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# Safety Artifacts in Oil and Gas Industry: An Analysis of Permit-To-Work Process

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Safety critical activities performed in oil and gas industries need to be constantly assessed by the Permit-To-Work (PTW) process. The PTW is a formal process to communicate safety critical tasks and control certain types of works identified as potentially hazardous. Despite its relevance beyond risk analysis, the imagined purpose of this safety artifact is sometimes different from the function of this artifact in practice, being seen as an enabling device, without its real purpose. The objective of this study is to analyse the PTW process in the oil and gas industry. The context was PTW authorized for a cargo handling between the oil rig and a supply vessel and was collected through observations, interviews, and documents analysis. The Functional Resonance Analysis Method (FRAM) was adopted to modelling the Work-As-Done (WAD) and the Work-As-Imagined (WAI). The analysis allowed identify four factors that could be linked with the differences of the artifact in the practice: lack of system integration on the rig; centralized information on the shift leader; compliance with the task registration; and lack of feedback concerning the operation. This study illustrates how this systematic approach helps to understand daily safety-critical operations, improving solutions to cope with the daily variability, instead of the linear approaches commonly adopted in the industry, focusing on eliminating them.

*Keywords*: Permit-To-Work (PTW), FRAM, artifacts, safety critical, complex system, oil and gas.

## 1. Introduction

In the organizational context of high-risk industries, certain processes and tasks are decisive and established as critical to the safety and integrity of the system (Aven and Renn 2009). Oil and Gas (O&G) rigs are complex systems where different processes such as drilling, extraction, processing, and storing take place in an integrated manner. It represents activities with a high degree of uncertainty and with potential unwanted consequences to the entire system (Walker, Waterfield, and Thompson 2014). In order to maintain a level of control over these activities, organizations rely on safety management systems to adopt a series of practices to guarantee safety operations, through the application of risk assessments and safety artifacts (Veland and Aven 2015).

The Permit-To-Work (PTW) is a formal safety artifact to communicate critical tasks and control certain types of works that are identified as potentially hazardous (Iliffe, Chung, and Kletz 1999). Moreover, permits are effective means of management between site managers, plant supervisors, operators, and the individuals carrying out the work, as it also considers a briefing as a routine before initiating the task. The exchange of information should complement the information present in procedures and routines, which by themselves are not capable of encompassing the diversity of situations and contexts present in everyday reality (Clark, Stanton, and Revell 2019).

Problems associated with PTW management and communication are contributing factors associated with some accidents, such as the explosion of the Piper Alpha platform in 1988 (Flin 2001), followed by other adverse events, like the Buncefield oil storage terminal explosion in 2005 (Johnson 2010), and the refinery accident Texas City in the same year (MacKenzie, Holmstrom, and Kaszniak 2007).

However, despite its relevance in the organizational context to mitigate risks, Hutchinson, Dekker and Rae (2022) pointed out that the imagined purpose of a safety artifact (i.e., controlling risks) is sometimes different from the function of this artifact in practice, being seen only as an enabling device, as it enables work to happen by encouraging a belief that the risks of the task have been managed, when in reality they have not been. Other studies shows that the probability of error was higher in tasks performed by frontline workers than with other groups involved in the PTW process (Jahangiri et al. 2016; Mousavi et al. 2020).

On the other hand, based on the assumptions of resilience engineering, Hollnagel (2015), has argued that differences between the Work-As-Imagined (WAI) and the Work-As-Done (WAD) are always present in complex system, due to daily variability. This implies that there is a gap between the planned activity (i.e., based on protocols and standard operating procedures) and the everyday work. Furthermore, the ability of complex system to adjust it performance – called resilience - is essential to operate successfully either in expected or unexpected situations (Woods 2019). In line with this perspective, the Functional Resonance Analysis Method (FRAM) is a tool that allow understand sources of variability and resilience of a system, understanding how the real work is done (Hollnagel 2012).

