

# KAIZEN-SIX SIGMA TO IMPROVE PIPELINE PROJECT PERFORMANCE BASE ON BALANCE SCORE CARD FRAMEWORK

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## ***Abstract***

### ***Purpose:***

This paper presents an example of a Kaizen – Lean Sigma for improving pipeline project performance at Project Site ABC base on Balance Score Card Framework.

### ***Methodology:***

Kaizen is a Japanese philosophy that focuses on continual improvement throughout all aspects. Kaizen looks to improve all aspects of a business through standardizing processes, increasing efficiency, and eliminating waste, include reworks in the process. Through Kaizen and Six Sigma, companies can make breakthrough improvements in existing processes. Six Sigma focuses more on improving the quality of the final product by finding and eliminating causes of defects, whether by variances in the business process or in manufacturing. Welding process takes important part for pipeline construction, and base on those approaches the defects on weld is decreased then thus to improve the project performance.

### ***Findings:***

The welding process in pipeline construction takes around 65% in the pipeline replacement project schedule and critical path for the project. From two previous segment, contractor have a reject welding ratio 14% and reject material 7%, so it will be reduce into less than 5% and 3%. The improvement process start from IPO diagram then the problem analyzed using fish bone. The improvement covered manpower skill, manpower certification, and procedure, and then resulted less rework and faster project. These improvements align with BSC Frame; Learning and innovation, Internal Process, Customer, and Financial.

### ***Research limitations/implications:***

This research focused on improvement of project performance on large diameter pipeline at site ABC, particularly on welding process. Future research work could consider variation on improved process, pipeline diameter, project site, and climate condition.

### ***Value:***

This paper presents an improvement in projects (Kaizen – Six Sigma) for pipeline replacement project that prove alignment the improvement process with BSC Framework for the company.

### ***Keywords:***

Kaizen, Six Sigma, Key Performance Indicator, Performance, Project Management, Pipeline, Fishbone.

## INTRODUCTION

Energy industry takes important part of economic growth in Indonesia. Energy sources in Indonesia dominate by crude oil, which are taken from the spread area then gathered in certain location such as terminals, harbors, or refineries. The Company has been doing transportation of crude oil and gas since 1950s from various on-shore-fields in central Sumatera spread over 2,400 kilometer square with 13,000 km pipelines and 6 million barrels of crude oil storage.

The Company vision is *“To be the HydroCarbon Transportation Organization, as part of CPI - IBU, most admired for its People, Partnership and Performance”*.

The Company mission is *“To transport "spec" crude oil with accurate measurement from Primary Meters to Dumai Tank Farm for subsequent delivery to Off-Takers & to transport "spec" gas from primary meters / delivery points with accurate measurement to CPI consumers in the safe, effective & efficient manner in compliance with established standards, procedures and regulations”*

The most economical way to transport crude and gas is by pipeline. Pipelines are also a safe and efficient means of transporting large quantities of crude oil and natural gas over land. The Company transporting not less than 360,000 barrels of crude oils each day, if use tanker trucks the Company needs 6,000 tankers truck loads every day that very un-economical to the business and a environment.

The crude pipeline in site ABC has been built since 1956, due to aging and also severe corrosion; there are some reasons to replace the pipeline instead of repair in spots. The Company is replacing the pipeline along 1.7 kilometers for the worst segment, which lied on the ground and some in half buried condition.

Half buried created soil-to-air interface corrosion that prone to corroded. Soil-to-air interface areas are often much more susceptible to corrosion than the rest of the structure because of moisture and oxygen availability. Others can cause degradation to the pipeline, such as microbial corrosion, sulfur’s effect, mechanical damage, etc.

The Company conducts the replacement work by project. Schedule of the project takes 31 weeks of welding works, about 67% of schedule, and represent of 33% of project value. The welding works dominates the project and give high impact since it is create critical paths to the projects.

Contractor of the project also works for two others project base on the contract, and produced welding defect on ratio 14% on welding and 7% on material reject on those two previous works. The Company needs do something to reduce the defect ratio on this project; therefore can get defect ratio 5% on welding and 3% on material reject or less. The Company identified that the welding process needs to improve to boost the project performance thru Kaizen-Six Sigma method.

The Company performance measure is only on Safety (OE/HES Metric), Internal Process (Reliability Metric), and Financial (CSOC & Financial Metric). The loss of Learning and Growth aspect in the Company performance measures as in Balanced Scorecard Framework unbalance the performance of The Company, and created the hole in its performance. The pipeline replacement project is a good example.

As the structure of this paper, the paper first review theory about BSC and Kaizen-Six Sigma approach. Then, the paper presents the logic how the Kaizen-Six Sigma improvement will complement and integrated with BSC effectively. Moreover, the paper describes sample of Kaizen-Six Sigma improvement and how to integrate with score card of the company. Finally, the paper gives some suggestion to the integration of Kaizen-Six Sigma and BSC, and also some proposed of improvement for The Company Performance Management.

