Identification of Behavior Based Safety by Using Traffic Light Analysis to Reduce Accidents

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Abstract. This work present the safety assessment of a case study and describes an important area within the field production in oil and gas industry, namely behavior based safety (BBS). The company set a rigorous BBS and its intervention program that implemented and deployed continually. In this case, observers requested to have discussion and spread a number of determined questions related with work behavior to the workers during observation. Appraisal of Traffic Light Analysis (TLA) as one tools of risk assessment used to determine the estimated score of BBS questionnaire. Standardization of TLA appraisal in this study are based on Regulation of Minister of Labor and Occupational Safety and Health No:PER.05/MEN/1996. The result shown that there are some points under 84%, which categorized in yellow category and should corrected immediately by company to prevent existing bad behavior of workers. The application of BBS expected to increase the safety performance at work time-by-time and effective in reducing accidents.

Keywords: Behavior-Based Safety; Traffic Light Analysis; Oil and Gas Industry; Safety Assessment, Fishbone Diagram.

1. Introduction
Safety at work is widely accepted as an accurate action to increase worker performance and reduce accidents [1]. Accidents at work occur either due to lack of knowledge or training, a lack of supervision, or a lack of means to carry out the task safely, or alternatively, due to an error of judgment, carelessness, apathy or downright reckless. Safety at work suggested as complex phenomenon that related with the subject of safety performance and safety behavior. In previous study [2], unsafe behavior is the most significant factor in the cause of site accidents and therefore provides evidence of a poor safety culture and may cause dangerous accidents at industrial companies. Among leading industry, oil and gas industry is one of the most risky industry in worldwide. Oil and gas industry jobs has highest number of accidents and facility rate such as explosion, struck by object, ambient heat condition, highway crash and other accidents [3]. Safety of workers in oil and gas industry is critically important. Figure 1 shows that the national average for the rate of fatal job injuries owned by oil and gas industry currently in high number year-by-year [4].
The figure implies a special challenge for safety improvement in oil and gas industry. The features of safety assessment should be determined when implementing any type of safety initiative to reduce accident rate. Therefore, the specific objectives of this study are first, to measure the behavior performance through worker that exist in the company (in this study in oil and gas industry). Second, to determine the group of factors that has the most effect on site safety, utilizing traffic light analysis and root-cause diagram.

2. Literature Review

2.1 Occupational Safety in Oil and Gas Industry
Workers in Oil and Gas industry are generally susceptible to following agents, which lead to various health and illnesses hazards including; chemical, physical hazards, biological hazards, ergonomic hazards and psychosocial hazards [5]. The aim of occupational safety and health risk management is to identify and assess safety and health hazard existing at the workplace and to define appropriate control/reaction and retrieval steps [6].

2.2 The Behavior Based-Safety Approach
Al-Hemoud and Al-Asfoor suggests that Behavior-Based safety (BBS) initiative are the current trend toward improving safety performance [7]. The definition of BBS itself is a proactive accident prevention effort that focus at riskbehavior/dangerous behavior that is likely to cause accidents. The quality of BBS implementation is not only a program, but also an integrated management process that...
undertaken continuously by company/organization [8].

According to J Agnew and Ashworth [9], to be successful BBS process must include all employees, from the CEO to the front line workers. Including but not limited to hourly, salary, union employees, contractors and sub-contractors. To achieve changes in behavior, a change in policy, procedures and/or systems most assuredly will also need some change. Those changes cannot accomplished without buy-in and support from all involved in making those decisions [10]. Zhang and Fang also stated that in this recent year, many researchers in various setting such as clinical medicine, manufacturing, petro-chemistry, mining/oil and gas and institution office have applied BBS successfully [11]. Implementation of BBS within field area of oil and gas industry may affect significant organizational benefit include:

- Significant reduction in number of accidents caused by inappropriate behavior
- Good opportunity for management and workforce participation
- Improving visibility of manager
- Behaviors and actions influence culture through attitudes and perceptions.

2.3 Ishikawa “Fishbone” Diagram

Many companies repeatedly experience the same type of incidents. Investigation indicate what seem to be right solution to reducing accidents. A cause and effect diagram, often called a “fishbone” diagram can help in brainstorming to identify possible cause of a problem and in sorting ideas into useful categories [12]. Fishbone analysis begins with a problem and the fishbone provides a template to separate and categorize the causes. Usually there are six categories, but the number can be change depending on the problem (Figure 3). This method allows problems to be analyze and, if it this used with employees, it gives everybody an insight into the problem so solutions can be develop collaboratively [13].

![Typical fishbone analysis](image)

Company in which employees are encouraged to evaluate practice, risk and mistakes when they occur tend to have a culture where root cause analysis or fishbone analysis is used. This helps to really understanding the cause of problems and clarify the issues. To support in identifying the root causes from all the ideas generated, observers consider a multi-voting technique such as having each team member identify the top three root causes. Behavior and feedback comment from employees are generated to establish the root –cause of problem in BBS appraisal.

