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Safety and risk management in oil & gas industry: Development of safety x-factor model

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ABSTRACT: It is noted that difficult market conditions faced by the oil industry during last several years have been manifested in a negative safety performance. No direct relationship exists to explain this trend. Even though many stakeholders instinctively believe that extreme cost-efficiency drives seen within the industry are somehow responsible for this outcome, any clear-cut mechanisms or pathways have not yet been proposed. This paper presents the preliminary development of a schematic model basis intended to explain the impacts of economic pressure on safety performance of a profit oriented organization when faced by market challenges. Further development of this model basis is expected to provide a clearer picture of this interrelation between safety performance and economic performance.

1 INTRODUCTION

Due to the downturn of oil industry ensued during last several years, many dramatic changes have been seen within the management structures of commercial entities engaged in the business. Some of these changes have unintentional consequences on the safety culture, barrier management, and the overall safety performance of organizations. These consequences can manifest as long lasting, and sometimes delayed, impacts and could lead to catastrophic major accidents as well as gradually deteriorating HSE performance. Therefore, timely recognition of these impacts and the pathways are crucial to avert short-term and long-term loses. Reasons (1998) pointed out that technologically complex high-tech industries are more vulnerable to organizational (major) accidents due to their intricate systems and subsystems that no single person could comprehend in isolation. Accordingly, weaken barriers or latent flaws accumulated during an economically hard time period could stay dormant for years or decades before they come into play a role in a major accident.

This paper explains possible mechanisms behind the recent negative trend in safety performance observed within the oil & gas industry proposedly instigated by the dramatic downturn of the crude oil economy seen during the last couple of years (Botheju & Abeysinghe, 2017). While recognizing the necessity of adopting certain organizational changes in order to face the new economic reality of the industry, the paper highlights the importance of understanding the drivers behind this discomforting trend that is threatening the prudent safety management procedures established over decades. It is recognized that there can be certain chain-linked relations between some innocent looking cost-cutting measures and the organization's safety culture dictating the overall behavior towards its safety performance and barrier management.

This article can also assist in developing prudent guidelines that could be used to implement a robust safety management system that performs even under challenging economic circumstances without compromising the safety and well-being of the organization.

The article is based on long-term experience of the authors, and careful observation of industrial dynamics related to safety and risk management. It is intended that this paper provides a much needed insight into the driving factors behind safety performance change currently being observed within the oil & gas industry, while establishing a schematic model basis to comprehend its safety dynamics under cost-efficiency pressure.

2 RECENT TRENDS IN SAFETY PERFORMANCE

The previous works of the authors (Botheju & Abeysinghe, 2017; Botheju & Abeysinghe, 2016) have argued that the downturn of oil industry has manifested itself as a sudden nosedive of the overall safety performance. Even more threateningly, some of the resultant impacts, especially regarding the process safety risks, could come into effect years later from now. In relation to Norwegian petroleum industry, Engen et al. (2017) have pointed out that, while the level of safety and working environment conditions still remain relatively high, several safety challenges and serious conditions were starting to be manifested during the last few years.

The existence of an apparent correlation between economic pressure and the safety performance had previously been identified by other authors as well (Rasmussen, 1997; Coles, et al., 2000; Barden, and Lodestone, 2006; Young, 2015). However, many of the past case examples that were relating major accidents to cost-cutting measures, had straightforward links connecting key management decisions to poor safety barrier management (Chauhan, 2005; US Chemical Safety and Hazard Investigation Board, 2007). The current trend in the oil industry, that we are experiencing right now, is more intricate where such clear-cut pathways are still difficult to be observed. Among previous modelling attempts, Rasmussen's (1997) migration model is quite unique. He proposed the existence of a boundary of functionally acceptable performance; operating outside of that would lead to accidents. Rasmussen further theorized that there exists a gradient created by management's pressure directing the organization towards higher efficiency. This gradient, unless sufficiently counterbalanced by a gradient of safety culture, can gradually migrate the activities towards the functionally acceptable performance boundary.

The challenge, therefore, is to exactly recognize the driving mechanisms behind this recent trend. The most of the commercial entities continue to emphasize that they are still prioritizing safety as a paramount factor during their operations, and refuse to accept that any of their management actions could have led to a deteriorated safety performance.

