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# Compliance tracking system for training element of OSHA process safety management

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**Abstract.** Studies show that many accidents have happened in process industries such as in chemical plants that have taken many peoples' lives. One of the contributing factors of such accidents happening is because of inadequate training provided to employees in particular operational training. One of the established standards highlighting this issue is the training element of OSHA Process Safety Management 29 CFR1910.119(g). Apparently the demand for effective ways to implement Process Safety Management (PSM) is on the rise. Basically the efficiency of standard implementation programme process mostly depends on the systematic framework, which means that all the requirements must be considered, ensuring continuity and completing the implementation process. This paper presents a system to track the performance of PSM training programme based on compliance percentage. Furthermore, the system helps process industries to manage and track information, documentations and required actions regarding the PSM training programme in systematic manner. Besides, it also provides a basis for gap analysis to be carried out for programme improvement. Implementation of this system could serve as a lagging indicator for improvement and to ensure the desired competency of plant personnel.

## 1. Introduction

Accidents are caused by either unsafe acts or unsafe conditions or both. Many accidents have happened in process industries such, for example, in chemical plants that killed many people. Based on the studies in the USA, inadequate training is one of the causes of accidents happening. The Texas City disaster was an industrial accident that occurred on April 16, 1947, in Port, Texas City. It was the deadliest industrial accident in U.S. history, and one of the largest non-nuclear explosions [1] in which about 15 people were killed and 180 people were injured. This happened because the training department budget was cut in half since 1998 to 2004, so the trainer spent little time on actual training. Similarly, in 2001, there are 785 deaths that are recorded in China while in 2000 about 1092 deaths because of the industrial accidents [2]. Based on the record, the lack of training is one of the main contributing factors as to why accidents take place. It is because the company did not know how to implement the training element, thus accidents were reported to happen year by year [3]. Likewise, on September 27, 2012, a chemical



leakage accident occurred at Hube Global Co., Ltd., a chemical products manufacturer located at the 4th National Industrial Complex in Gu-mi City, Gyeongsangbuk Province. In this tragic accident, the hydrogen fluoride was released when the valve of the lorry tank was mistakenly opened by a worker who was injecting the gas into a facility [4]. This human error factor also happened due to the inadequate training of workers.

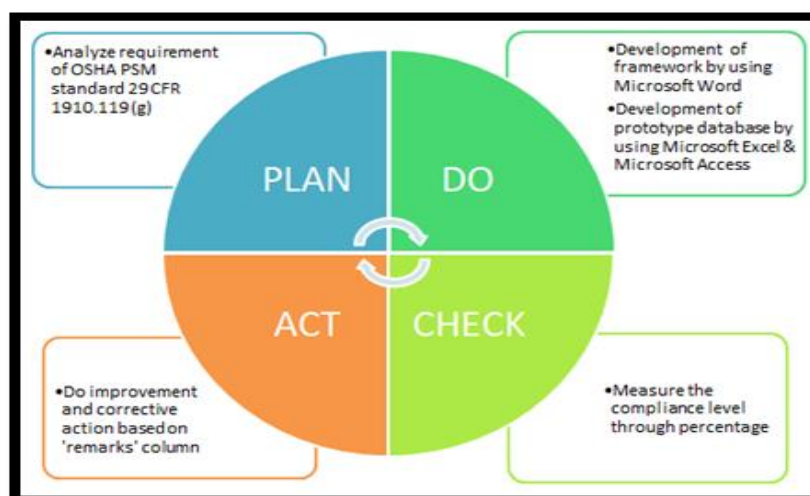
To overcome or minimize accidents from continuing to occur, every industry should understand and realize that having the trained workers do high risk operating jobs is very important. Occupational Safety and Health Administrative (OSHA) Process Safety Management (PSM) Standard 29 CFR 1910.119(g) is the regulation that is established for process industries. In this regulation, it stated that all employees, including maintenance and contractor employees involved with highly hazardous chemicals, need to fully understand the safety and health hazards of the chemicals and processes they work with so they can protect themselves, their fellow employees, and the citizens of nearby communities. Therefore, there is urgent to have a training system that can ensure company develop, implement and maintain their training program as per PSM requirements.

There are many systems which have been developed to manage trainings such as Training Tracker, Safety Tracker, Pink Staff, Instructional Design System (ISD) and Operational Training Management System (OPTRAMS). The functions of Training Tracker are to schedule training for employees and create training records. Safety Tracker, on the other hand, records accidents to fulfill OSHA logs, Pink Staff provides more than 70 hours of computer-based training and testing [5] while ISD focuses on how to create and deliver highly effective training programs [6]. Of all the systems developed, only OPTRAMS was qualitatively developed based on PSM regulations [7]. In this study, the system that is presented is a quantitatively enhanced OPTRAMS system, whereby the performance of training program is measured based on compliance percentage. The value will become a lagging indicator for improvement.