## CONSEPTUAL FRAMEWORK

### Six Sigma and Kaizen

The Six Sigma strategy originated with Motorola and became popular by Jack Welch, former CEO of General Electric. The Six Sigma strategy focuses on the elimination of hidden costs generated as a result of producing defective products and services. Six Sigma is an organized and systematic method for strategic process improvement and new product and service development that relies on statistical and scientific methods to make dramatic reductions in customer defined defect rates (Hahn et al., 1999). The focus of Six Sigma is to create processes that only have random causes of variations present. An organization operating at six-sigma level can expect its products and services to attain no more than 3.4 defective parts per million. Basically, organizations can estimate the benefits of Six Sigma projects presented in financial returns by linking process improvement with cost savings (Kwak and Anbari, 2006).

One of sub-methodology in Six Sigma is DMAIC, an acronym for Define-Measure-Analyze-Improve-Control. Generally, after the project Definition phase, key process characteristics are identified and benchmarked in the Measure and Analyze phases, followed by the Improve phase where a process is modified for better performance, and then the Control phase aims at monitoring and sustaining the gains. For showing the logic of the DMAIC sub-methodology in Six Sigma, the main activities are summarized chart bellow. (Lin&Chen, 2007; Greg, 2005).

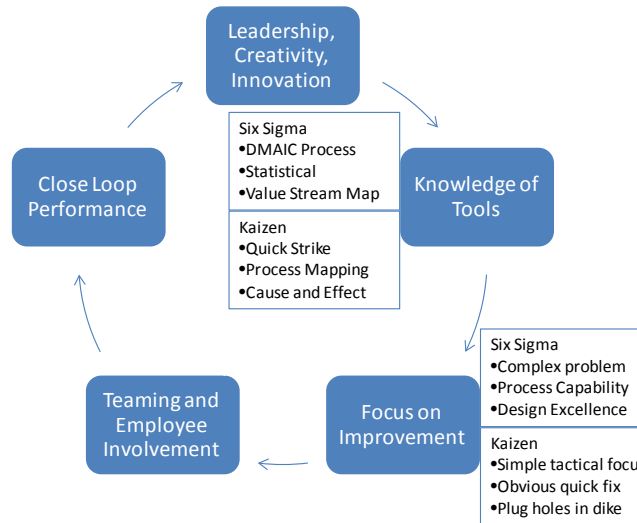
Kaizen is the practice of continuous improvement. Kaizen was originally introduced to the West by Masaaki Imai in his book *Kaizen: the Key to Japan's Competitive Success* in 1986. Today kaizen is recognized worldwide as an important pillar of an organization's long-term competitive strategy. One of the most notable features of kaizen is that big results come from many small changes accumulated over time. However this has been misunderstood to mean that kaizen equals small changes. In fact, kaizen means everyone involved in making improvements. While the majority of changes may be small, the greatest impact may be Kaizen that are led by senior management as transformational projects, or by cross-functional teams as kaizen events.

Kaizen generates small improvements as a result of coordinated continuous efforts by all employees. Kaizen events bring together a group of process owners and managers to map out an existing process and identify improvements that are within the scope of the participants. To generate a Kaizen, everyone involved must begin thinking about their work in a new way  in terms of:

- Now: Present condition

- Next: Desired state
- New: How to reach that state

Understanding the application of Six Sigma or Kaizen to various improvement opportunities is the key to success. The figure below provides a perspective on how to integrate Six Sigma and Kaizen into a total business improvement strategy.



Six sigma is more statistical, base on value stream map, and very discipline process. Therefore, six sigma is to handle the complex problem, related with process capability and also design excellence. In the other hand, Kaizen is quick to solve the problem, base on process mapping, and rely on cause and effect analysis. Kaizen is simple tactical focus to solve the problem that requires quick fix and action.

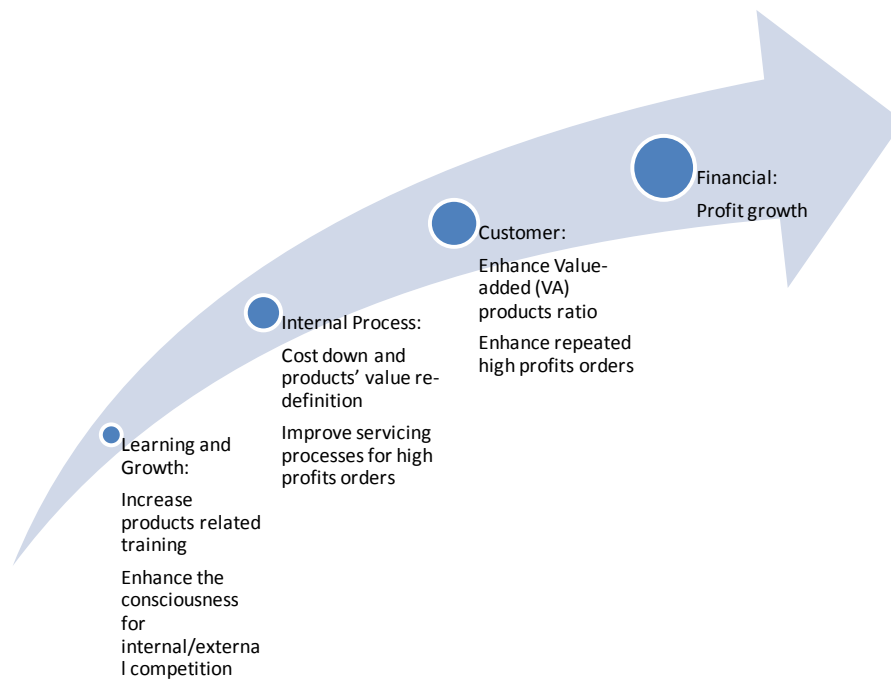
Some improvement opportunities are low hanging fruit, and can be harvested through several quick-strike Kaizen Blitz efforts. These are the obvious localized no-brainers that we trip over every day. The solution is not rocket science, simplicity, action and common sense.

