Lessons Learned from Applying Safety Culture Maturity Model in Thailand

Bordin Vongvitayapirom
Center for Advanced Studies in Industrial Technology, Faculty of Engineering, Kasetsart University, 50 Pahonyothin Rd, Jatujak, Bangkok 10900, Thailand
bordinv@pttep.com

Punnamee Sachakamol
Center for Advanced Studies in Industrial Technology, Faculty of Engineering, Kasetsart University, 50 Pahonyothin Rd, Jatujak, Bangkok 10900, Thailand
fengpmsa@ku.ac.th

Hanna Kropsu-Vehkapera
Department of Industrial Engineering and Management, Faculty of Engineering, Oulu University, P.O. Box 4610, FIN-90014, Finland
Hanna.Kropsu-Vehkapera@oulu.fi

Pekka Kess
Department of Industrial Engineering and Management, Faculty of Engineering, Oulu University, P.O. Box 4610, FIN-90014, Finland
Pekka.Kess@oulu.fi

Abstract

Purpose – The purpose of this paper it to provide practitioner and researcher lessons learned from applying a safety culture maturity model in the oil and gas industry in Thailand. It proposes a roadmap to improve safety culture maturity in an organization

Design/methodology/approach – A safety culture maturity of 5 levels was chosen (Hudson's model) to be applied in oil and gas company, and a questionnaire survey was conducted with 2,251 employees or 74% of the target group across the company. The results were used to develop a roadmap to improve the safety culture maturity of the company.

Findings – Results from questionnaire survey showed a safety culture maturity level of the company is at 3.3, or calculative, with correlations among competency, work planning, worksite techniques, hazard reporting, responsibility and benchmarking elements. Using these findings, a roadmap was developed into 5 action plans to improve the safety culture maturity level for the company in the long term.

Practical implications – This paper could serve practitioners as a guideline and a tool to understand and implement safety culture maturity concept in an organization

synergia
International Journal of Synergy and Research
Vol. 2, No. 1, 2013
p. 5–21

Originality/value - This paper also furnishes lesson learned for practitioners in the same and different industries on safety culture maturity implementation and assessment in organizations.
Keywords - Synergy, Research, Lessons learned, Safety culture maturity, Oil and Gas, Thailand
Paper type - Case study

1. Introduction

From 2009 – 2011, the overall energy consumption in Thailand (Petroleum products, Natural gas, Coal, Lignite and etc.) was higher than country production. Hence, the Government had to import resources to maintain the demand, which was increasing rapidly and for which domestic production could only satisfy 1/3 of the country hydrocarbon demand (Department of Mineral Fuel, 2011). In past decades, the government promoted investment in the manufacturing sector in heavy industries, including auto manufacturing, metalworking and petrochemicals factories. Those require substantial amounts of energy, which far exceed what country can normally produce (Board of Investment, 2012). Moreover, in 2011, Thailand's oil and gas consumption was ranked 19th and 25th among overall countries, or 1.2 % and 1.1% respectively of the world consumption, which was higher than its neighboring countries (British Petroleum, 2011); hence, Thailand has had to import more energy resources than they can produce.

Petroleum Authority of Thailand in Exploration and Production [PTTEP], the National Oil and Gas Company and a subsidiary of PTT Group, is a key player to find energy resources, both domestic and international, to meet country's energy demand. If there are any major incidents in company's operations, it may cause an unplanned shutdown and a delay in the energy supply to power plants. One eventual outcome could be an electricity shortage which would impact many stakeholders in Thailand.

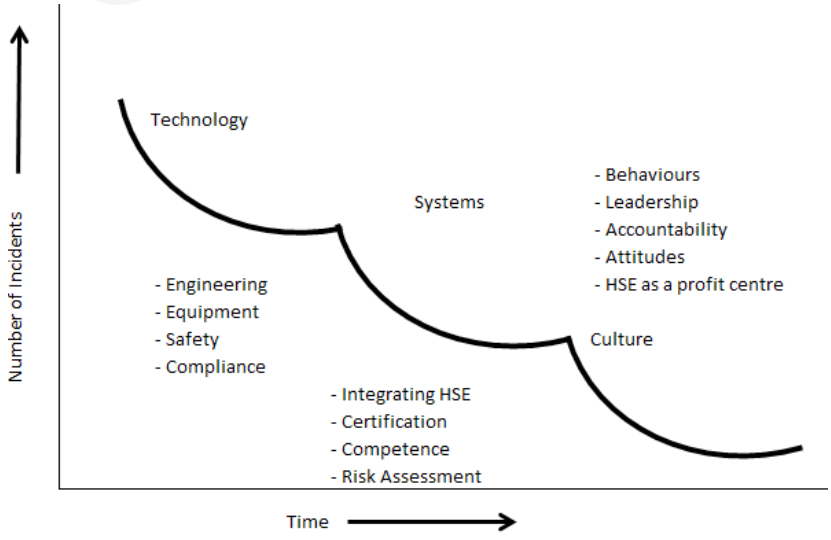

Figure 1:
Safety focus area from times to times (Hudson, 2007)

In general, the safety focus areas relevant to reducing incident rates are highlighted into 3 approaches as explained in figure 1. The first approach, which was used in the 1980s, was a technique wherein organizations attempted to reduce their accident rates by developing technologies, such as hardware and designs to avoid hazards and prevent employees from entering the line of fire.

The second highlight is a systems approach. It focused in the early 2000s on improving employee competency by training, conducting risk assessments and implementing management systems such as ILO 2001 and OHSAS 18001. Nevertheless, accidents still happened in organizations that successfully improved their technology and systems. They were able to better control their safety equipment, and engineering designs; competency of employees and management systems, but culture and behavior turned out to be much hard to control. The third highlight is the culture approach that focuses on leadership, safety attitudes and people.