In a way, what companies are claiming has a surface truth. Unlike in the past eras, the modern socio-ethical context and the associated legal and regulatory frameworks leave only a limited room for management bodies to initiate direct actions that could openly jeopardize safety. And above all, the most companies understand the gravity of such detrimental actions nowadays. Therefore, no sensible management would consciously support any action that clearly leads to poor safety performance.

Nevertheless, this paper argues that there are certain pathways linking the dramatic cost-efficiency actions and deteriorating safety performance. We denote these links as "Safety X-factors". The schematic model so named as "Safety X-factors Model", which is currently in its development stage, tries to explain these enigmatic connections and establish them within a model structure.

3 SAFETY X-FACTOR MODEL

As indicated in section 2, the overall safety performance within the oil and gas industry is being influenced in a negative trend aligned with the market downturn, with much visible evidence. Nevertheless, no management is accepting that they are actually driving this trend. This raises the question "what mechanisms are responsible for this trend then ?". The Safety X-factor model (abbreviated as SXF model) is presented as a basic attempt to answer this question. Note that this paper only presents its preliminary development. Figure 1 provides a schematic illustration of this model showing some of the key components and pathways proposed.

3.1 *What is SXF model*

SXF can be introduced as a basic schematic model in development aimed at explaining the safety performance outcome of an organization (or an entire

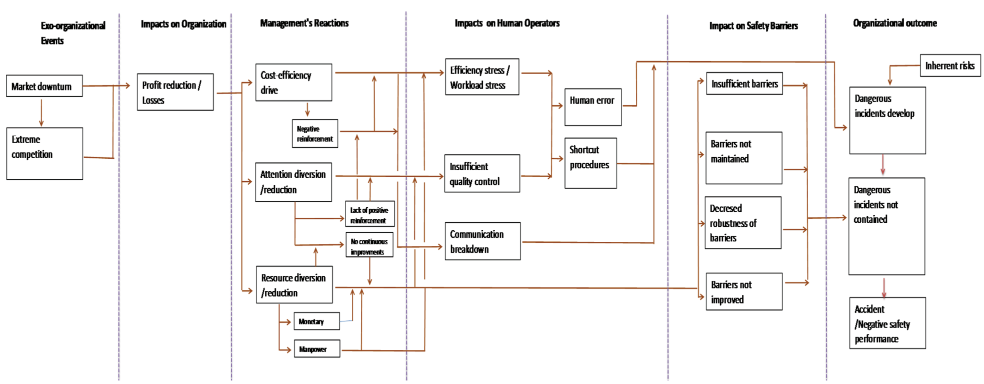

Figure 1. Schematic Illustration of the *Safety X-factor Model* (Preliminary).

industry in a broader sense) when faced by one or more exo-organizational events bearing certain economic impacts to the organization. In the current context, the relevant exo-organizational events are the market downturn triggered by low crude oil prices, and the extreme competition (the second is actually, to a larger degree, a resultant of the first in this case). The consequential prime organizational impact is the reduction of profit or even losses.

3.2 *The model structure*

The model is included with the behavioral dynamics of three (3) entities; namely, (i) Management, (ii) Employees/operators (Executors), and (iii) the technical safety barrier systems. In the current version of the model, the organizational and procedural safety barriers are not separately addressed, but considered to be embedded within the human operators behavior.

The model describes various influence pathways between the above 3 entities, that eventually lead to negative safety performance materialized as near misses, accidents, poor health, or degrading environmental impacts.

3.3 *Management reactions*

The SXF model describes the apparent management reactions as a threefold approach; i.e. (i) cost-efficiency drive, (ii) Attention diversion/reduction, (iii) Resource diversion/reduction; the each of these is briefly described below.

3.3.1 *Cost-efficiency drive*

This is the natural "panic action" by most managements when faced by market threats. Loss of profits forces top management to run for extreme cost reduction /efficiency enhancement measures. While the necessity of some such actions is justified, some extreme measures could significantly change an existing positive safety culture as explained by Botheju & Abeysinghe (2017). It is argued that such cost-efficiency measures could lead to negative reinforcements on behavioral safety under certain situations.

3.3.2 *Attention diversion/reduction*

When good economies exist backed by favorable market conditions, top managements usually have high attention to HSE aspects. This is the normal behavior of organizations possessing an adequately good safety performance history. However, a management is tested when it faces difficult market conditions and poor economic performance. Will they be capable of maintaining the same level of commitment to safety under pressing economic situations? Often, many managements yield under such situations and their attention is significantly drawn from their usual emphasis on safe performance to other more urging matters such as economic issues and profitability of operations. This in turn reduces the positive reinforcement previously received by operators for their good safety performance.