## 2. Methodology

### 2.1 Plan-Do-Check-Act Cycle

In this study, the concept of Plan Do Check Act (PDCA) cycle is adopted to develop the training program performance tracking system as shown in figure 1.



**Figure 1.** PDCA Cycle adapted from (Chakraborty, 2016) [8].

## 2.2 Compliance Measurement

In PSM standard, there are four main provisions that need to be fulfilled. They are initial training, in lieu of initial training, refresher training and training documentation. The total requirements of each provision is tabulated in table 1. Each provision can then be assessed by calculating the percentage of the weighted score. The weighted score is assigned using a Likert Scale. Table 2 shows the description of the scores that govern the calculation.

**Table 1.** Training Element Requirements [9]

PSM Training Provisions	Number of Requirement
Initial training	19
In lieu of initial training	2
Refresh training	4
Training documentation	4
Total	28

**Table 2.** Description of Answer Options and Scores [10]

Term	Description	Score
NO	The company did not fulfill the requirement, thus there was no documentation	1
YES, but no document	The company has fulfilled the requirements but there was no documentation	2
YES and documented	The company has fulfilled the requirements and documentation was provided to verify the compliance	3

The percentage of the weighted score, maximum score and the percentage of compliance for each phase is calculated based on equations (1), (2) and (3) respectively, as shown below.

$$\frac{\text{Total Maximum Score for a phase}}{\text{Total Maximum Score for all phases}} \times 100\% \quad (1)$$

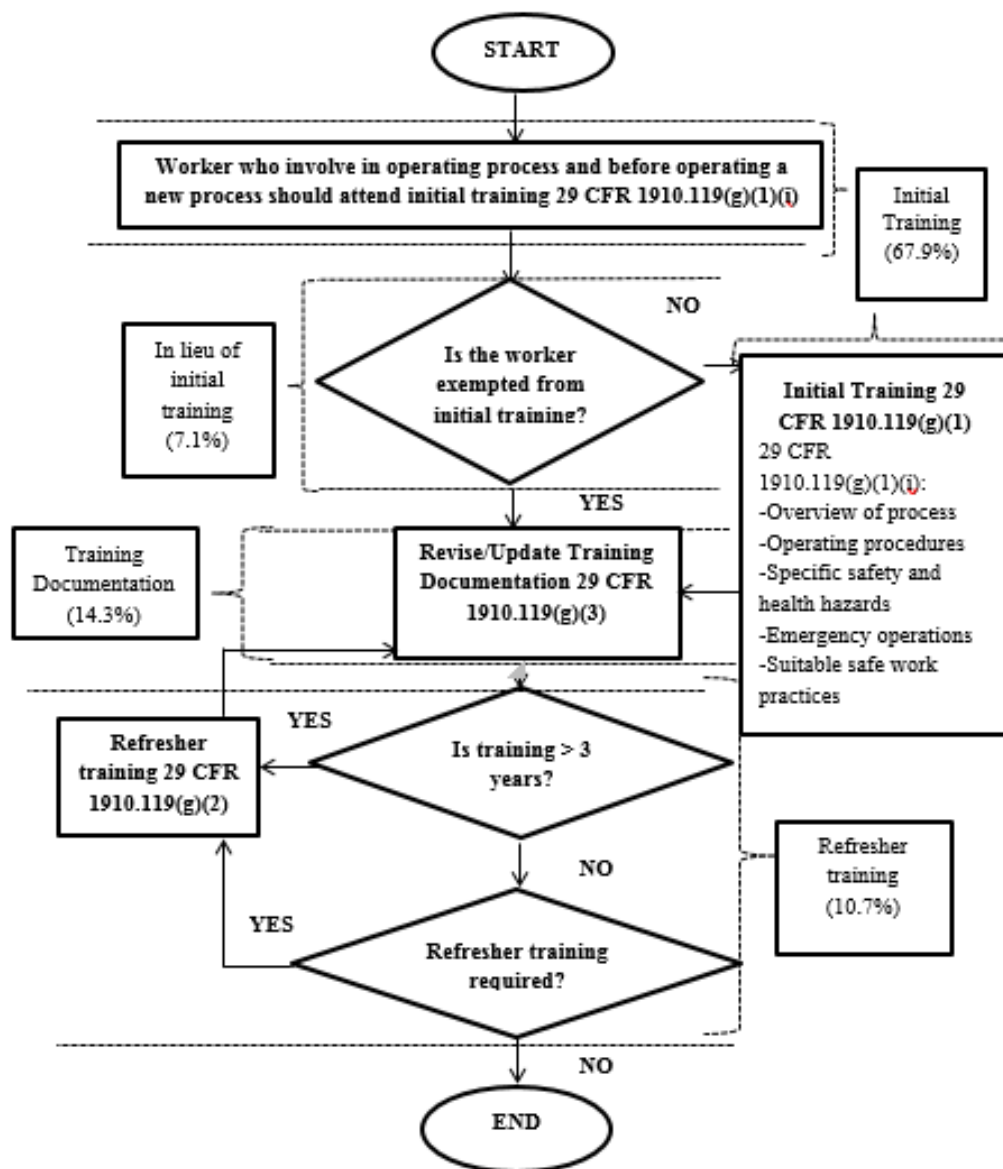
$$\text{No of requirement in a phase} \times 3(\text{highest score}) \quad (2)$$