When we consider industry in Thailand, in 1980-90s, Occupational health and safety were not significant to production and quality since many industries aimed to maintain the highest productivity and profitability and relevant legislation was not being fully enforced by the government in terms of any safety management system (SMS). On-site improvement of engineering design, operating equipment and personal protective equipment were adopted in the stages of Thailand's industry. In 1999, the Thai government issued its first safety management system called "Thailand Industrial Standard 18001 or TIS 18001" (Industrial Standard Institute, 1999). As a result, Thailand's incident trend slowly began to trend downward. Hence, improvement that targeting a more effective safety culture in Thailand's industry is needed in order to improve organizational behavior toward safety and accountability to individual work (Ministry of labor, 2012).

2. Literature review

2.1 Safety Culture

The word "Safety culture" originated and came into common use after the Chernobyl nuclear industry disaster in 1986. It was seen that the behavior of employees can impact the outcome of safety performance (Flin et al., 2000). A safety culture has been described as the collective values and attitudes of the people in the organization and defined as the attitudes, values and beliefs that underpin "the way we do things here" (International Association of Oil and Gas Producer [OGP], 2010).

In the oil and gas industry, the safety culture has been a matter of great concern ever since the Piper Alpha disaster (IAEA, 1991) that caused such horrific consequences to the company both in reputation and financial damage in long term. Additionally, in 2009 the "Montara" accident caused a huge amount of contamination to the environment, marine and wildlife. Moreover in 2010, the "Macondo" accident in the Gulf of Mexico became one of the largest environmental oil spills in history. 11 men died and 17 were injured. The impact upon society totaled rapidly and more than $17.7 billion has been spent on many years of response activity. Accident root causes from these catastrophes have stemmed from poor safety culture and human error, mistakes in cost reduction, integrity and reliability, core competency and just plain wrong decision-making.

2.2 Safety culture maturity model

The importance of safety culture has been highlighted in high risk industries and studied by many researchers. At the first stage of study, a typical safety culture has been categorized into 3 stages, namely: pathological, calculative/bureaucratic and generative. Pathological is defined as careless about safety and failures are normally just covered up. The bureaucratic/calculative stage is where safety is just in place and the organization feels comfortable about what they have in place, even though they might be able to improve. In the generative stage, safety behavior is fully integrated into employees' minds and everything they do. (Weick, 1987; Westrum, 1991; Westrum and Adamski, 1999)

Over the years, the study of a safety culture was extended into 5 levels, with reactive and proactive being included (Reason, 1997) with the original three stages. So as to make the framework broader, better classifications are easier to implement and identify safety culture maturity in an organization. Further in depth research of these 5 levels has been conducted within the Oil and Gas industry and a more detailed set of descriptions of the different types of different safety culture resulted e.g., communication, organization attitudes and behaviors (Lawrie et al., 2006; Parker et al., 2006; Filho et al., 2010). This type of model was later successfully implemented in Royal Dutch/Shell Company as their "Heart and Mind program" which aims to identify the safety culture maturity level of the organization (Hudson and Willekes, 2000). Furthermore, it has been highlighted in OGP report and EU-OSHA as recommendations for safety culture improvement.

3. Methodology

The methodology of this research is described in practical way, from finding a volunteer company, reviewing of documents and accidents, gaining management acceptance and initiating the campaign as company's annual event to gaining the results for developing a roadmap to improve safety culture maturity in a volunteer company, as shown in figure 2.

3.1 Case study selection

Many studies of safety culture for high-risk industries exist, e.g., nuclear, aviator and petrochemical in Europe, America and the Middle East. While in Thailand, there is, as of yet, no theoretical study for safety culture maturity in the broader and oil and gas industry, indicating that coming to grips with the concept of a safety culture in this country is still a very new idea. This research team sent a request to the Thai Ministry of Labor to find a volunteer company to study safety culture maturity in a high risk industry and was given a permission to conduct a study in PTTEP, the national oil and gas industry in exploration and production (upstream), in 2011 – 2012.

3.2 Document review

In order to understand safety culture development within a single company, a Chronological SMS implementation review for the company is needed to assess the