3.3.3 *Resource diversion/reduction*

Diversion of monetary and human resources to other purposes, than for the continuous improvements of safety systems as well as for proper maintenance of existing safety barriers, is a natural trend that can be observed under economically challenging periods.

When it comes to many technical safety barriers, they are costly to establish and their benefits are not immediately apparent, or may be perceived as "it can wait". Meanwhile, the actual cost components associated with such safety systems are very real and will have to be immediately dispatched from the existing economic resources. Under this scenario, many managements could be tripped into abandon or delay various continuous safety improvement actions and maintenance/upgrade actions. This forever conflict between production vs. protection (Reasons, 2000) can lean heavily towards production when the resources are more limited.

3.4 *Human operator impacts*

The above described management reactions generate multiple responses from human operators, as briefly described below.

3.4.1 *Efficiency stress and workload stress*

The extreme cost-efficiency drives combined with negative reinforcements, and the lack of positive reinforcements originating from attention diversion reaction leads to high level of worker stress which is further accelerated by reduced amount of human resources (Resource Diversion/Reduction).

3.4.2 *Insufficient quality control*

Both the attention diversion management reaction and the resource diversion/reduction reaction generate this impact on human operations. The lack of positive reinforcements further aids safety quality control barriers.

3.4.3 *Communication breakdown*

The extreme cost-efficiency drives coupled with associated negative reinforcements lead to increased rift between the management and the executors leading to the breakdown of efficient two-way communication. A coherent safety management becomes increasingly difficult under such communication breakdown situation.

3.4.4 *Human error*

A human error is an inadvertent event generated through the actions of human operators while trying to follow a preplanned course of actions. The likelihood of human error rapidly increases when operators are under stress. The probability of discovering such error is also diminishes in the face of insufficient quality control.

3.4.5 *Shortcut procedures*

A shortcut procedure is an intentional diversion from the planned (safe) course of action. Operators resort to such short-cut procedures either because such actions are indirectly promoted by the organizational culture or else as a way-out from the high workload and stress. The lack of safety quality control would further contribute to this situation. The short-cuts may work during most of the times but eventually can trigger chain reactions leading to dangerous incidents/accidents.

3.5 *Performance of technical safety barriers*

Stemming primarily from the resource diversion management reaction, technical safety barriers experience following impacts described below.

3.5.1 *Insufficient barriers*

If the amount of barriers are not sufficient to cover all the high-probability accident scenarios, then the risk of an incident developing into a full scale accident is high.

3.5.2 *Barriers not maintained*

All technical safety barriers require certain maintenance to keep them under optimum performance level. The lack of maintenance leads to their degradation over time and therefore their reliability decreases.

3.5.3 *Decreased robustness*

The robustness can be defined as the spare capacity of a safety barrier to handle accident scenarios beyond the normally expected magnitudes, frequencies, and operational conditions. A more robust safety system has a high tolerance for errors, so that it can still break the propagating incidents originating from significant human errors.

3.5.4 *Barriers not improved*

All safety systems need continuous improvements /adjustments over time. The facilities face different kinds of risks during their lifetimes. For example, an old facility may have a different risk picture compared to a similar but newer facility. Similarly, plant modifications lead to changed risk scenarios. Therefore, the safety barriers must continuously be adopted or upgraded according to the changing conditions.

3.6 *Organizational outcomes*

On top of the existing inherent risks of a facility, additional pathways leading to the development of dangerous incidents are generated as a result of the aforementioned human operator impacts. Meanwhile, due to the simultaneous weakening of the safety barriers, the possibility of containing/resisting dangerous incidents under propagation becomes increasingly difficult. This makes the likelihood of accidents higher. The term "accident" here also embodies other slow phase outcomes such as poor health and weak environmental performance.

4 CONCLUSIONS

This paper briefly presents the preliminary development of a schematic model aimed at recognizing mechanisms behind the apparent correlation between economic pressure vs. safety performance of a profit oriented organization. It is theorized that there exists several indirect pathways leading to a deteriorated safety performance initiating from an economically stressed management, even when the management may not intentionally compromise safety for economic gains.

So named Safety X-factor (SXF) Model is to be further expanded in order to fully explain the negative safety performance trends observed under market downturn situations. The eventual aim is to describe an organization's safety culture using more concrete and measurable terms.

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