In this sense, this study aims to analyse the how the PTW process is carried out in the oil and gas industry. Through the application of the FRAM, two process was modelled, the process-as-imagined and the process-as-done, in order to understand the potential difficulties and dissociation of the artifact in practice.

## 2. Permit-To-Work (PTW)

Given the dynamic hazard and the integrated operations in the oil and gas industry, the PTW is mandatory artifact. The work-permit process aims to ensure that consideration is given to the risks of certain critical activities, as well as communication between managers, supervisors, and operators (HSE 2005). Tasks performed in confined spaces, at heights and maintenance of equipment close to areas with a high risk of fire and/or explosion are some examples of critical tasks subjected to PTW authorization.

In general, the PTW process is a safety artifact to manage critical risks and to inform that work is being carried out in a specific area. The complete PTW process, from the need for service to the completion of the task, can be seen in Figure 1. A document needs to be full field to request approval of this tasks, where those involved assume different roles. In general, there are three main actors: a requester, an approver, and the work team. The process starts with a person requiring the job to be done in some place on the site. This requestor will issue a request document describing the type of task, the place it will occur, the team involved, and the risks associated with this job and measures to control the risk. After requesting, the managers of the rig (generally deck, safety, maintenance and drilling leader, and the installation manager) will analyse the work request and decide if it will be allowed or not. Situations where the activity does not fit within the scope of the PTW process, it will be disregarded. On the other hand, if it is a routine service, the existing assessment will be revised, considering the present conditions of the job. Or, if the task has not been performed previously, a new assessment will need to be carried out by this team (HSE 2005).

The next step, still on the responsibility of these managers, consists of the agreement or not of the assessment of the task, issuing considerations to implement controls and barriers to limit the area and perform the task safer or issuing a recommendation to redefining parameters of the activity. At the end, the PTW is issued, which may or may not be accepted by the requestor based on the considerations of the leaders and the other criteria. In the front line, the workers will receive a written paper or electronic form which is used as part of an overall system of work. Before the start of the task, a pre-task meeting needs to be performed as also a log registration. This register is also mandatory before starting the task and include information such as the operators' names and key information concerning safety and risk issues (Jayakumar and Liyanage 2016).

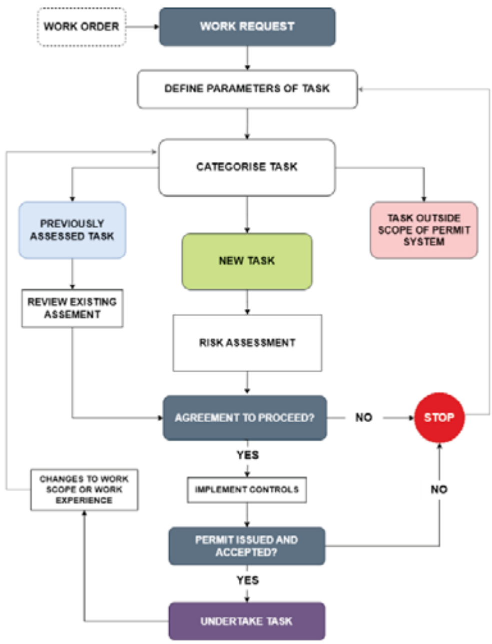


Fig. 1. Flow diagram illustrating the Permit-To-Work process. Source: adapted from HSE (2005).

## 3. Method

### 3.1. *Study Context*

This study was developed in the context of a drilling operation, conducted onboard an oil and gas rig in the Santos Basin, Brazil. The PTW authorization meeting was performed with five rig managers (the rig captain, drilling leader, marine leader, technical leader, and the deck leader). Based on the company's standard operating procedure, all tasks requiring authorization were reviewed one day in advance of the intended operation. In the meeting, seven tasks were authorized for the following day. Based on complexity and observation availability of the task, the transfer of cargo between the rig and a support vessel was chosen as a case study.