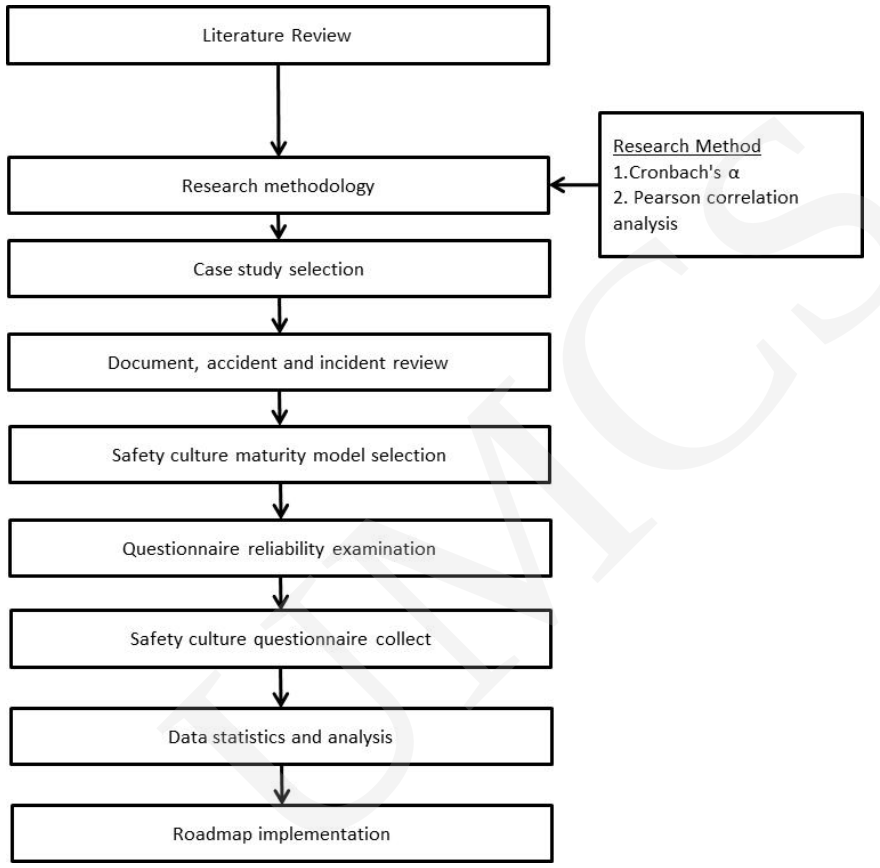

Figure 2: Research methodology for this paper

safety culture readiness in the organization (Guldenmund, 2000; Guldenmund, 2010). Documents and activities from 1994 – 2011 have been reviewed from the company intranet, document database, campaigns, rewards and recognitions, internal and external certifications. PTTEP has continuously improved in safety, security, health and environment (SSHE) ever since 1994 driven by the need to comply with international standards and industry trends. Improvement can also be categorized into 3 focus areas, based on figure.1 as shown in table 1.

3.3 Incident and accident review

More than 1,000 recorded data cases of accidents/incidents e.g., lost time injury, total recordable injury and medical treatment, have been reviewed in the PTTEP database. The development of technology and systems in the company improved safety statistics time after time as the root cause of accidents became straightforward; for instance, improper PPE, no work standard and procedure for risky tasks. From 2007 to 2011, when all hardware and systems were in place, the human factor became one of the key

Technology	System	Culture
1994: Established HSE and Audit department	1996: Strengthened HSE internal system via compliance, audits and HSE risk assessments	1996: Developed Internal HSE Awareness survey
1995: Established HSE management system, policy, committee	1996- present: provided HSE training for corporate level	2003-present: Conducted benchmarking safety performance with OGP and peers
1995- present: improved operation via new technology investment and hardware improvement	1997-present: Implemented SSHE Management system to into line with OGP	2006 – present: Implemented behavior based safety, Step change in Safety and Safety toward sustainability
1996- present: Issued corporate HSE standards, procedures, and guidelines	2010: Conducted Corporate Risk profile	2011 - present: implemented safety culture maturity model and questionnaire

Table 1: Chronological safety management system implementation of PTTEP

contributing factors that caused protective barriers to fail easily because of no safety culture or leadership that was ineffective or not in place. It can, therefore, be concluded that, in PTTEP history, there has been no campaign to create an organizational safety culture at the company level. Carrying this point to the next step, using safety culture maturity model to identify and improve safety culture at the company level is an appropriate method in terms of a next step.

3.4 Selection safety culture maturity model

PTTEP choose this model from industry best practice "heart and mind program". It furnishes an HSE culture ladder, which generates into 5 levels, descriptions and a tool guide to improve HSE. To identify the organization HSE safety culture or safety culture maturity level, a safety culture questionnaire is needed. Seven safety culture dimensions have been chosen to match the organization's Safety Management System (SMS) and to make them easily recognizable to employees. Each dimension description is shown in table 2.

Dimensions/Attributes	Definition
1. Leadership and Commitment	Top-down commitment and safety, security, health and environment (SSHE) culture
2. Policy and Strategic Objectives	Corporate intentions, principles of action and aspirations with respect to SSHE
3. Organization, Resources and Documentation	Organization of people, resources and documentation for sound SSHE performance
4. Evaluation and Risk Management	Identification and evaluation of SSHE risks for activities, products
5. Planning and Operational Control	Planning the conduct of work activities
6. Implementation and Monitoring	Performance and monitoring of activities, and how corrective action is to be taken when necessary
7. Audit and review	Periodic assessments of SSHE management system performance effectiveness

Table 2: PTTEP 7 safety culture dimensions

In each dimension, sub element standards support every hierarchy level e.g., Corporate oversight, roles and responsibility and contractor management. The questionnaires break down each safety culture maturity state into quantitative descriptions based on the company SMS. The survey collects the age, years of experience, job position, etc. The scores for each location are different, depending on the culture in each country and the organizational culture evolution (Schein, 2004).

3.5 Questionnaire reliability examination

A pilot test was conducted and validated with the HSE division (n = 60) before the campaign launch. The questionnaire, 20 questions, was presented in the Corporate HSE division monthly meeting and meeting participants were asked to complete and comment on the survey. Participants are from many disciplines; for example, Occupational health and safety, Safety engineer, technical safety, environment engineer, operational safety engineer, safety advisor and analyst with experience ranges between 1 – 35 years in safety and related fields. Some survey adjustments and comments have been collected and revised in order to comply with organization requests. Overall, feedback from the HSE division has been positive and results have proven practical in that PTTEP has determined their state of safety culture maturity level. The reliability testing for the questionnaire with 20 items was conducted by using cronbanc's α coefficient with acceptable result >0.5 as shown in table 3.

Attributes	Mean	Stdev	Cronbach's α	#Item
1: Leadership & Commitment	3.32	0.90	0.676	3
2: Policy & Strategic Objective	3.3	1.02	0.517	3
3: Organization Resources & Documentation	3.2	0.93	0.585	3
4: Evaluation & Risk Management	3.4	0.86	0.777	2
5: Implementation & Operational Control	3.58	0.93	N/A	1
6: Monitoring & Measurement	3.37	0.93	0.791	6
7: Audit & Review	3.26	0.96	0.613	2

Table 3: Mean, standard deviation, cronbach's α for reliability examination

Attributes 1, 4, 6 and 7 had acceptable reliability coefficients. Attributes 2 and 3 show coefficients below 0.6; but they could not be improved by removing any of the items.

3.6 Management acceptance

After consensus with HSE division was reached, a campaign was proposed to top management. They endorsed conducting an annual campaign to identify and improve company's safety culture maturity level. Moreover, they continue to provide support for this campaign. For example, management is the first group to complete the survey, and employee can use their low activity working time to attend the survey sessions. This time spent can also be used as one of their safety key performance indicators.