2.4 Traffic Light Analysis
The Traffic Light Assessment (TLA) is a high-level indicator of the potential risks that can occur on government/division projects. According to Rochmoeljati [14], the achievement of TLA implementation expressed in three categories; green, yellow, and red refers to National Regulation of Minister of Labor Occupational Safety and Health No: PER.05/MEN/1996. The description for each category mentioned as follows:

I. Green
   This indicator states that the implementation well done achieved. The range of values for this indicator is 85% -100%.

II. Yellow
   This indicator states that the value is close to the target. The range of values for the performance indicator is 60% -84%.

III. Red
   The red color of this indicator states that the implementation is done below the target that should be fixed as soon as possible. The range of values for this indicator is 0% -59%.

To measure TLA’s performance indicator, the raw data that obtained will be converted into performance score and score of specific behavior calculated as follows:

\[ \text{Score} = \left( \frac{\text{Number of safe behavior}}{\text{Total number of behaviors observed}} \right) \times 100\% \] (1)

3. Method

3.1 Data collection
As per the plan, the company implemented the BBS management system with the company’s management team and writer was involved in development of the BBS technique analysis, which using TLA indicator. One division of the company that focuses on operational and maintenance work selected as participant in this study. A number of questionnaires survey were distributed to seek the current implementation of BBS and the barriers towards its implementation from safety officers, safety supervisors, project manager, engineers, contractor, sub-contractor and other managerial and technical staff. The entire participant from these division were asked to fill out the question but were not required to complete all questions and return these questionnaires as they were for their information and recording the explanation of how they need to act safely during conducting their tasks. Through questionnaires, encountered problem of work behavior will be detected.

3.2 BBS Questionnaire
The company has sets the list of questionnaire previously, it is depend on what kind of work behavior that will be ask to the workers. In this study, the questionnaire are divided into 2 categories, first related with BBS checklist items and second is an essay to clarifying the behavior of the worker at work. Checklist of questionnaire distributed to the entire participant of the division. These steps, company’s observer required to submit completed checklists and writer responsible for entering these results from the checklist into a computer data for compiling the result. A sample checklist items for BBS questionnaire that used in research shown in Table 1.

| No | Point of Behavior | Behavior Description | At-risk/safe? |
|----|-------------------|----------------------|--------------|
| 1  | Body Position     | Avoiding Line of Fire|              |
|    |                   | Walking/Moving with Eyes on Path |              |
|    |                   | Keeping Eyes on Task   |              |
|    |                   | Ascending/Descending  |              |
| No | Point of Behavior     | Behavior Description                                                                 | At-risk/safe? |
|----|-----------------------|--------------------------------------------------------------------------------------|--------------|
| 2  | Body Use              | Lifting/Lowering/Pushing/Pulling                                                    |              |
|    |                       | Avoid Twisting                                                                      |              |
|    |                       | Responding to Industrial Ergonomic Risks                                            |              |
| 3  | Tools & Equipment     | Selecting and Using Tools/Equipment                                                 |              |
|    |                       | Using Guards/Barricades / Warning Devices                                           |              |
| 4  | Work Procedure        | Job Preparation and JHA                                                             |              |
|    |                       | Doing-Hot Work                                                                      |              |
|    |                       | Entering a Confined Space                                                           |              |
|    |                       | Communication to Co-Workers                                                         |              |
| 5  | Work Area             | Office Ergonomics                                                                   |              |
|    |                       | Cleaning Up/Storing Tools and Equipment (Housekeeping)                               |              |
|    |                       | Working in a Well-Lighted Environment                                               |              |
| 6  | Office Ergonomics     | Taking Rest Breaks                                                                  |              |
|    |                       | Phone Posture, Back Support                                                         |              |
|    |                       | Shoulder Posture, Wrist and Arm Position                                            |              |
|    |                       | Holding/Moving Mouse                                                                |              |
|    |                       | Recognizing and Reporting Discomfort                                                |              |
| 7  | Environmental Stewardship | Preventing Spills                                                                     |              |
|    |                       | Preparing for Spill Clean-up                                                        |              |
|    |                       | Managing Waste                                                                      |              |
| 8  | Personal Protective Equipment | Protecting Head, Hearing, Respiration, Hands                                       |              |
|    |                       | Protecting Eyes and Face                                                            |              |
|    |                       | Fall Protection                                                                      |              |
|    |                       | Protective Clothing                                                                  |              |
|    |                       | Protecting Feet                                                                      |              |
| 9  | Driving               | Journey Planning                                                                    |              |
|    |                       | Pre-Trip Inspection and Seat Belt                                                    |              |
|    |                       | Driving at Proper Speed                                                             |              |
|    |                       | Following Distance                                                                  |              |
|    |                       | Changing Lanes                                                                       |              |
| 10 | Marine Operations     | Preparing for a Vessel Trip                                                          |              |
|    |                       | Moving/Breaking Vessels                                                              |              |
|    |                       | Entering Inspections                                                                 |              |

The second BBS questionnaire emphasize the question in detail why those bad behaviors occurred during work. This question focused to seek-out the reasons of the worker by explaining the case of bad behavior by giving feedback, suggestion etc. A sample of questionnaire that used shown in Table 2.

