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Evaluation of the Pre-Startup Safety Review Effectiveness (PSSR) in Process Industries: a Gas Refinery Case Study

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ABSTRACT

Industrial accidents that have occurred in oil and gas industries have always created trouble for these industries' workers. The pre-startup and start-up of refineries accidents are one of the most critical challenges in this area. Therefore, this study was conducted to evaluate the effectiveness of the Pre-Startup Safety Review (PSSR) process and its compliance assessment. This descriptive-analytical study was carried out in a gas refinery in 2018. The study tools included the National Iranian Oil Company (NIOC) Guideline and the PSSR executive method in a gas refinery. Data analysis was performed via SPSS software version 22.0. The significance level in this study was considered 0.05. The results showed that the highest and lowest compliances were related to the accident management and emergency response (65%), readiness for assignment (12%). Also, the frequency rate of accidents showed a significant difference ($p<0.001$) between refineries which was performing PSSR and did not do this process. The findings indicated that PSSR implementation can play a significant role in controlling and reducing accidents, as well as stopping and interrupting process operations. Besides, PSSR checklist details more accurately implementation, helps the process of pre-startup safety review to be controlled better and be more productive.

KEYWORDS: *Pre-Startup Safety Review, Gas Refinery, Safety, Process Industry*

INTRODUCTION

In recent years, there has been an upsurge in the oil, gas, and petrochemical which makes more concerns [1-3]. The fundamental question now is whether we should expect more accidents? To answer this question, the causes of these accidents should be answered.

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Pre-startup and startup phases are often one of the most critical and most dangerous phases of the project life-cycle [4]. The startup can be considered as a set of tests which is testing equipment activities, but from a comprehensive perspective, the startup is defined as a procedure to complete engineering processes and quality control. The leading industrial companies have found that problems associated with

the startup phases estimated less than actual. Nowadays, most of them are looking for solutions to reduce dangers and problems caused by initial startup, gas and fluid injection into process equipment and reservoirs, changes in temperature, pressure and the chemical reactions initiation [4-5].

Promoting and institutionalizing preventive approaches are one of the strategic objectives of health, safety, and environment (HSE) management, passive defense and crisis management for the establishment and development of a management system [6-7]. Accordingly, HSE requirements consideration in the early stages of designing and developing a project may minimize the need for future changes during operation and will effectively help reducing costs in the future [8]. Therefore, it is essential to predict and implement the necessary measures in each stage of design, construction, and installation of the facility by considering the potential and type of hazards. In this case, one of the most critical and vital stages of implementation from the perspective of probable hazards and potential accidents is the entry into the startup phase, and it is necessary to identify and predict possible risks with more profound arrangements and identify deficiencies and inadequacies in design and installation stages. So that installations with the least incident can be safely set up and operated. In this regard, one of the most important instructions before operational stage of a project is the pre-startup safety review (PSSR) [9].

Therefore, the novelty of the PSSR implementation process at refinery industries will increase the need for more research into PSSR. Consequently, this study was designed and implemented to evaluate the effectiveness of the PSSR process implementation to reduce accidents, increase productivity and project progress, as well as confirming assessment of this PSSR with upstream instructions.

METHODS

This descriptive-analytic study was conducted to evaluate the effectiveness of the implementation of the PSSR instructions in identifying, preventing, controlling, and eliminating process hazards at the refinery industry using PSSR guidelines complied from the National Iranian Oil Company (NIOC).

In the current study, a gas sweetening unit at the refinery in a pre-startup period was selected to assess the PSSR process. This study was conducted during summer to autumn of 2018. A gas sweetening unit was designed to eliminate and purify di-hydrogen sulfide (H2S) using methylene di-Ethanol Amie (MDEA) gas.

The PSSR guideline was used as a primary tool for this study which had been introduced by NIOC center of health, safety, environment, passive defense and crisis management in 2012. This document describes the PSSR study process in details and defines requirements for the implementation at work. The report was reassessed in 2015, and the first version was drafted to complete and determine the minimum requirements for the PSSR study implementation, to ensure that all new facilities or development projects are set to be restored to the service, they are entirely safe to operate. To maintain the integrity of the unit design, all safety and process requirements in design, construction, and installation phases of the unit are re-controlled.