3.7 Collect safety culture questionnaire survey

This task force comprises several research team members, including behavior based safety and safety engineers. Sessions were set up to explain the objectives of the survey and each element description in small group. Each session began with 10-15 minutes of introduction on how to answer the questionnaire (Likert scale, 1. Pathological to 5. Generative). The survey remained available for a few days in every location and to every employee in every level was freely encouraged to use a non-busy time to come and complete the survey. A total of 150 sessions in 10 locations (head office, operation sites, drilling rigs, construction and exploration sites) were employed to conduct the survey and collect data, resulting in 2,251 out of a total of 3,041 employee respondents. This measures out as 74% of the target group across the company.

4. Results

4.1 Organization safety culture maturity level

The average company score as computed from the questionnaire data led to a figure of 3.33 or the calculative level, described in the 7 attributes of the company safety management system and safety culture questionnaire shown in table.4, along with organization safety culture maturity in each element/question that require methods for improvement.

Questionnaire number	Mean	Standard Deviation	Pearson correlation >0.5
1.1 Communicating SSHE issues	3.31	0.84	–
1.2 Commitment level of workforce and care	3.45	0.92	–
1.3 Reward and recognition	3.24	0.93	–
2.1 Who caused accidents in the eyes of management?	3.43	1.01	–
2.2 Balance between SSHE and profitability	3.55	0.88	–
2.3 Safety talk	2.93	1.11	–
3.1 Contractor management	3.16	0.91	–
3.2 Competency/training	3.16	0.97	Q4.1**
3.3 Size of SSHE group	3.42	0.73	–
4.1 Work planning	3.45	0.84	Q3.2** ,Q4.2**, Q6.2** , Q6.5**
4.2 Work-site job SSHE techniques	3.37	0.87	Q4.1**,Q6.2**,Q6.4**, Q6.5**
5.1 What is the purpose of SSHE procedures	3.58	0.93	–
6.1 Incident/accident reporting, investigation and analysis	3.34	0.93	-
6.2 Hazard reporting, Safety observation and Communication report	3.3	0.86	Q4.1**, Q4.2**, Q6.4** ,Q6.5**, Q7.2**
6.3 What happens after an incident and feedback?	3.66	1.02	-
6.4 Who checks SSHE on a day to day basis (SSHE responsibilities)	3.18	0.97	Q4.2**,Q 6.2**, Q 6.5**

Table 4: Questionnaire survey result with mean, standard deviation and Pearson correlation

6.5 How do SSHE meeting feels (participants)	3.41	0.84	Q4.1**, Q 4.2**, Q6.2**, Q6.4**
6.6 Behavioral based safety (BBS)	3.36	0.91	-
7.1 Audits and review for SSHE	3.27	0.90	-
7.2 Benchmarking, trends and statistics in SSHE	3.25	1.01	Q6.2**

**. Correlation is significant at the 0.01 level (2-tailed)

4.2 Correlation among elements

The results from table.4 show that the 3 lowest elements are safety talks, competency/ training and contractor management with means of 2.93, 3.16 and 3.16 respectively. Correlations among questionnaire should be considered when designing a campaign to simultaneously improve safety culture maturity in multiple aspects. A summary of Pearson correlations >0.5 among questionnaire elements are shown in figure 3.

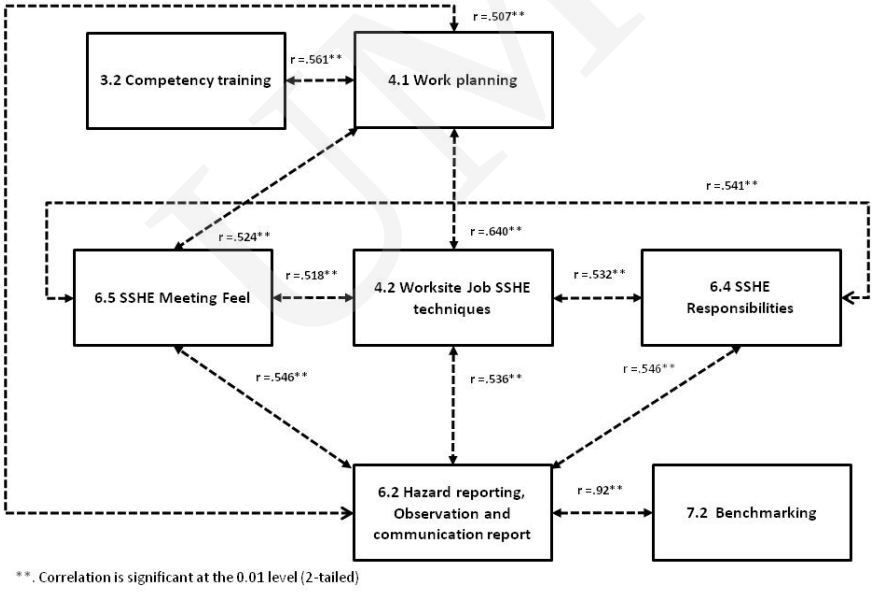

Figure 3: Result of Pearson correlations >0.5 among each questionnaire

Work planning in an organization relates closely with Competency training (Q3.2, r=0.561) when attempting to design or improve a training matrix for employee competency in long run. It can also relate with how the meeting (participants) feels (Q6.5, r=0.524) or work pressure depending on assigned work during the period. Work planning for each job and phase activities e.g., construction, commissioning and production, will also help determine the worksite job SSHE techniques (Q4.2, r=0.640) that workers use, how they conduct hazard reporting, observation and communicate (Q6.2, r=0.507) to provide feedback regarding safety management system effectiveness.