The cargo handling is a common operation in the oil and gas industry. Due to the short size of the rig, not all materials are available on board, so whenever there is a change in the drilling phase and new materials are needed, a support vessel brings all the necessary materials to the rig from the onshore support base. In the analyzed context, five containers were transferred in total, three from the rig to the vessel and two from the vessel to the rig. The cargo handling was operated by six workers (the deck leader, one crane operator, one signalman, and three roustabouts with the function of guiding the load) and took around two hours.

### 3.2. *Data Collection*

In this qualitative study data were collected through non-participant observations, interviews, and analysis of documents. The data collection occurred in October 2022 by two researchers. The observation totaled 52 hours, focusing on the entire process of PTW, starting since the need for the service until the completion of the activity. In this process was observed the PTW authorization meeting with the rig leaders; the pre-task meeting with the workers, minutes before starting the job; and the entire process of cargo handling between the vessel and the rig. A Non-structured interview (1,5 hour) was conducted with the workers (one crane operator; one signalman; and three roustabouts), aiming to better understand the process and constrains of work. Finally, the company's policies and standard operating procedure were analyzed to compare the descriptive orientation of the PTW process and the real one.

### 3.3. *Data Analysis*

The Functional Resonance Analysis Method (Hollnagel 2012) was adopted to model this entire process. The data collected were analyzed considering the five main categories: (i) recognize the purpose of the FRAM; (ii) identify and describe the functions; (iii) identify variabilities; (iv) aggregate variabilities; and (v) analyze factors to improve operations. In FRAM, the function is usually represented by a hexagon. In each edge is one of the six possible aspects of a function: input (which activates the function and/or is used for output); output (the result of the function); control (that supervises or regulates the function); precondition (a conditions that must be met before the function can be executed); time (related with temporal aspects that affect the execution of the function); and resources (element necessary or consumed by the function when activated). According to Hollnagel (2012) the output of the functions can vary either in precision (acceptable, unacceptable, imprecise) or/and in time (too early, on time, late, or did not happen), describing what should be expected at certain conditions or context. Finally, the model is completed, if the aspects of the functions have a relationship with at least another function.

In this study, two PTW processes were modelled using the FRAM Model Visualiser Pro (FMV) software (version 2.1.6). The first model was the process as imagined, based on the document analysis and the interviews, and the second model was the process as done, pointing out how the real process occurred. The analysis allowed identify seven differences between the WAI and the WAD, including functions that did not actually occur and others that occurred differently than proposed.

## 4. Results

The Appendix A shows the PTW process as imagined. Overall, 23 functions from service need to update PTW system were identified. These functions were related with five groups in this process: the deck leader (purple color); rig managers (red color); workers (blue color); workers and deck leader (yellow color); and worker from shift A and workers from shift B (black color).

The process starts with the function <Need for Service>. The leader defines the parameters and category of the task, as well as carry out the risk assessment with the protentional dangerous in the environment and to the workers. After this stage, it was requested a work permit through a computer system. Then, it's analysed by the rig manages if the documentation is corrected, as well if there are other activities taking place in the vicinity. If there is no conflict, the work permit is categorized, and an authorization is issued. With the authorised PTW, it was up to the sector leader to start the PTW (i.e., indicating that the operation was started) to then mobilize the workers, tools and barriers to start the job.

At the site, it is necessary to carry out a pre-task briefing, commanded by the sector leader with the workers, where relevant information for that activity in question would be discussed, as present in the documentation and initial risk analysis. During work, the documents indicate that if any unforeseen condition is found, the operation must be stopped, and new safety criteria must be re-established. With everything going well, at the end of the task, operators must communicate with the sector leader to then carry out a debriefing and update the PTW system, as well as update the new team that may change shifts.