The Company can make improvement in existing process and resulted in cost saving, but not always reflected in the bottom line. The reason for this is the absence of small improvements. The Company can combined system of six sigma, a strict adherence to established processes, and the workers that always looking for ways to make their processes better (Kaizen), makes the company in a better financial position in the long-run because improvements happen on an ongoing basis in addition to the occasional breakthrough.

### Balanced Scorecard

Due to the fault of financial-focus performance measurement, both practitioners and researchers have emphasized the need to move beyond financial indicators of operations and to incorporate a much wider variety of non-financial metrics in an organization's performance reporting and reward systems (Banker et al., 2004). Thus, in recent years, the integration perspective, the balanced scorecard (BSC), a comprehensive measurement system including both financial and non-financial aspects, has been designed to keep track of an organization's key success factors (Souissi and Itoh, 2006). Based on the concept of

going concerned, the spirit of the BSC is based on the assumption that the efficient use of investment capital is no longer the only determinant for competitive advantages, but increasingly soft factors such as intellectual capital, knowledge creation or excellent customer orientation become more important. It supplements traditional financial measures with measures from three additional perspectives: those of customers, internal business processes, and learning and growth (Sara et al., 2007).



The goal of Profits growth presents linkage for definitive four aspects in BSC. The BSC approach gives several significant benefits compared with traditional performance measurement systems. First, for improving the shortcoming of financial-centric measures, BSC is designed to broaden managers' vision by guiding their attention to wider aspects of the company's operations. Second, as an effective holistic performance measurement system, BSC provides robust causal linkage to connect the multiple levels between non-financial measures and financial measures. Thirdly, the strategy maps and its corresponding Key performance indicators (KPI) in BSC show clear profile of the linkage between company's visions down to directive business operations.

## METHODOLOGY

### The Integration and Complementary BSC and Kaizen-Six Sigma

Kaizen and Six Sigma are widely applied in manufacturing and servicing industries. However, how to link the application of those improvement initiatives with company's strategy and vision firmly is an important issue in practice fields. Nevertheless, the Balanced Scorecard System is an effective framework to describe the strategy for creating value and powerful tool to manage the execution of that strategy. In other word, Balanced Scorecard and Kaizen-Six Sigma can be integrated as one combination module for searching for excellence because the former provides the concrete context for targeted strategic initiatives and the latter is a scientific improvement methodology that can improve performance significantly

HCT Performance Dashboard				
May-14	Goal	YTD Plan	YTD Act	Status
<b>OE/HES Metrics</b>				
DAFW	0	0	0	✓
TRI	0	0	1	⚠
MVC	0	0	1	⚠
BBS Observation	100%	100%	100%	✓
LBA Participation	100%	100%	100%	✓
RSIP Compliance	100%	100%	99.4%	✓
Hazard Hunt	144	60	117	✓
Oil Spill (Volume)	0	0	0.0	✓
<b>Reliability Metric</b>				
Crude Quality (BSW)	98%	98%	100%	✓
Pipeline MTBF (day)	25	25	21	⚠
Metering Reliability	98%	98%	99.7%	✓
% Crude PL Flow Assurance	96%	100%	100%	✓
<b>CSOC &amp; Financial Metric</b>				
LS Value Creation \$ MM	6	1.72	0.87	⚠
Key Milestones	90%	100%	75%	⚠
Close Out Report Submission	97%	NA	NA	✓
Non Fuel OPEX \$ MM	38.4	16.0	11.1	✓
CEB - HCT \$ MM (Local)	6.8	3.1	1.9	✗
CEB - HCT \$ MM	1.4	0.8	1.05	✓
CEB - AIP \$ MM	14.2	5.2	1.9	✗

Site Governance

The Company has a performance measure system as above. The performance measurement consists of Safety perspective, Internal Process perspective, and financial perspective.