Worksite Job SSHE techniques relate to SSHE responsibilities (Q6.4, r=0.532) which explains each job responsibility and who has responsibility to perform what

activities. For example, at the beginning of offloading a booster compressor from a boat to a shipyard, the SSHE job techniques e.g., job hazard analysis and safety observation, should be conducted prior to the operation, led by a supervisor at the operating site with all the working team's participation, enabling them to follow work procedures and ensuring effective communication to all stakeholders.

SSHE responsibilities relate to worksite job SSHE techniques, SSHE meeting (participants) feel (Q6.5, r=0.541) and hazard reporting, observation and communication report (Q6.2, r=0.546) which target each task and its activities, the person responsible will hold a different responsibility as indicated in the standard. SSHE meeting feel also relates with worksite job SSHE techniques (Q4.2, r=0.518), SSHE responsibilities, work planning, hazard reporting observation and communication report (Q6.2, r=0.546).

4.3 Safety culture maturity level of each location

The safety culture maturity for the corporate level and each operating location was measured through use of this safety culture questionnaire. Each location's job scope is different, along with its safety management system. Each culture has additionally been developed by its own management level, and safety manager, with corporate HSE division assistance.

There are old and new locations that have different safety histories and services year ranging from 2 to 30 years. Those have been tested by the Pearson correlation to find the relation between safety culture maturity level and location service year, and it was found that there is no correlation (n= 10, r= 0.19, sig 2-tailed = 0.58, $p>0.05$). Long lengths of service with a poor safety culture maturity level can reflect poor management leadership, misdirection of a safety culture, insignificance of the safety performance, bad safety attitude at the supervisor and employee level.

4.3.1 Safety Culture Maturity by Working Level

The score of each working level in each location indicate the same directions as shown in table.6. The results show that leadership and commitment from top management toward safety in each location can impact all working level safety awareness from the document review. Results of feedback during the survey show that all working levels, except for the front line supervisor, have a high concern for safety. Indeed, the average score of workers and managers in many locations are higher than supervisors. Many supervisors have negative attitudes toward safety as they directly control the workers in the front line, not the managers, and due to tight working schedules, safety is not always the priority when it comes to production.

Below is an example of a supervisor negative perspective toward safety

"*When an accident happens, it is not a job for front line but corporate safety to investigate and create a countermeasure, conduct a gap analysis and report for us. We have other tasks to complete not this.*"

4.4 Result validation with OGP: HSE tools

OGP (OGP, 2010) provides tools which can be used to raise the HSE performance in each safety culture maturity level from pathological to generative. There are 15 HSE tools in different areas, for example: reporting/recording HSE information, incident investigation and HSE management system. Results from a comparison between survey results and 15 HSE tools from OGP report are shown in table.5 with all PTTEP's tools matching with OGP's safety culture maturity levels.

5. Roadmap implementation

5.1 Maturity improvement from Calculative to Generative

To create a culture shift upward from calculative into proactive and generative in a mid-long term plan, PTTEP developed a 3-year plan roadmap to improve its safety culture prior to the next survey. It can be categorized into 5 actions as shown in figure 4.

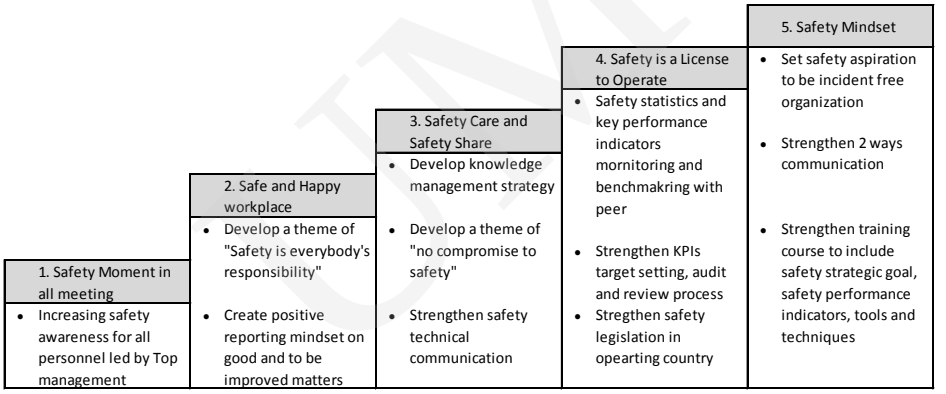

Figure 4: Roadmap to improve safety culture maturity

5.1.1 Safety moment in all meetings

Results from the safety culture questionnaire show the safety talk (Q2.3) scored lowest in the questionnaire. This reflects poor safety awareness in the organization, with a mean = 2.93. The result from the correlation shows SSHE meeting (participants) feel there is a relation and impact on how worksite perform tools and techniques to perform safer work (Q4.2). Specifically, this can encourage front line workers to report on unsafe act/condition and hazard in their area (Q6.2) based on their responsibilities e.g., supervisor to monitor overall area and operator to report to line management on improvement area (Q6.4).

To change organizational behavior toward safety talks, a safety team has to create a safety talk database (tools) for everyone usage. Corporate safety needs to encourage that such a talk be scheduled and take place before every meeting's start, i.e., every meeting should begin with a safety talk or a sharing session about safety for the benefit of all members. This can be information sharing either work or non-work related to the build up of safety awareness at the corporate and operational levels. The safety team has to take serious action in serving as the representative of the safety talk in the early stages of such

a campaign, also setting up a top-down approach in every management committee, which should be led by the CEO, conducted twice a month or even more often.

5.1.2 Safe and Happy workplace

This action aims to create the common understanding that "safety is everybody's responsibility" via various communication routes internally e.g., visualizing the safety policy and campaign and technical information board in various locations in the company headquarters and operating assets. The questionnaire shows a correlation from SSHE responsibilities (Q6.4) with the responsibility to report and improve work condition by each working level (Q6.2). It also encourages employee to report on "good" and "to be improved" regarding behavior, equipment and process by using "Safety observation card", "Hazard reporting card" provided by the company (Q4.2).

