Human factors analysis and classification system for the oil and gas industry (HFACS-OGI)

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ABSTRACT

The oil and gas industry has been beset with several catastrophic accidents, most of which have been attributed to organisational and operational human factor errors. The current HFACS developed for the aviation industry, cannot be used to simultaneously analyse regulatory deficiencies and emerging violation issues, such as sabotage in the oil and gas industry. This paper presents an attempt to improve the existing HFACS investigation tool and proposes a novel HFACS named the Human Factors Analysis and Classification System for the Oil and Gas Industry (HFACS-OGI). Result found the HFACS-OGI system to be suitable for categorising accidents, following the analysis of 11 accident reports from the US Chemical Safety Board (US CSB). The HFACS-OGI system moreover revealed some significant relationships between the different categories. Furthermore, the results indicated that failures in national and international industry regulatory standards would automatically create the preconditions for accidents to occur.

1. Introduction

The process industry has experienced some devastating accidents and statistics have shown that these are mostly attributed to human factors [1,2]. For example the Bhopal toxic release (1984), one of the worst industry disasters, resulted in 2500-6000 fatalities and over 200,000 injuries [3]. The Flixborough explosion (1974) caused 28 fatalities and the near total annihilation of the NYPRO plant [4]. The BP Texas City refinery explosion (2005) resulted in around 15 fatalities [5] and the Piper Alpha offshore oil industry disaster (1988) left 167 dead and dozens badly injured [6]. These have all been investigated and found to be a result of both direct and indirect human factor failings. Studies have shown that some of the investigative tools and measures adopted were not robust enough to avoid accidents, especially in an industry prone to risks and accidents. Shappell and Wiegmann therefore assert that it is imperative to take accident investigation beyond the actions of immediate personnel [7]. An attempt to accomplish this resulted in the development of the Human Factors Analysis and Classification System (HFACS) by Shappell and Wiegmann, for use in the investigation of US military aviation accidents [8–11]. The framework was based on James Reason’s “Swiss Cheese” model which explained the occurrence of system failure at four levels: 1) Organisational failures, 2) Unsafe supervision, 3) Preconditions for unsafe acts and 4) Unsafe acts. The framework uses a systems approach to identify deficiencies that have led to an accident rather than focusing on and blaming the individuals involved [11,12].

Whilst the HFACS framework was originally developed and applied successfully in the analysis of aviation accidents [11], other industries have also successfully used the original framework, or a modified version, in accidents analysis. These include the maritime and railway industries and medical organisations [13–18]. Table 1 shows that the HFACS framework as it was originally constituted has been modified for use in several different sectors.

The existing HFACS is effective for the analysis of human factors, particularly as it relates to safety culture, management commitment, safety leadership [25], organisational erodive drift [26], technical failure of ageing equipment and the operators’ lack of knowledge or competency [26,27]. It cannot however simultaneously analyse regulatory deficiencies [28,29] and emerging violation issues like sabotage, in response to problematic organisational factors particular to the oil and gas industry [17]. At present, there is no Human Factors Analysis and Classification System (HFACS) specifically designed for the oil and gas industry. A HFACS framework specifically for accident analysis in the oil and gas industry therefore would be particularly advantageous.

2. Analysis of the proposed framework for the oil and gas industry (HFACS-OGI)

The original HFACS was based on Reason’s theory of accident causation but has been modified to fit specific industries and applications.
The proposed HFACS-OGI has considered oil and gas technical reports. These include the 2014 SPE technical report titled The Human Factor: Process Safety and Culture, produced after a two-day summit held in July 2012 on the best way to address human factors affecting the oil and gas industry [7]. The proposed changes focused on preventing catastrophic accidents, particularly toxic releases, fires and explosions associated with the Control of Major Accident Hazards (COMAH) regulations (1999) [29].

### 2.1. Unsafe acts (level 1)

The Health and Safety Executive defines an unsafe act as: "any act that deviates from a generally recognised safe way or specified method of doing a job and increases the potential of an accident" [30]. Unsafe acts as shown in the proposed HFACS-OGI (Fig. 2) could be a result of error by omission (where a required action was disregarded) or error by commission (where an incorrect action was performed) [31]. In both cases, these errors are unintentional and unplanned. In the case of violation however, the error is intentional although usually the perpetrators perceived they had a better idea, a quicker process, superior knowledge or a different way to accomplish a given task. Sometimes violations occur due to the impression that there are too many layers of protection which are bypassed with no intention to cause deliberate harm.

#### 2.1.1. Act of sabotage

An act of sabotage suggests intentionality. It may be defined as a deliberate act to negatively affect the system, process, work or production in a plant, system, factory or workplace that may lead to a serious accident or damage, in response to a challenging identified organisational factor [17]. In this form of violation, all layers of protection are deliberately removed to cause harm.

There are two main theories that have been advanced to explain how water entered Tank 610 in the Bhopal disaster: 1) water-washing of the pipes and 2) sabotage [32]. The second theory states that an act of sabotage by an aggrieved employee in response to organisational issues caused one of the world’s worst process safety accidents. Kalekark and Little [33] argued in support of the second theory that although ‘minor incidents of process sabotage by employees had occurred previously at the Bhopal plant, and, indeed, occur from time to time in industrial plants all over the world… it was during a shift change that a disgruntled operator entered the storage area and hooked up one of the readily available rubber water hoses to Tank 610, with the intention of contaminating and spoiling the tank’s contents.” [33]. Operators’ acts of sabotage can take different forms: working slowly, destroying equipment and polluting the system among others. Such interventions in normal operational procedures might result in severe consequences like fire, major explosions, toxic releases and environmental contamination [34].

Although it was only after the 9/11 terrorist attacks in New York City that the chemical industries included sabotage in their formal risk assessments [34], it is essential to differentiate between acts of sabotage and terrorist attacks. An act of sabotage is an internal act carried out by a disgruntled employee in response to a challenging organisational issue. A terrorist act on the other hand is mostly an external act carried out by terrorists for any reason. They are therefore different both in the nature of the perpetrator and the reason for the act. The Centre for Chemical Process Safety has developed a guideline in its new initiative on sabotage risk in the process industry "[that]…demonstrates process and tools for managing the security vulnerability of sites that produce and handle chemicals, petroleum products, pharmaceuticals, and related materials…” [35]. This study therefore introduces a third violation subcategory named “acts of sabotage”. However, this is related to the violation issue only insomuch as the act was internal and intended to trigger a domino effect within the process plant in response to an identified challenging organisational factor. This was also considered in HFACS-RR [17].
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