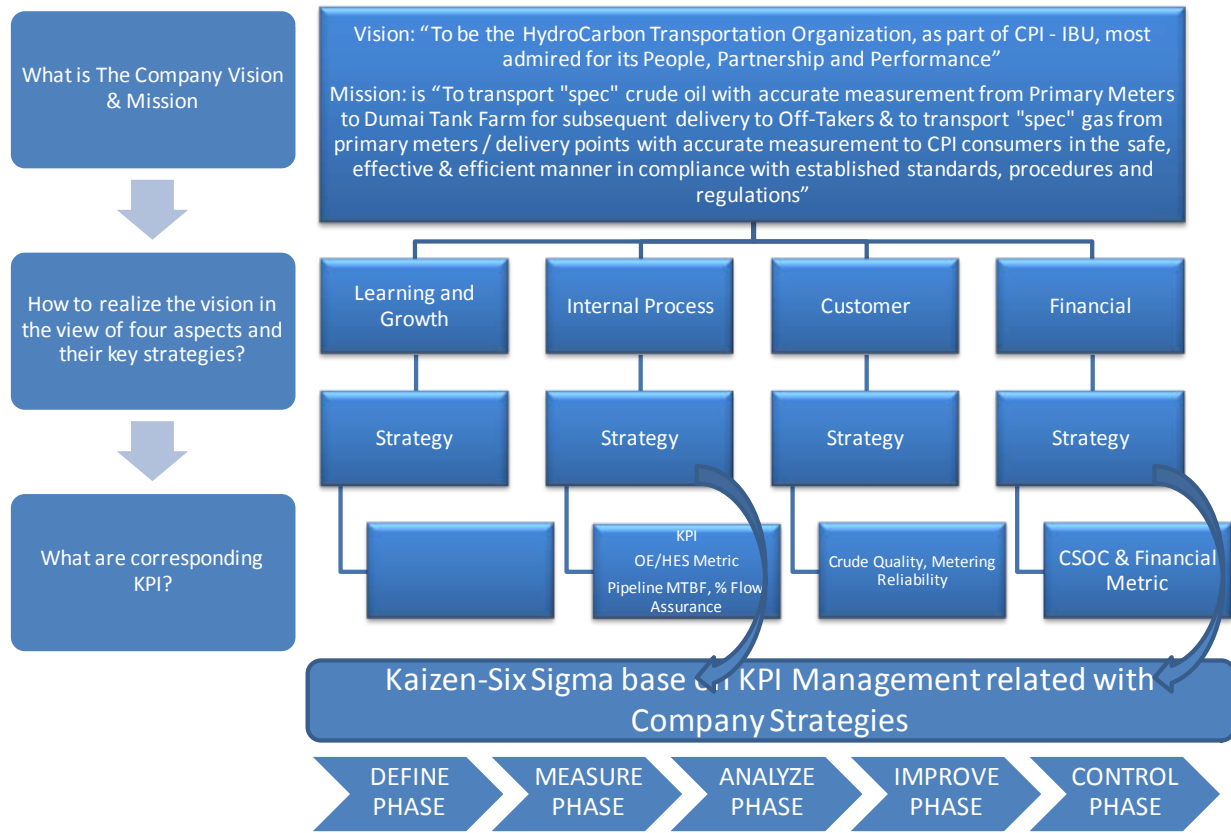
The Company vision is *“To be the HydroCarbon Transportation Organization, as part of CPI - IBU, most admired for its People, Partnership and Performance”*. The vision is what The Company wants to be in the future, what the Company wants to achieve, and what the Company dreams about. As part of the bigger company, the Company refer its vision to its parent company.

The Company mission is *“To transport "spec" crude oil with accurate measurement from Primary Meters to Dumai Tank Farm for subsequent delivery to Off-Takers & to transport "spec" gas from primary meters / delivery points with accurate measurement to CPI consumers in the safe, effective & efficient manner in compliance with established standards, procedures and regulations”*. The mission is why the company exists, that inform that the company provide to the society or customer. The Company mission is highlighted in three words;

1. To transport crude oil to the customer within spec with accurate measurement
2. To transport gas to the customer within spec and accurate measurement
3. Works with safe, effective, and efficient manner in compliance

The vision and mission of the Company translated to three perspective; Internal Process, Customer, and Financial. Figure bellow presents the validated cause-and-effect linkage logics with Kaizen-Six Sigma and BSC based on KPI management. Firstly, BSC demonstrates a concrete management tool of converting company vision into strategies and their corresponding measurement KPI. Then, with proper

target objectives setting, the corresponding performance metrics and goals required to accomplish the key strategies are to be created later. Thirdly, companies should pay attention to allocate demanded resources to actualize the commitment strategies in order to approach company vision. Therefore, to establish Kaizen-Six Sigma projects teams based on BSC framework and monitor the performance of corresponding strategy’s KPI outcomes are essential for approaching company vision respectively. In other words, the Kaizen-Six Sigma management approach can be performed more powerful and effective when integrating with BSC approach concurrently.