The success of this action depends on how much employees and line management see the campaign as encouragement to improve, and as positive action with direction from Top management committees, monthly safety meetings, etc. (Q6.5). Hidden reports, ignorance regarding improvement, changes are likely to happen if employees and line management have negative feelings and blame the culture in the organization. Moreover, corporate safety should develop a campaign to improve safety in the organization by utilizing incident statistics, increasing employee awareness and creating a common understanding. Rolling out campaigns at the corporate level and in each operating location is also vital.

5.1.3 Safety Care and Safety Share

Information, knowledge management and communication have been highlighted in this action along with work planning as they should be carefully conducted to create an effective, simultaneous improvement when dealing with multiple areas. Improper work planning can unintentionally pressure the taskforce to complete jobs within time frames by compromising safety in return (Q4.2). It can be seen in meetings (Q6.5) when safety becomes insignificant when compared to production and thus hidden safety report may begin to occur as supervisor compromise safety and employee feel the fear of being pointed out as the cause for a job having to be delayed (Q6.2). When the safety is being sacrificed with incompetent worker in operational tasks (Q4.1), incidents will always happen.

At PTTEP internal communication was improved with their intranet becoming a center of information sharing for safety policies, standards, SMS roll outs, procedures and guidelines with highlighted activities (Q1.1 and Q1.2). In addition, safety has also become part of the key activities in the organization e.g., in operational excellence, sustainable development, corporate communication, risk management, project and technical review (Q4.1 and 7.1). Attempts have been made to put safety into every related campaign so as to make it visible to employees and to put it into the beginning of the design phase in every project to ensure its compliance with safety requirements.

5.1.4 Safety is a license to operate

A license to operate means that a company has the right to operate in each country based on their legislation and the requirements with company's own performance. A good safety performance record compared with peers in the operating country is a true advantage for the company when considering long term investment in that country. Benchmarking, trends and statistics in SSHE (Q7.2) have important parts in this category because they are outcome resulting from the sums of all activities, such as a safety management system of company correlating with Hazard reporting, observation and communication reports (Q6.2) and indirectly related with work planning (Q4.1), worksite job SSHE techniques (Q4.2), SSHE responsibilities (Q6.4), SSHE meeting feel (Q6.5), competency and training (Q3.2)

PTTEP company growth has steadily prospered not only domestically, but also internationally since 1992, with employees and contractors sometimes tending towards exposure with risk during climate change, at times of rushed work, when on tight schedules, and under unfamiliar work circumstances and atmosphere (Q3.1). To comply with an SMS, implementing safety documentation e.g., standards, procedures and guidelines must cover all operations for employees to understand the nature and cautions required for each work task beforehand, and then appropriately follow the given instruction (Q4.1, Q4.2, Q5.1 and Q6.1).

5.1.5 Safety mindset

In this stage, PTTEP aims to improve the safety culture in the organization and assist everyone in understanding the company's safety targets and aspiration for a target zero/ incident-free organization in the future. To have everyone fully familiar with the same safety language, training courses (Q3.2) provided by corporate safety are required for all employees in the organization (Q1.1 and Q1.2). These courses stress the importance of a safety culture (Q6.5), raise employee safety awareness (Q6.1, Q6.2 and Q6.3), promote a common understanding the existing tools available (Q4.2), discuss safety as prerequisite by the government for each country and finally, benchmark safety performance with peers in domestic and international levels (Q7.2).

Therefore, company efforts center on motivating both employees and management to pull together to help the company achieve a top quartile performance at the global level. In line with these efforts, PTTEP corporate safety statistics are updated with top management in management committee meetings weekly, which maintains raise awareness and caution about the company's safety situation at the very top level. If accidents are trending upward, the CEO, corporate safety and line management will notify all stakeholder and line partners will focus greater attention on monitoring the issue and the front line to prevent reoccurrence.

6. Conclusion

This research team and the HSE division agree that top management leadership remains extremely important in improving a safety culture. Perhaps management's most critical

role is to make it visible to the workforce, which require effective communication in various ways. When safety is common occurrence in daily operations, it is easier for employees to express what is wrong in their normal routine, help to maintain safe working environment, and show care for others. Line responsibility, however, is also important as safety is not only a task for corporate HSE as good safety performance is maintained, but it is also a task for line management in that they must take ownership for all their tasks and commit to safety.

The five actions in the roadmap may be different in other organizations and countries due to varying focus areas and national cultures. The aim continues to be, nevertheless, to raise safety awareness for employees, perhaps using different methods and communication with a variety of concepts of improved technologies and culture sensitivities. Roadmap effectiveness can be monitored via lagging indicator, e.g., direction of the incident rate trends after the campaign. If root cause behind incidents persist to be the human factors, it means the company has to review its effort, and trace back through its steps to identify what component they missed. By monitoring not only the lagging but leading indicators e.g., safety campaign participation and compliance can help a company improve on safety performance and it safety culture.

Given these results in 2012, the PTTEP roadmap has helped the company's LTIF reduction by 45%; also, incident severity has been mitigated and reduced. This specific safety culture maturity assessment and roadmap have been selected as best practices for developing a safety culture in the PTT Group, beginning with the petrochemical industry unit.

7. Future research

This study was conducted in one Upstream Oil and Gas Company in Thailand which implement in 2011. The model needs to be tested and carefully implemented in other industries because safety culture maturity continues to be a very new phenomenon in Thailand. Further research regarding safety culture maturity in broader spectrum of industries in order to find communities, or differences between high medium and low risk industries before a roadmap totally appropriate for use at a national level can be used to benefit the Thai government in its future policy making.

Reference

Board of Investment (BOI) (2012), *The Report Thailand 2012*, Ministry of Industry, Bangkok, Thailand.

British Petroleum (2011), "Statistical Review of World Energy 2011", [Online] Available at: http://www.bp.com/assets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2011/STAGING/local_assets/pdf/statistical_review_of_world_energy_full_report_2011.pdf. [accessed 8 July 2013].