In the first part of this study, all of the PSSR documentary sections were reviewed then the necessary checklist and critical points were extracted. In the second step, the gas refinery PSSR was designed as a checklist and table format. At the last stage, the two documents were compared at the moment of coverage and encompassing all the units and processes in the gas refinery, and the points of the strength and weakness of each were evaluated.

In the second part of this study, the start-up process including shutdowns and process accidents at the time of startup compare in the refinery as PSSR implementer and another gas refinery as a refinery in which the PSSR was not executed.

Data analysis was performed using SPSS software version 22.0. The significance level in this study was considered 0.05.

RESULTS

The findings of this study showed that the checklist derived from the PSSR document of the NIOC included four areas: health, safety, and environment (28 items), process safety management (37 items), accident management and emergency response planning (7), and the preparation for devolution (9 items) (Figure 1). The results of the NIOC designed PSSR instruction review showed that the requirements in the PSSR checklist have more emphasis on process safety management.

The evaluation of the PSSR checklist carried out at the refinery also showed that the guidelines included 5 areas for HSE (34 items), process safety management (13 items), fire prevention (15 items), integration of facility design (11 items), and emergency management (13 items) (Figure 1). The results of this PSSR instruction showed that the items presented in this checklist are more focused on reactive attitudes, control and management of accidents and dealing with emergencies.

The results of the PSSR implementation process compliance assessment based on two guidelines have been presented in Figure 1. These findings showed that although NIOC's PSSR guideline do not include two areas of fire prevention and integrated design of facilities as two separate domains, some of them are in other areas of this PSSR instruction. However, PSSR instructions for the studied gas refinery in question did not exsst in the field of preparedness for assignment as a separate domain but some of its clauses were included in other areas of this PSSR instruction. In general, the highest percentage of compliance was related to accident management and emergency response (65%), health, safety, and environment (54.83%), and process safety management (46.5%), respectively.

The results of the PSSR implementation effectiveness evaluation in oil and gas industries have been presented in Table 1 based on the comparison of the accident frequency rate in two similar gas refineries. As it can be seen, the incidence of accident types among gas refineries which the PSSR instructions were not implemented and implemented had a significant difference ($p<0.001$). Therefore, in refineries that the PSSR weren't implemented caused process errors, operation process disruption, and production process stop (shutdown).

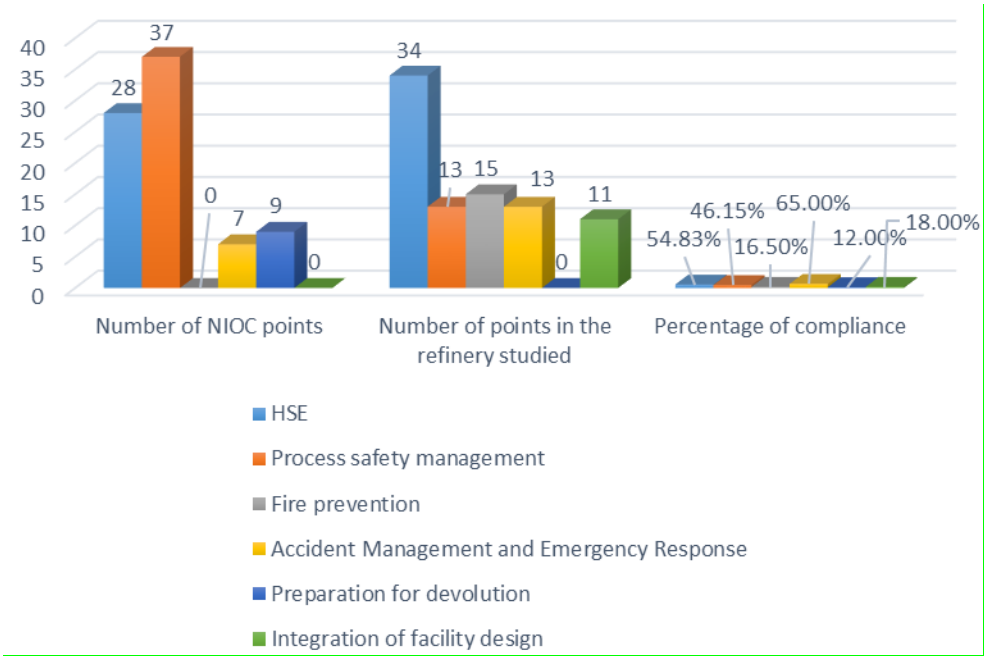

Fig.1. PSSR compliance assessment based on the NIOC two instructions and studied gas refinery