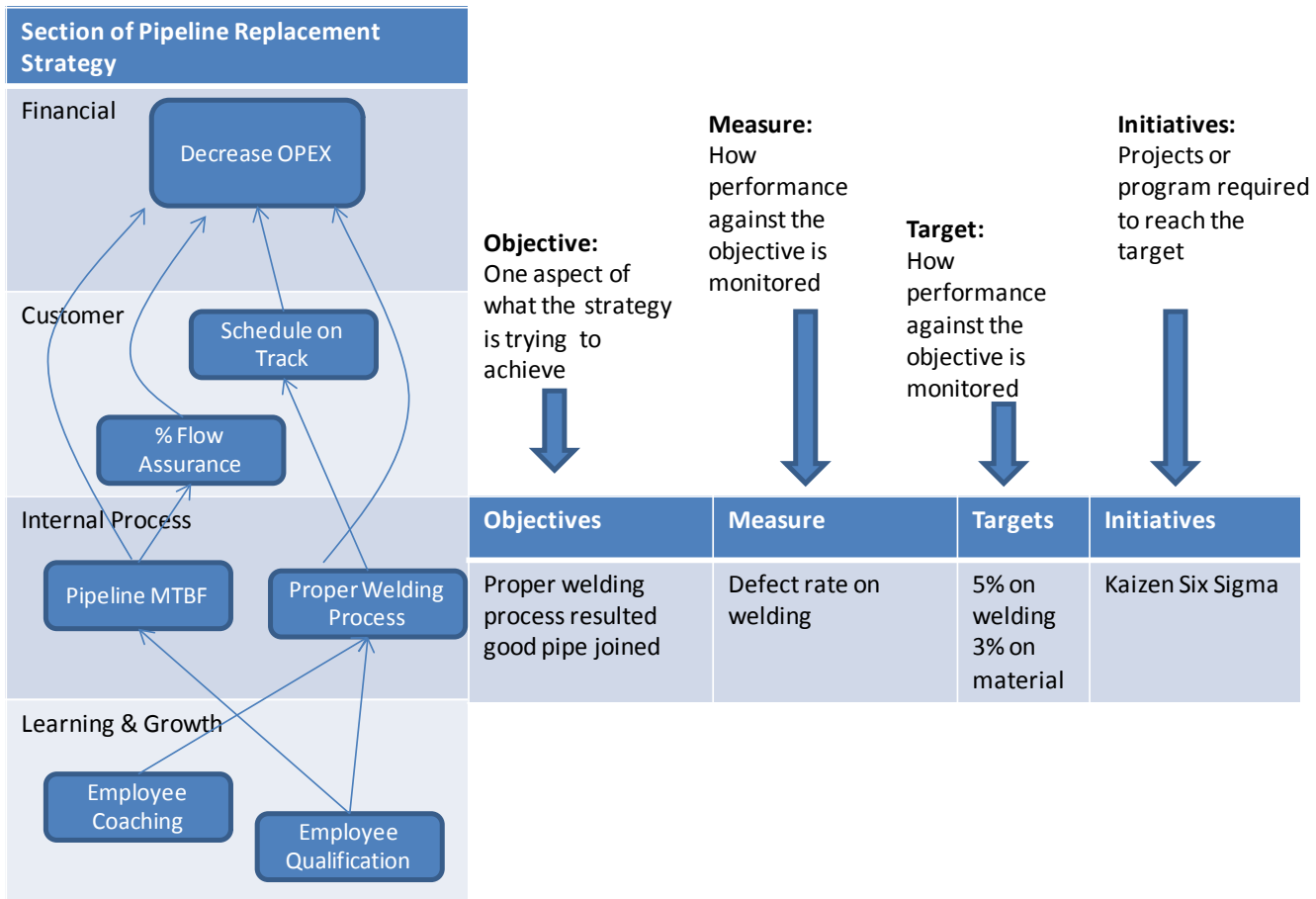


In this case, The Company has old pipelines that severe corroded along about 1.7 kilometers with sizes 24 inches, and the company wants to replace the section in strategy to improve pipeline MTBF and decrease Operating expense. The Balanced Scorecard is a framework to describe the strategy for creating value and tool to manage the execution of the strategy. The BSC identified gaps and is used to facilitate decision on how to address specific performance issues. Unlike Kaizen-Sig Sigma, the BSC is not a solution for closing the gaps. BSC and Kaizen-Six Sigma are complementary because the former provides the strategy context for targeted improvement initiatives and the later is a business improvement approach that can solve of performance issues.

The following graphic, the left side of illustration is a portion of strategy map that describes performance gaps. The left side of illustration is a portion of strategy map that describes strategic objectives across the four BSC perspectives. The arrows represent the cause and effect relationships

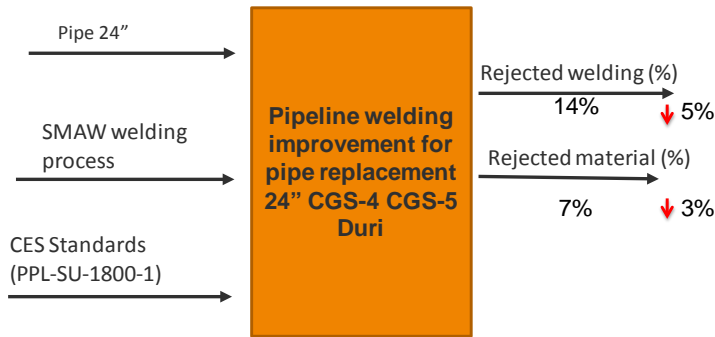
between strategic objectives. In the right, each objective has a corresponding measure, targets, and initiatives.