Department of Mineral Fuel (DMF) (2011), *Annual report*, Ministry of Energy, Bangkok, Thailand

European Agency for Safety and Health at work (EU-OSHA) (2011), *Occupational Safety and Health culture assessment – A Review of Main Approaches and Select Tool*, European Agency for Safety and Health at Work.

Flin, R., Mearns, K., O'Connor, P. and Bryden, R. (2000), "Measuring Safety Climate: Identifying the Common Features", *Safety Science.* Vol.34, No.3, pp. 177–192.

Filho, A.P.G., Andrade, J.C.S. and Marinho, M.M.O. (2010), "A Safety Culture Maturity Model for Petrochemical Companies in Brazil", *Safety Science*, Vol. 48, No. 5, pp. 615–624.

Guldenmund, F.W. (2000), "The Nature of Safety Culture: A Review of Theory and Research", *Safety Science,* Vol. 34, pp. 215–257.

Guldenmund, F.W. (2010), "(Mis)understanding Safety Culture and Its Relationship to Safety Management", *Risk Analysis,* Vol.30, pp. 1466–1480.

Hudson, P. and Willekes, F.C. (2000), "The Hearts and Minds Project in an Operating Company: developing tools to measure cultural factors", paper presented at SPE International Conference, Texas.

Hudson, P. (2007), "Implementing a Safety Culture in a Major Multi-National", *Safety Science,* Vol. 45, No.6, pp. 697–722.

Industrial Standard Institute (1999), *Thailand Industrial Standard-Occupational Safety and Health Management System*, Ministry of Industrial, Bangkok, Thailand.

International Labor Office (ILO) (2001), *Guidelines on Occupational Safety and Health Management System*, International Labor Office, Geneva.

International Atomic Energy Agency (IAEA) (1991), *Safety Culture*, International Atomic Energy Agency, Vienna.

International Association of Oil and Gas Producers (OGP) (2010*), A guide to selecting appropriate tools to improve HSE Culture report 435*, International Association of Oil and Gas Producers, London.

Lawrie, M., Parker, D. and Hudson, P. (2006), "Investigating Employee Perceptions of a Framework of Safety Culture Maturity", *Safety Science,* Vol. 44, No. 3, pp. 259–276.

Ministry of Labor (2012), *2012 Annual Report*, Ministry of Labor, Bangkok, Thailand.

Parker, D., Lawrie, M. and Hudson, P. (2006), "A Framework for Understanding the Development of Organizational Safety Culture", *Safety Science,* Vol. 44, No.6, pp. 551–562.

Reason, J. (1997), *Managing the Risks of Organizational Accidents,* Ashgate Aldershot.

Schein, E.H. (2004), *Organizational Culture and Leadership*, Jossey-Bass, San Francisco, CA.

Weick, K.E. (1987), "Organizational Culture as a Source of High Reliability", *California Management Review,* Vol. 29, No. 2, pp. 112–127.

Westrum, R. (1991), "Cultures with Requisite Imagination", in Wise, J., Stager, P., and Hopkin, V. D. (Eds.), *Verification and Validation in Complex Man-Machine Systems*. Springer Berlin Heidelberg, New York, pp. 401–416.

Westrum, R. and Adamski, A.J. (1999), "Organizational Factors Associated with Safety and Mission Success in Aviation Environments", in Garland, D. J., Wise J. A., and Hopkin, V. D. (Eds), *Handbook of Aviation HumanFactors.* Lawrence Erlbaum, Mahwah, NJ, pp. 67–104.

Appendix

OGP HSE tools	PTTEP Attribute	Average	PTTEP tools	Comparing tools type with OGP
1. Reporting and recording	6	3.37	– Open reporting	Ok
2. Incident investigation	6	3.37	– Root cause and proactive analysis	Ok
3. Auditing	7	3.26	– Management system audits	Ok
4. Human factors in design	5	3.58	– HF design standard – Operator design review	Ok
5. Work procedures	5	3.58	– Mandatory standards	Ok
6. Risk management	4	3.4	– JSA, PTRA, MOC	Ok
7. HSE MS	Overall	3.33	– ISO, OHSAS, TIS	Ok
8. Training and competence	3	3.2	– Workforce, supervisory, Manager and Executive HSE training	Better
9. HSE appraisals	7	3.26	– Performance appraisals – 360 degree appraisals	Ok
10. Situation awareness	2	3.3	– Supervisor led task discussion – Self-led task evaluation	Ok
11. Questionnaire and surveys	6	3.37	– Safety culture questionnaire	Ok
12. Observation and intervention	6	3.37	– Observation by supervisor – Reinforcement of positive actions	Ok
13. Incentive schemes	1	3.32	– Performance recognition	Ok
14. HSE communication	1	3.32	– HSE meeting – HSE alerts	Ok
15 Other	Overall SMS	3.33	– Step change in SSHE – Life saving program	Ok

Table 5: OGP HSE tools comparison with PTTEP

Location	Service years	Average Score	Worker	Supervisor	Safety personnel	Manager	Vice president /above
1	19	3.6	3.63	3.42	3.61	3.59	3.45
2	3	3.53	3.61	3.22	2.84	3.4	3.22
3	4	3.29	3.27	3.36	3.27	3.46	3.12
4	27	3.21	3.18	3.27	3.34	3.3	3.52
5	30	3.48	3.44	3.49	3.72	3.94	3.46
6	6	3.62	3.6	3.23	4.21	3.69	3.44
7	9	3.21	3.33	3.01	3.26	3.33	3.62
8	6	3.33	3.41	2.82	2.86	3.29	3.1
9	19	4.37	4.36	4.75	4.24	4.31	4.42
10	2	3.33	3.4	2.88	3.6	3.4	3.23