$$\frac{\text{Total Score for a phase}}{84} \times 100\% \quad (3)$$

## 3. Results and Discussion

### 3.1 Framework of Training Tracking System

The framework of training element in figure 2 was developed based on OSHA PSM requirements. Each of training sub-standards in the framework has its own percentage that needs to be fulfilled. Based on equations (1) - (3), the percentage of weighted score is about 67.9% for initial training, 7.1% for in lieu of initial training, 10.7% for refresher training and 14.3% for documentation. The framework shows that initial training is really important to ensure the competency of the employees prior to any operating tasks.



**Figure 2.** Framework of Compliance Tracking System based on 29 CFR 1910.119 (g).

For the verification of the proposed concept and feasibility study of developed system, a case study was conducted using real plant data at Plant K. In this paper, only a case study on initial training program performance is discussed in detail.

### 3.1.1 Main Interface

Figure 3 shows the main interface of the Performance Tracking System. All the sub-requirements are listed and linked with the main interface. The 'Percentage (%)' column directly shows the compliance percentage for each sub-standard. The 'Remarks' column is to explain or comments about the incomplete information or condition of the sub-standard. From the comments, the end users can take action and do improvement in order to comply with the standards. The 'Issuance by' column is to allow users to identify the responsible persons when the section needs to be updated or completed.

Requirement	Complete	Incomplete	Percentage (%)	Remarks
Initial Training	<input type="checkbox"/>	<input checked="" type="checkbox"/>	63.1/67.9	Some of the requirement has done, but it does not have any document
In lieu of initial training	<input checked="" type="checkbox"/>	<input type="checkbox"/>	7.1/7.1	Identified gaps
Refresher Training	<input type="checkbox"/>	<input checked="" type="checkbox"/>	6.0/10.7	There are some incomplete information and requirement that Plant K didn't comply
Training Documentation	<input checked="" type="checkbox"/>	<input type="checkbox"/>	14.3/14.3	
TOTAL	<input type="checkbox"/>	<input type="checkbox"/>	90.5/100	

**Figure 3.** Main Interface.

Based on figure 3, it shows that Plant K has only complied with 'In lieu of initial training' and 'Training Documentation' provisions. According to the 'Remarks' section, there was some incomplete or lack of information identified for 'Initial training' and 'Refresher training' provisions. The 'Percentage' column shows that the compliance percentage of 'initial training' is 63.1/67.9, in lieu of initial training is 7.1/7.1, refresher training is 6.0/10.7 and training documentation is 14.3/14.3. The system shows overall total for the compliance percentage is 90.5% of PSM compliance as well as the gaps that exist in their training program. The identification of the gaps could serve as a lagging indicator for industries to prioritize their efforts and resources.