In this paper, the Company wants to decrease the operating expense. The strategy for doing this requires proper employee qualification and coaching to employee that result the proper welding process and high pipeline MTBF. Consistent with achievement of these four objectives enables the Company to satisfy the customer and avoid penalty by high percentage of flow assurance and also pipeline replacement on time. The Company measures proper welding process by defect rate is 5% respectively. To improve the actual performance on the target, the company uses six sigma. After process mapping, the company realize that the improvement can do in the quick strike; therefore the company apply kaizen in the six sigma methodology, to make simple tactical focus and quick fix.

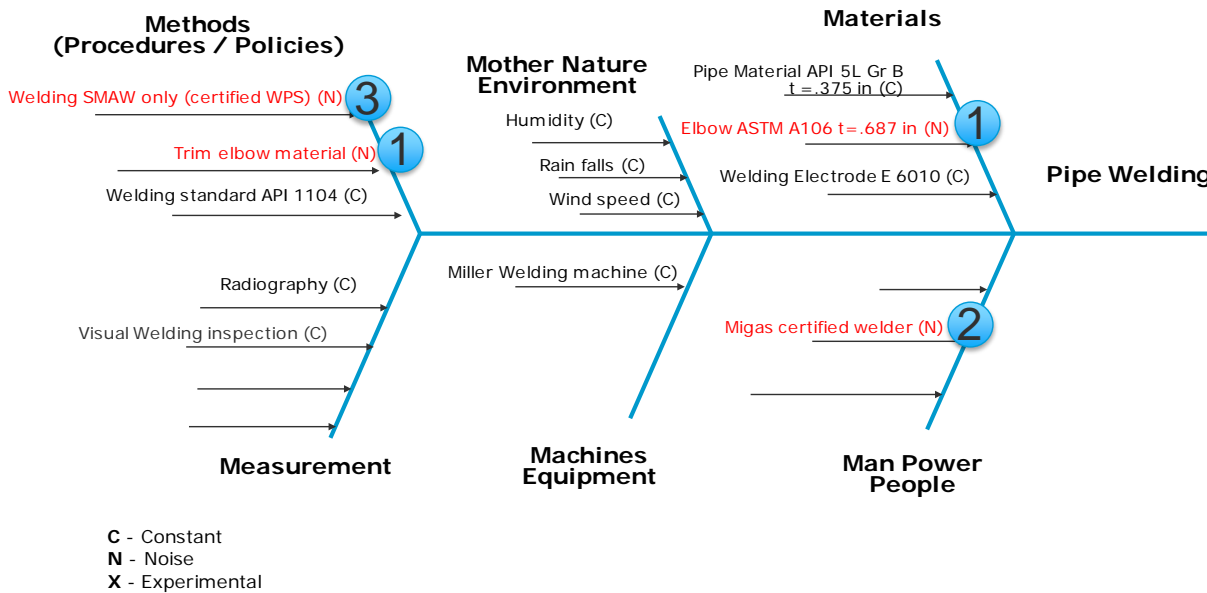


In the Define Phase, the Company tries to identify the problem by defining the scope, the objectives, problem statements, and opportunity. The objective is to reduce reject rate of pipeline welding process and reduce reject material for pipe replacement 24” CGS-4 CGS-5 Duri, with business objective to support on time schedule completion. The problem is the contractor in the previous work has defect rate 14% on welding and 7% on material, so it will reduce to be 5% and 3% or less, with opportunity to improve welding process for getting less rework and remove reject material.





IPO Diagram constructed as above for this improvement process. The input is material line pipe 24 inch, the welding process, and the standard related with welding process. The expected output is rejected welding decrease from 14% to 5%, and rejected material decrease from 7% to 3%.