Table 6: Result of each location

Correlations

		Q1.1	Q1.2	Q1.3	Q2.1	Q2.2	Q2.3	Q3.1	Q3.2	Q3.3	Q4.1	Q4.2	Q5.1	Q6.1	Q6.2	Q6.3	Q6.4	Q6.5	Q6.6	Q7.1	Q7.2
Q1.1	Pearson Correlation	1																			
	Sig. (2-tailed)																				
Q1.2	Pearson Correlation	.364**	1																		
	Sig. (2-tailed)	.000																			
Q1.3	Pearson Correlation	.335**	.263**	1																	
	Sig. (2-tailed)	.000	.000																		
Q2.1	Pearson Correlation	.253**	.201**	.255**	1																
	Sig. (2-tailed)	.000	.000	.000																	
Q2.2	Pearson Correlation	.309**	.253**	.282**	.289**	1															
	Sig. (2-tailed)	.000	.000	.000	.000																
Q2.3	Pearson Correlation	.296**	.164**	.230**	.151**	.207**	1														
	Sig. (2-tailed)	.000	.000	.000	.000	.000															
Q3.1	Pearson Correlation	.030	-.251	.098**	.068**	.030	.087**	1													
	Sig. (2-tailed)	.178	.000	.000	.002	.189	.000														
Q3.2	Pearson Correlation	.251**	.170**	.226**	.169**	.250**	.242**	-.128**	1												
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000													
Q3.3	Pearson Correlation	.242**	.171**	.22**	.145**	.234**	.204**	-.121**	.424**	1											
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000													
Q4.1	Pearson Correlation	.255**	.175**	.219**	.139**	.225**	.168**	-.138**	.516**	.283**	1										
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000											
Q4.2	Pearson Correlation	.281**	.185**	.248**	.174**	.240**	.222**	-.090**	.475**	.430**	.640**	1									
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000										
Q5.1	Pearson Correlation	.297**	.252**	.276**	.212**	.305**	.226**	.079**	.268**	.234**	.284**	.312**	1								
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000									
Q6.1	Pearson Correlation	.335**	.239**	.292**	.222**	.267**	.248**	.067**	.2678**	.295**	.304**	.348**	.379**	1							
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.003	.000	.000	.000	.000	.000								
Q6.2	Pearson Correlation	.272**	.174**	.244**	.169**	.191**	.212**	-.097**	.423**	.410**	.507**	.536**	.266**	.431**	1						
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000							
Q6.3	Pearson Correlation	.285**	.218**	.295**	.306**	.271**	.211**	.098**	.203**	.213**	.258**	.277**	.320**	.416**	.353**	1					
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000						
Q6.4	Pearson Correlation	.282**	.196**	.257**	.150**	.142**	.190**	-.054**	.413**	.420**	.494**	.532**	.273**	.356**	.546**	.321**	1				
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.016	.000	.000	.000	.000	.000	.000	.000	.000					
Q6.5	Pearson Correlation	.320**	.172**	.257**	.133**	.186**	.239**	-.090**	.461**	.405**	.524**	.518**	.257**	.306**	.546**	.293**	.541**	1			
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000				
Q6.6	Pearson Correlation	.331**	.263**	.299**	.138**	.234**	.296**	.019**	.291**	.310**	.325**	.357**	.356**	.407**	.364**	.331**	.402**	.385**	1		
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.404	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000			
Q7.1	Pearson Correlation	.383**	.079	.332**	.326**	.369**	.341**	.292**	.208**	.203**	.184**	.246**	.354**	.342**	.282**	.417**	.294**	.239**	.496**	1	
	Sig. (2-tailed)	.000	.124	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		
Q7.2	Pearson Correlation	.410**	.047	.341**	.233**	.331**	.317**	.319**	.111*	.150**	.058	.058	.334**	.287**	.092**	.288**	.145**	.052	.343**	.467**	1
	Sig. (2-tailed)	.000	.370	.000	.000	.000	.000	.000	.031	.000	.261	.265	.000	.000	.000	.000	.005	.311	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is signifcant at the 0.05 level (2-tailed)

Table 7: Pearson correlation result of safety culture questionnaire survey

Biographical Notes

Bordin Vongvitayapirom currently works as performance analysis engineer in Safety, Security, Health and Environment Division at Petroleum Authority of Thailand in Exploration and Production (PTTEP) and part time Ph.d student in Industrial Engineering, Kasetsart University, Thailand. He also has experienced as safety engineer in Automotive industry in Asia Pacific region. He has a bachelor's degree majoring in Industrial Engineering and Master's degree majoring in Engineering Management. His research interests cover safety management system, safety culture maturity, performance development and improvement.

Punnamee Sachakamol is a lecturer at the Department of Industrial Engineering, Faculty of Engineering, Kasetsart University. He received his B.A.Sc., M.A.Sc. and Ph.D. in Industrial Systems Engineering from University of Regina, Canada. His research interests are Optimisation of Production Process, Ecological Footprint, Supply Chain/Value Chain Management, Cool Chain Management, and Pharmaceutical Operation Management. He has involved with many big projects from private firms.

Hanna Kropsu-Vehkapera works as a postdoctoral research fellow at the Department of Industrial Engineering and Management, University of Oulu, Finland. She has a Doctors degree and a Master's degree both majoring in Industrial Engineering and Management. Her research interests cover information management, product lifecycle management, and business process development. She has some years of experience in the IT industry.

Pekka Kess (Dr. Sc., Dr. Eng.) is professor of Industrial Engineering and Management at the University of Oulu, Finland. He has extensive managerial experience both from universities and industrial enterprises. He has worked in managerial positions in chemical, steel and electronics industries as well as in the software business. He is an active project evaluator and manager in international research and development projects. His research areas are strategic management, production organisations, knowledge management, quality management and e-Learning. He has an extensive network of partners in Europe, Asia and Americas. Dr. Kess is an editor and reviewer in several international scientific journals.