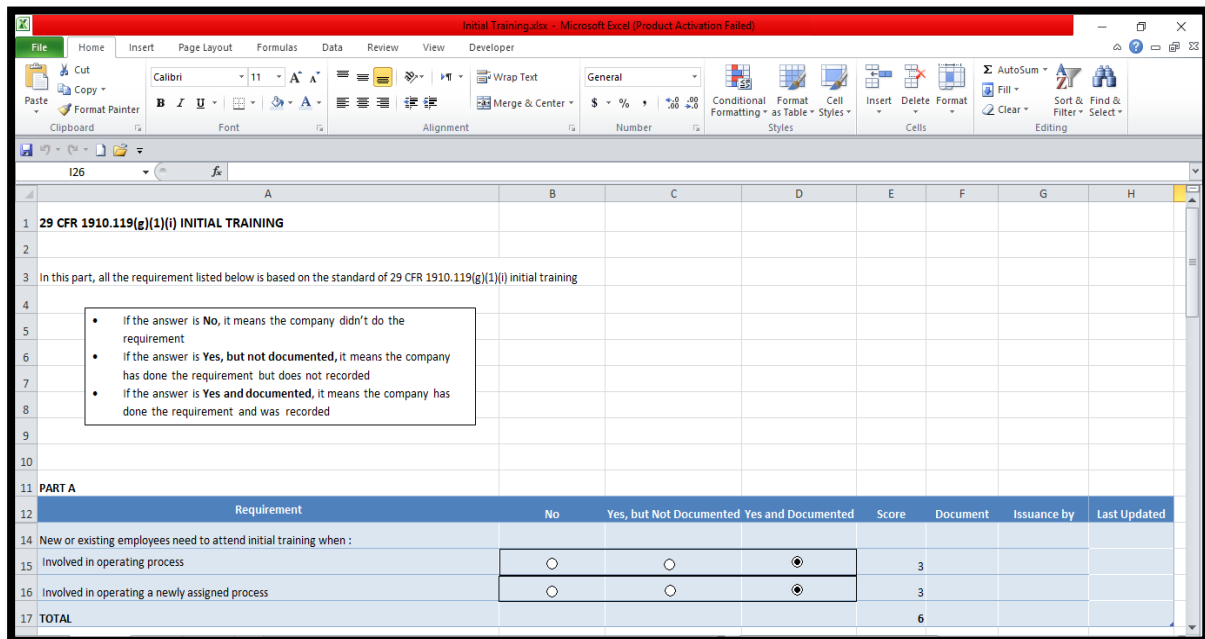
### 3.2 Model for Performance Tracking System with Case Study

**3.2.1 Initial Training.** The interface of 'Initial training' consists of two parts, which are Part A and Part B. Part A (figure 4) is for initial training requirement while Part B (figure 5 and 6) covers the training program. In this provision, PSM requires new or existing employees who are involved in operating process and a newly assigned process to attend initial training. Figure 4 tabulates that Plant K has fully complied with both of the requirements with the total score of 6.

Figure 5 shows the continuity of interface for Initial Training (Part B). This interface consists of training program that should be conducted for the employees who are involved in the operating process. According to PSM standards, the training should be conducted based on the overview of the process and operating procedures of the process. The training must include emphasis on the steps for each operating phase, operating limits and specific safety and health hazards consideration. Based on the conducted case study (figure 5), Plant K has trained their employees on the consequences of deviation but the document or evidence was not available. Therefore, the score for training of operating limit is 5. Similarly, for 'Related safety and health training', part one of the required document was also not available, bringing the total score to 17 out of 18. Thus the score Plant K obtained for Part B is 47.

In Overall, the score from both parts were automatically calculated and displayed at the 'Total' row. In this case, the total score from both parts shows that the compliance rate of initial training provision

in Plant K is 53 out of 57 or 63.1%. In order to ensure that Plant K fully complies with initial training requirement, all the training designed and conducted should be documented to verify the compliance and future reference.



**Figure 4. Initial Training Interface (Part A)**

Training Program	No	Yes, but Not Documented	Yes and Documented	Score	Document	Issuance by	Last Updated
Does the training conducted based on the overview of the process?	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	3			
Does the training in your company is conducted based on the operating procedures of the process?	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	3			
Is the training of the operating procedures conducted in your company based on the elements below?							
i) Steps for each operating phase :							
Emergency Operations	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	2			
Emergency shutdown	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	3			
Normal shutdown	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	3			
Startup following a turnaround, or after an emergency shutdown	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	3			
Initial startup	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	3			
Normal operations	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	3			
Temporary operations	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	2			

**Figure 5. Training Program.**

ii) Operating limits :							
Consequences of deviation	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>				2
Steps required to correct or to avoid deviation	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>				3
iii) Safety and health considerations							
Properties and hazards presented by the chemicals used in the process	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>				3
Necessary precautions to prevent exposure, including engineering control	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>				3
Control measures to be taken if physical contact or airborne exposure occurs	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>				2
Quality control for raw materials and control of hazardous chemical inventory levels	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>				3
Any special or unique hazards	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>				3
Safety systems such as interlocks, detection or suppression systems and their functions	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>				3
TOTAL							47
						TOTAL SCORE A+B (57)	53
						WEIGHTED SCORE (0.679)	0.631
						PERCENTAGE (67.9%)	63.1

**Figure 6.** Training Program (continued).

#### 4. Conclusion

This paper introduces a system to track the compliance of PSM training program at the workplace. The indication of performance is shown by the percentage of compliance with the standard requirements. The framework was developed as a guide for employers to manage their training programs in a systematic way. This system prototype is based on the proposed concept that was developed and embedded with the proposed equation and scoring scale for easy implementation and explanation. Implementation of this system could serve as a lagging indicator for improvement in order to ensure the desired competency of plant personnel. Industries need a systematic framework and system to ease and trace their program performance to ensure safe operation, prevent major accidents and also to comply with the training element of PSM standard.

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