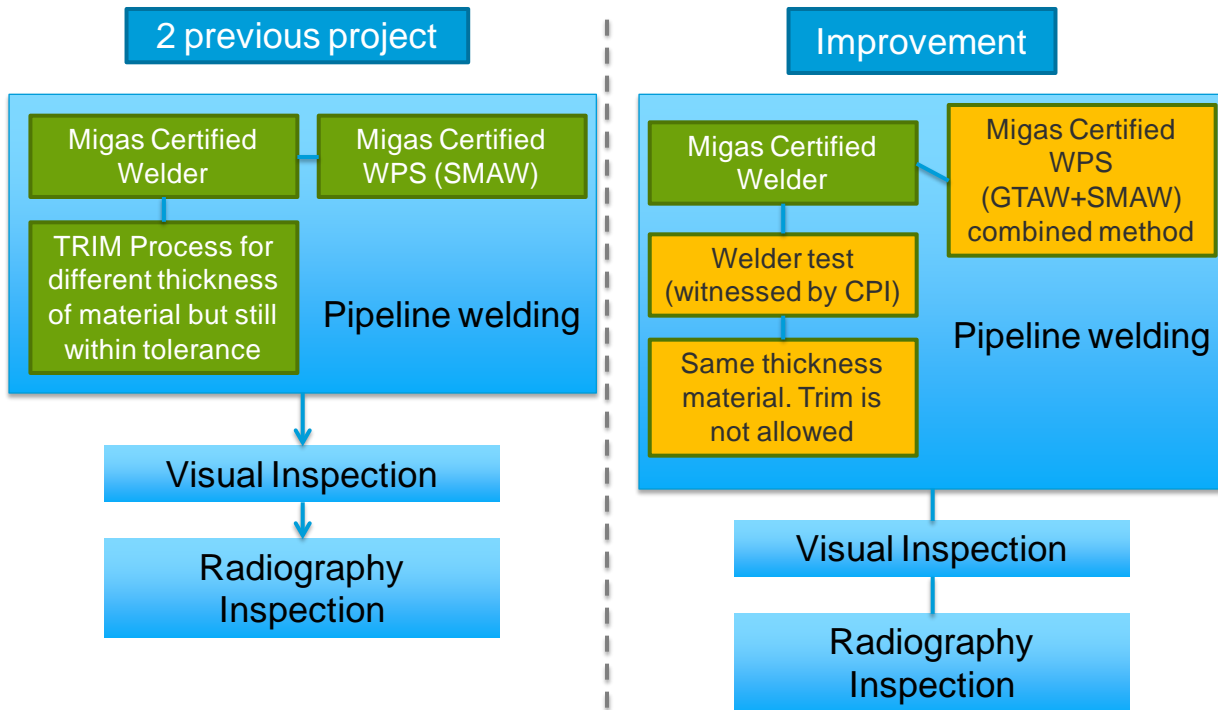
The Company analyzes cause and effect of the problem using fish bone diagram. Cause and Effect Analysis was devised by Professor Kaoru Ishikawa, a pioneer of quality management, in the 1960s. The technique was then published in his 1990 book, "Introduction to Quality Control." Cause and Effect Analysis was originally developed as a quality control tool.

From the analysis, defect can be caused by six M; man, machines, measurement, material, methods, and mother nature, then classified which is constant, something that cannot change – invariable causes, and which is noise, the causes which cannot be influenced directly and occur. In the analysis, there are not found any experimental, the decisive variables which the project can influence.

The noises found in the analysis are;

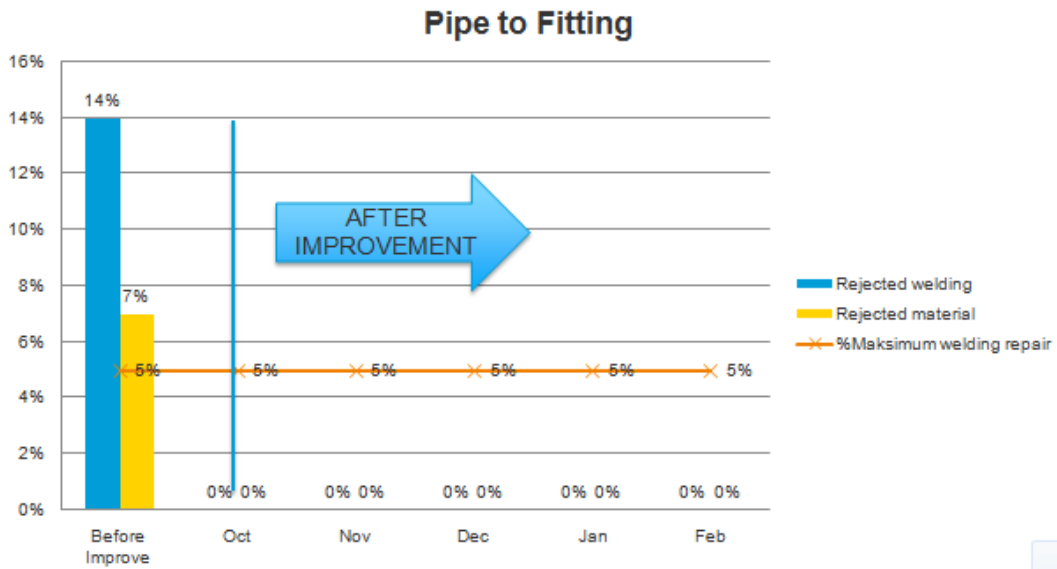
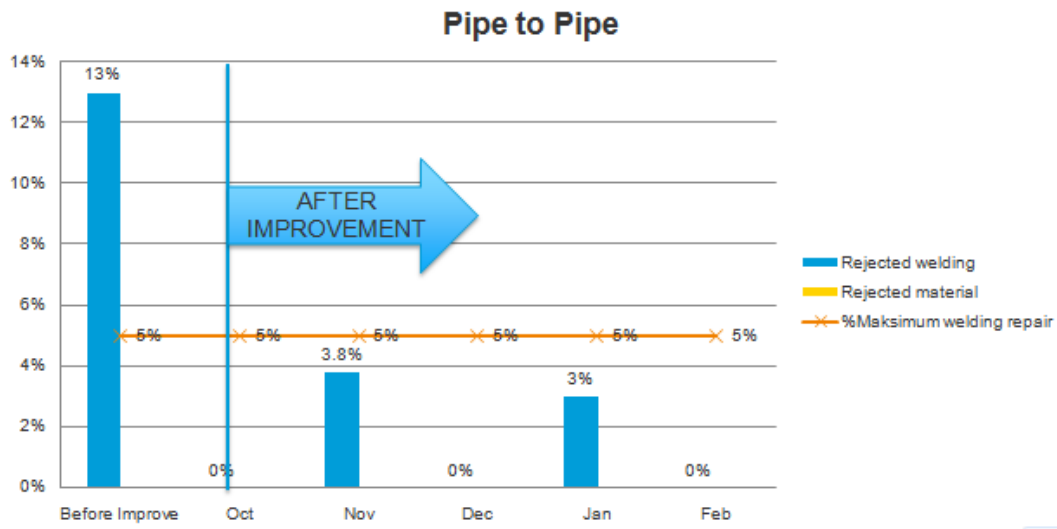
1. Differences in the thickness of the material pipe and elbow (fitting) will potentially lead to failure
2. Only rely on certificates without testing the ability of the welder will potentially lead to failure
3. To avoid failure in particular welding especially root undercut defect, using GTAW method should be considered

