark and shows that the process is highly incapable and needs improvement.

3. Analyze Phase

The analyze phase is started with the Key Process Output Variable (KPOV) ‘gas leakage’. On the basis of Failure Mode and Effect Analysis (FMEA) in Table 1, it was detected that Risk Priority Number (RPN) of the four potential causes is highest i.e., 720 so these are high risk areas and must be critically observed and analyzed.

Table 1: Failure Mode and Effect Analysis (FMEA)

SR .#	ITEM & FUNCTION	POTENTIAL FAILURE MODES	POTENTIAL EFFECTS OF FAILURE	SEVERITY	POTENTIAL CAUSES OF FAILURE	OCURRENCE	CURRENT CONTROLS	DETECTION	RISK PRIORITY NUMBER RPN
01	Threaded Joints in New Domestic CMSs	Lose Joints not joined properly	Gas Leakage	9	Poor Regulator Joints	8	No check	10	720
					Poor Meter Coupling Joints	8	No Check	10	720
					Poor Pipe Fitting Joint	8	No Check	10	720
					Poor Service Valve Joint	8	No Check	10	720

Severity, Occurrence and Detection on a scale of 1 – 10

On the basis of Table 1, the regression analysis was performed to validate the significance of input (predictors) variables in the process; the output of the analysis is shown in Table 2.

Table 2: Predictor’s Significance

Predictor	Coefficient	SE Coeff	T	P-value	VIF
Constant	0.01603	0.09022	0.18	0.859	
Pipe Fitting	0.08340	0.03206	2.60	0.011	1.270
Meter Coupling	0.02980	0.02861	1.04	0.301	1.625
Regulators	0.09431	0.03992	2.36	0.021	1.155
Service Values	0.18456	0.03512	5.25	0.000	1.371
S = 0.474592		R-Sq = 53.7%		R-Sq(adj) = 51.3%	

Table 3: Model’s Significance (ANOVA)

SOV	DF	SS	MS	F	P-value
Regression	4	20.3382	5.0845	22.57	0.000
Residual Error	78	17.5685	0.2252		
Total	82	37.9067			
Durbin-Watson statistic = 1.84188					

From the output summary of the regression analysis given in Table 3, it was observed that model is significant; one of the predictor i.e. leaking meter coupling joints is insignificant whereas other three are significant (Table 2). As far as the model diagnostics are concerned, there is no problem of multicollinearity in the data (Durbin-Watson statistic = 1.84188). Though achievement of R^2 is not very good yet it is pretty clear that the primary purpose of the analysis was to validate the input variables instead of using the model for estimation.

As the conclusion of Analyze Phase, the Key Process Input Variables (KPIV) extracted on the basis of significant predictors in Table 2, are:

- (i) Leaking Service Valve Joints
- (ii) Leaking Regulator Joints
- (iii) Leaking Pipe Fitting Joints

4. Improve Phase

The leakage in all these three types of joints may be caused due to two factors namely ‘Team’ and ‘Tools’ each having two levels. Team is divided into two levels one is ‘Experienced Team’ and other is ‘New Team’ while tools is divided into two levels, one is ‘Local Tools’ and other is ‘Imported Tools’. These two factors with two levels were declared for improvement, for which experimentation through full factorial design was suggested. Four replicates with randomized runs were used. It was concluded on the basis of Table 4 & 5 that:

- (i) The model is explaining 96% of the variation in the system (R-Sq = 96.09% & R-Sq(adj) = 95.11%).
- (ii) Team has estimated effect 6.875 i.e. installation by experienced team can result on average 07 more non-leaking joints as compare to new team.
- (iii) Tools has estimated effect 4.625 i.e. installation by imported tools can result on average 05 more non-leaking joints as compare to local tools.

(iv) Interaction (Team*Tools) has estimated effect -1.875 i.e. installation done by other than experienced team and imported tools, can result on average 02 lesser non-leaking joints in the installation.

Table 4: Estimated Effects, Coefficients and Significance

Term	Effect	Coefficient	SE Coeff	T	P-Value
Constant		353.188	0.2474	1427.70	0.000
Team	6.875	3.437	0.2474	13.90	0.000
Tools	4.625	2.312	0.2474	9.35	0.000
Team*Tools	-1.875	-0.938	0.2474	-3.79	0.003
S = 0.989529					
PRESS = 20.8889					
R-Sq = 96.09%		R-Sq(pred) = 93.05%		R-Sq(adj) = 95.11%	

Table 5: Analysis of Variance

SOV	DF	SS	MS	F	P-value
Main Effects	2	274.62	137.312	140.23	0.000
2-way Interaction	1	14.06	14.063	14.36	0.003
Residual Error	12	11.75	0.979		
Total	15	300.44			