**Table 2.** BBS clarifier form/observation comments

| Behavior Comment | Condition | Date | Location | Company (observed) | Observer |
|------------------|-----------|------|----------|--------------------|----------|
| Feedback         |           |      |          |                    |          |
| While            |           |      |          |                    |          |
| Was              |           |      |          |                    |          |
| Because          |           |      |          |                    |          |
| Suggestion/try   |           |      |          |                    |          |
Agree behavior at occurred?

At Risk behavior?

The Checklist of BBS observation form (Table 1) will converted to TLA indicator to determine what point of behavior categories that experienced in highest levels of risk. The highest-level point of identified work behavior will used to encounter the problem of improper work behavior by using fishbone diagram. Meanwhile BBS clarifier form (Table 2) are used to supporting and identifying the root-cause of a problem.

4. Result and Analysis

This section describes result of the BBS research that carried out at operation and maintenance division in oil and gas industry that located on Sumatra. An experiment conducted to measure the safety score of behavior of based safety at the company. Data collected over a period of 12 months for experimental observation. By used equation formula (1), the result of performance indicator for BBS questionnaire shown in Table 3.

Table 3. Result of performance indicator of BBS observation form

| No | Point of Behavior                | Percentage (%) |
|----|----------------------------------|----------------|
| 1  | Body Position                    | 75.42          |
| 2  | Body Use                         | 56.84          |
| 3  | Tools & Equipment                | 81.94          |
| 4  | Work Procedure                   | 71.11          |
| 5  | Work Area                        | 85.55          |
| 6  | Office Ergonomics                | 85.59          |
| 7  | Environmental Stewardship        | 81.48          |
| 8  | Personal Protective Equipment (PPE) | 94.07      |
| 9  | Driving                          | 95.83          |
| 10 | Marine Operations                | 95.83          |
| % Average |                                | 82.37%        |

Table 3 recapitulated that there are several points that classified in yellow indicator based on Traffic Analysis Assessment (TLA) and indicated as bad behavior at work. To ease the identification point, graphic of radar indicator presented as follows:
Figure 4. BBS result in radar indicator. Appointment of green line (85%-100%), yellow line (60%-84%) and red line (0%-59%) refers to National Regulation of Minister of Labor Occupational Safety and Health No: PER.05/MEN/1996

In behavior point of body position, body use, tools & equipment, work procedure, and environmental stewardship categories, measured scores of safety performance at this division were below 84%, which stationed in yellow and red boundary line (Table 3). In body position, ascending and descending are the most complained position by the worker. In tools and equipment, selection and its utilization are not being consideration at work. Bad behavior point also occur at work procedure, the worker did not fully give their attention to job preparation, job hazard analysis (JHA) and isolating energy (LOTO).

In environmental stewardship, the worker also ignoring to managing waste. However, the most critical point showed on point 2, which “body use” was 56.84%. This point categorized in dangerous behavior and stationed in red boundary line. Concerning with this behavior point, common workers in this division did not give full attention with the proper of body utilization like ignoring the movement of body twisting, lifting/lowering/pushing/pulling load etc. To identify what is the root of problem why those bad behavior happen, the use of fishbone diagram are providing as follows:

Five problem categories depicted on Figure 5. Policy, material, personnel, environment and method are figure-out to encounter the root of bad behavior that occur in the division. In sum, overall root cases that appear in the fishbone diagram concluded that the most problem occurs in human resources issues. This happens due to lack of awareness and commitment of the workers themselves. By overcoming the problems that described in fishbone diagram, improper/bad behavior at work can be reduce. Therefore, engagement from both employees and management system for continuous improvement in this division being critical point that must considered by the company.

5. Discussion

The concept of Behavior Based Safety (BBS) approach revealed as to change bad/unsafe behavior to safe behavior and to eliminate the occurring accident at workplace. The result of questionnaire based on 10 points of behavior related with BBS appraisal was 82.37%. Referring to the concept of Traffic Light Assessment (TLA), are know that overall work behavior in operation & maintenance division at the company is in yellow category. Unsafe work behavior that encountered in this study discovered in body position, body use, tool & equipment, work procedure and environmental stewardship.
point of work behavior inserted in “quite safe” category, which mean the company must conduct continuous controlling and regular evaluation for this division. To deal with those five core issues, result that obtained from fishbone diagram also giving the same direction to encountered improver work condition/unsafe behavior. The problems encountered has been identified such as; less involvement of management, staff and workers, workers worried on blaming and penalties, lack of community involvement, improper method of handling, ignoring SOP and lack of commitment. As dynamic case problems of accident at work, the use of BBS study is not only for the company, but also should improve the wellbeing of the workers as they worked together, provided feedbacks and social praises, and motivated each other toward achieving the goal of reducing accidents[16].

The result clearly indicated that the BBS intervention useful to encountered bad behavior within the oil and gas industry. Intervention within BBS and evaluation based on fishbone diagram can used effectively to reduce work accidents that derived from bad behavior at work. Thus, behavior based approach can be implemented towards safety performance improvements in all industries including the oil and gas industry with full commitment and involvement at all levels. Although this paper fully focused on BBS appraisal, psychology study can include for further research.

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