Man power is one of the noise, it is a signal that Kaizen can apply in this improvement process, due to it can do quick and tactical focus.



On the two previous works, the contractor employed welders with qualification that proven by welder certificate. In the new process, those welders are test again and witnessed by the Company representative to ensure the welder performance. In the welder test, some welders failed and the consequences is grounded, not allowed to weld the line pipe. Along grounded time, the welding is coaching by the company representative in weekly, and after they confidence can propose another welder test.

The material also improved in the new process, which is not allowed difference thickness, even within tolerance. The difference of thickness shall be machined in the shop, not in the field. And the last, to improve welding quality, the welding combination is used; due to the contractor cannot provide the better welding consumables that prevent defects on the welding root.



After improvement process started the defect rate decrease to around 3% on welding defect and 0% on rejected material. The saving from this project is USD 23,000 for rejected welding (calculated from total welding) and USD 16,000 for rejected material (calculated from total material welded) from this pipeline replacement project.

To sum up, the BSC describes the strategy for creating value and align resources to ensure the strategy is successfully executed. Six sigma and Kaizen execute the strategy by using data and process improvement tools, therefore BSC is the map and Six-Sigma and Kaizen is the vehicle to achieve the destination.

## **RESEARCH FINDING**

The Company already successfully integrated BSC Framework and Kaizen-Six Sigma approaches. Moreover, the lack of learning and growth perspective in the company performance measurement clearly identify in the case pipeline replacement work, which is man power qualification is one of the cause. In order to ensure the success of each strategy, the learning and growth perspective (people perspective) shall be a foundation, and built in performance management system.

Based on the performance management system, each strategic objective has a corresponding measure, target and concrete definition. The company also shall formulate a consistent system for assessing the performance indicator and ensuring the appropriate linkage between individual performance and their corresponding rewards. Reward and encouragement system for skillful key personnel in the field, such as welder, should be in place to improve their performance align with the Company performance.

The Company also included the improvement tools (Lean, Kaizen, Six-Sigma) in its performance management, in the financial metric part, it is a good approach to ensure continuous improvement in the Company. Moreover, it gives an indicator how the Company improves in their business process, but if there are no clear alignment and guidance, it could make confuse in the internal organization. The improvement only viewed from the financial perspective make the Company only doing improvement in the big money involved, more than USD 100,000, and ignored for the sustainability of improvements.

## **DISCUSSION AND RECOMMENDATION**

The project-based organization of Six Sigma focuses on digging out and solving the root causes of specific performance problems. On the other hand, BSC is an effective perspective to profile the framework toward enterprises' strategy linkage and aligns the organization's resources to achieve their goals and vision. This paper proven that the integration of BSC and Kaizen-Six Sigma could be effectively improving the Company performance. This paper also shown that the integration could reveal interaction between BSC and Kaizen-Six Sigma and prove to the Company performance management that the people perspective (learning and growth) is foundation. The Company should add people perspective (learning and growth) in their performance management. It also align with the Company mission, "compliance", where in the oil and gas industry there are a lot of standard and regulation that have to follow and fulfill. The skill that needs certificate not only relies on the certificate, but also there are regular check and testing to ensure the fluency. Additionally, the reward and encouragement system shall in place to motivate people in the field.

For the project that use contractor, the Company can put contractor performance align with the Company performance management, to ensure what the contractor do is to support and related with company strategy and performance. Until now, there are no full alignment within contractor performance management and the company performance management. The alignment only present in the safety issue.

In other words, both Six Sigma and BSC approaches should not be treated as yet stand-alone management tools respectively. It means that combining both approaches can offer more powerful potential contributions on strategies implementation. BSC and Six Sigma can be firmly integrated because the former provides the strategic context concretely for targeted initiatives of strategies implementation and the latter is a robust systematic operations improvement approach. Organizations that perform the BSC management approach can utilize Six Sigma as the strategic improvement tools to implement the planed strategies which underlie the KPI management system respectively. The Company should not place the Six Sigma related in the financial metric, in order to sustain the improvement process and not emphasize only for cash generated issue.

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