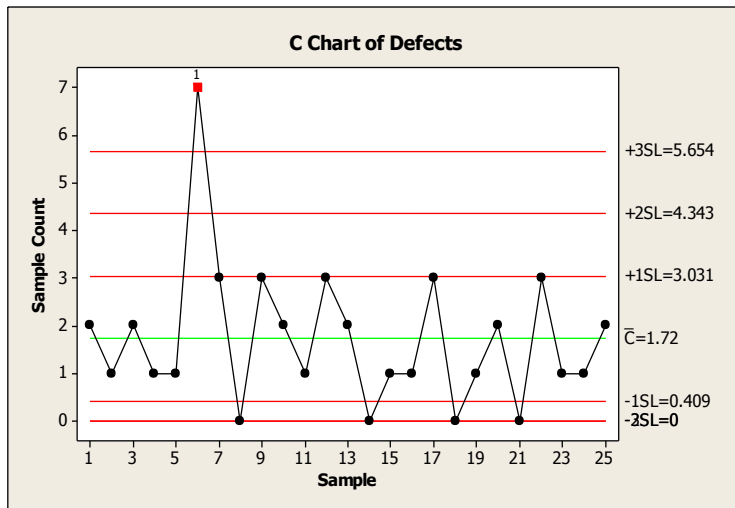
So the Improve Phase was started with the key process input variable and its technical reasons. Now at the end of the phase it was concluded that best combination to obtain maximum number of good quality joints is ‘Experienced Team’ using ‘Imported Tools’.

5. Control Phase

In the Control Phase, for mistake proofing, a ‘Soap Test’ by the installation team was advised as mandatory so that the defect is checked and rectified at site. The process map was revised with the inclusion of above mentioned step.

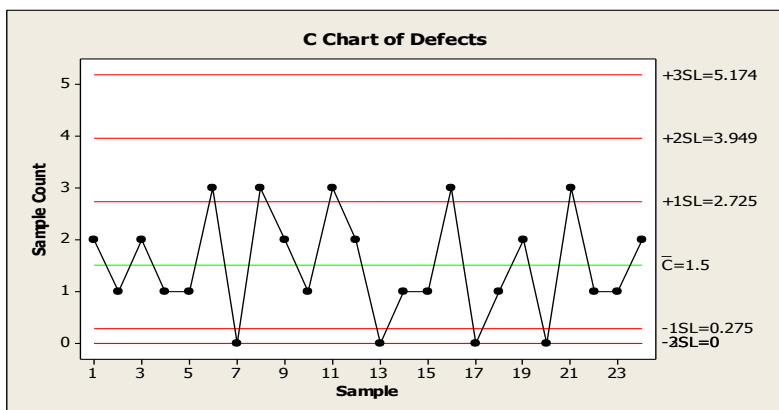
It was decided that for an initial period of three months, the project team will check 15 new domestic CMS (120 opportunities) for each team every day. On the basis of preliminary data of count of defects (leakage) available by applying soap test, the C-chart was made in Fig. 4. It was shown that one point (point # 6) was more than 3.00 standard deviation from central line at which test failed. The root cause of failure was the fitter had some work so he left the site before completing the task and the fitting was completed by his helper who did not perform the soap test after work.

Figure 4: C- Chart of Defects



A revised control chart was constructed in Fig. 5 after removing the point that was more than 3.00 standard deviation from central line. It was observed that all the remaining points were in control. So the process is in control in the revised chart.

Figure 5: Revised C- Chart of Defects



As the conclusion of Control Phase, different parameters were controlled through a control plan and a saving of Pak Rupees 2.1 million per annum (Pak Rupees 2,171,480/) was achieved. Sigma value was improved from 3.55 to 3.66 i.e., an improvement of 0.11σ was achieved.

Comments

It has been very common nationwide and internationally with industry whatever its type is like manufacturing, healthcare, agriculture, telecommunication, education, food, services oriented etc. that it is bearing a lot of cost due to poor quality which is obviously cutting down their profit and reducing overall productivity.

To reduce the cost of poor quality many organizations and corporations are struggling as much as possible. They are standardizing their processes for which different quality management systems are being implemented. Several quality tools such as Quality Circles, Kaizen, 5S, FMEA, Kan Ban, Kano Models and so many others are in progress in many national and multinational organizations. They are more or less improving their processes and reducing their cost of poor quality.

When one talk about the international benchmark about the cost of poor quality where it is zero, the only possibility observed in the international market is that cost of poor quality can be zero if the defect rate in the processes is reduced to 3.4 parts per million(ppm).

Conclusions

The above figure of defect rate has been achieved by so many corporations in the world by implementing SSM thoroughly. That's why the technique was applied in the study with the purpose to save finances being lost due to gas leakages in SNGPL. SSM was applied through define, measure, analyze, improve and control phase to improve the quality of work and reduce leakages. The targeted sigma value of the process was set at 3.7. As the solution obtained from SSM was implemented the revised process sigma value from the short term data was computed to 3.66. Though achieved sigma level is below the target by 0.04 yet it is highly expected that as more people are trained, their skill level is improved and process improvement plan is continued the sigma level of the process can easily cross the targeted value. The saving in this project was Pak Rupees 2,171,480. This value is bit less than the targeted but is still a healthy saving.

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