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Table 1. Startup accident rate comparing

Accident type	Cause of occurrence	Studied refinery	Compared refinery	P-value
Total Shutdown	Trip electric relay	7	12	<0.001
Local Shutdown	Compressor stop	6	17	<0.001
Total Shutdown	Flare Drum	1	5	<0.001
Local Shutdown	Instrumental error	1	4	<0.001
Local Shutdown	Tube rupture	0	6	<0.001
Local Shutdown	Air Fan Disabling	0	4	<0.001
Total Shutdown	Safety valve operation failure	0	1	<0.001
H_2S emission	Deficiency of valve operation	0	2	<0.001
Sulfur storehouse fire	Lack of fire alarm system	0	1	<0.001

DISCUSSION

The process industries due to the dynamic and complexity of the industrial processes are risky and strategic industries. Work in process industries such as gas refineries always associated with health, safety, and environmental hazards. In these industries production, storage, transportation, use, and disposal of potentially hazardous chemicals and catastrophic accidents potential are relatively high. These hazards may appear in different forms of work, and in the absence of proper planning and control, some consequences sometimes cannot be compensated [10-11]. Therefore, a regular program to detect process hazards and to take preventive plans to avoid adverse consequences in the workplace was remained [12-13].

The results of this study and other onshore and offshore high-risk projects finding showed that the safety process management elements implementation were known as the safest approach in the startup and operation stages in those industries with high-energy and high-risk fluids in their ventricles. A scheduled program and a specific strategy ensure safety of personal health, cost management as well as a secure setup [12-14-15]. Having considered these issues, it is imperative to use an appropriate and complete implementation algorithm to assess the pre-startup safety.

This study was aimed to assess the PSSR effect in the project accidents prevention and delays reduction. The results of this comparison showed that the number of shutdowns and process accidents at the refinery, in which PSSR studies carried out, were significantly lower than those without PSSR implementation ($p<0.001$). The comparison results of two similar gas refineries in terms of form, content, type of production and project execution time (the studied refinery as an executor of the PSSR and another refinery without the implementation of the PSSR). Consequently, process stop failures may enhance due to the lack of PSSR implementation and the lack of checklists in all units such as power, piping, and mechanics. The results of Table 1 indicated that the pre-startup safety review implementation at any level and with different power may reduce the frequency rate of various accidents that may have adverse consequences on safety system, employee, health, quality, and quantity [4].

To the best of our knowledge, this study objectives limitation were realized, due to the sensitivity scope of the research and the materials needed, researchers had limited access to the quantity and quality of reported accidents and other data requirements. It should be noted that mangers sometimes ignore safety issues, procedures, related

researches, and guidelines to accelerate production activities. Furthermore, more studies regarding pre-startup safety review (PSSR) will be reduced the lack of accident statistics transparency and the lack of access to financial damages caused by the occurrence of any shut down.

CONCLUSIONS

As a conclusion, it can be admitted that trust in management processes and safety techniques always has more benefits than their losses, as various studies proved that the failure or lack of a process management system is one of the main reasons for accidents in the oil and gas industry. The findings of prominent studies proved that the application of the PSM and particularly the implementation of one of its most essential requirements, the PSSR, can play a crucial role to control and reduce accidents at refineries. Also, when the PSSR checklist details are more and more detailed, the precautionary safety assessment process is controlled more precisely, so we can prevent accidents and operational interruption. The process-oriented approach based on design, engineering, and implementation principles is much more effective than the after-incident approach and can be far more beneficial. Pre-startup safety instructions with the process-oriented approach, monitor all processes, equipment, tools, and communication among them, which reduces the probability of the process accident occurrence, especially during the initial startup and restart.

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CONFLICT OF INTEREST

There is no conflict of interest for any of the authors.

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