However, in the actual operation, as shown in Appendix B, several differences were noticed. Five functions did not occur in the real process performed: <Analyse Ongoing Works>; <Categorise the Permit to Work Risk>; <Continue Task Plan>; and <Modify Task Plan>. With other three functions that were performed differently than expected: <Open Permit to Work>; <Perform Pre-Task Meeting>; and <Update Supervisors>. The activity of opening the PTW was carried out by another leader, responsible for the rig positioning control (represented as green color).

Based on the analysis of the FRAM and the interviews, four factors were identified that could be linked with the dissociation of the artifact in the practice of the workers and the organization: (i) lack of system integration on the rig; (ii) centralized information on the shift leader; (iii) compliance with the task registration; and (iv) lack of feedback concerning the operation.

### 4.1. *Lack of system integration on the rig*

The leader of the deck had the role of opening the PTW every shift. This function is a precondition to perform the pre-task meeting where they discuss about the risks concerning the task. Because of the lack of integration of the PTW system on the rig, the leader did not have access to the system. So, deck leader was dependent of another person – the rig positioning operator, to open it. This operator was not expected or included in the PTW process, and, in many times, he was busy and couldn't accounted for it. In summary, it directly impacted the team that did not have the printed PTW documentation, guidelines, nor if there were other safety recommendations issued by the rig managers.

### 4.2. *Centralized information on the shift leader*

As already mentioned, the pre-task meeting is a briefing held with the aim of contextualizing and aligning the operations planned for that shift. The deck leader had the role of conducting this meeting before starting the job, addressing aspects related to the identification of the loads that would be handled, the risks foreseen, and which barriers would be used as a way to mitigate them. However, the absence of this leader led to workers not having access to the assigned task. As result of the centralization of the information on the shift leader, the workers could not start the task, waiting until further information or having to look for the leader.

### 4.3. *Compliance with the task registration*

Before starting the shifts, operators fill in the task registration. As the operators did not know what the day's tasks would be, as the deck leader was often not enrolled in the meeting, they filled out this document based on a standard template posted on the room's wall. This resulted in the condition where operators did not discuss the associated risks, they just filled in the log. Table 1 presents the content filled in by the workers, containing broad and non-contextualized information about the operation.

Table 1. Registered information on the PTW log

| Log section | Registered information |
|---|---|
| Hazard and risk | Miscommunication; poor operation, poor organization of the area, cargo balance; load crashes |
| Controls | Radio check; check objects and equipment; use the tool instead of the hand; clean area |

### 4.4. *Lack of feedback concerning the operation*

Due to the dynamics of the environment, the leader also did not collect details about the operation, causing a lack of feedback regarding opportunities for improvement and different risks found in the real operations. The consequence of this was workers mentioned that the information contained in the PTW was sometimes inconsistent with the risks and operations found in practice.

## 5. Conclusions

Based on the systemic approach of resilience engineering, this study made it possible to analyse some reasons for the dissociation of PTW in the context O&G industry. The analysis based on the FRAM models brought results that demonstrated a difference of WAI when compared to WAD. The PTW, as artifact, is designed to manage safety, but in practice it could be promoting a reduction in safety levels due to several organizational factors. This study indicates that some of the industry's safety tools may be being used as false safety benchmarks, while the lack of monitoring of the real effectiveness may be allowing the gaps between what is imagined and what is done become bigger. The study recognizes the importance of PTW for the risk assessment, however it is important to analyse how this process is actually performed in the local context of each organization, so adjustments and improvements are carried out continuously, increasing the effectiveness of the artifact. The way the PTW process takes place also affects the way workers deal with this tool, which can be geared towards its real purpose or only to meet the compliance required by the industry. The results obtained refer to a specific case and local observation, conducted onboard a specific O&G rig. More studies are needed to observe the differences between these processes and its practical reality. For further studies, we encourage observations in different contexts and even other complex system, such as chemical industries or onshore operations. Similarly, new studies may seek to develop strategies to deal with these difficulties in order to improve the artifact and the safety level of the systems.

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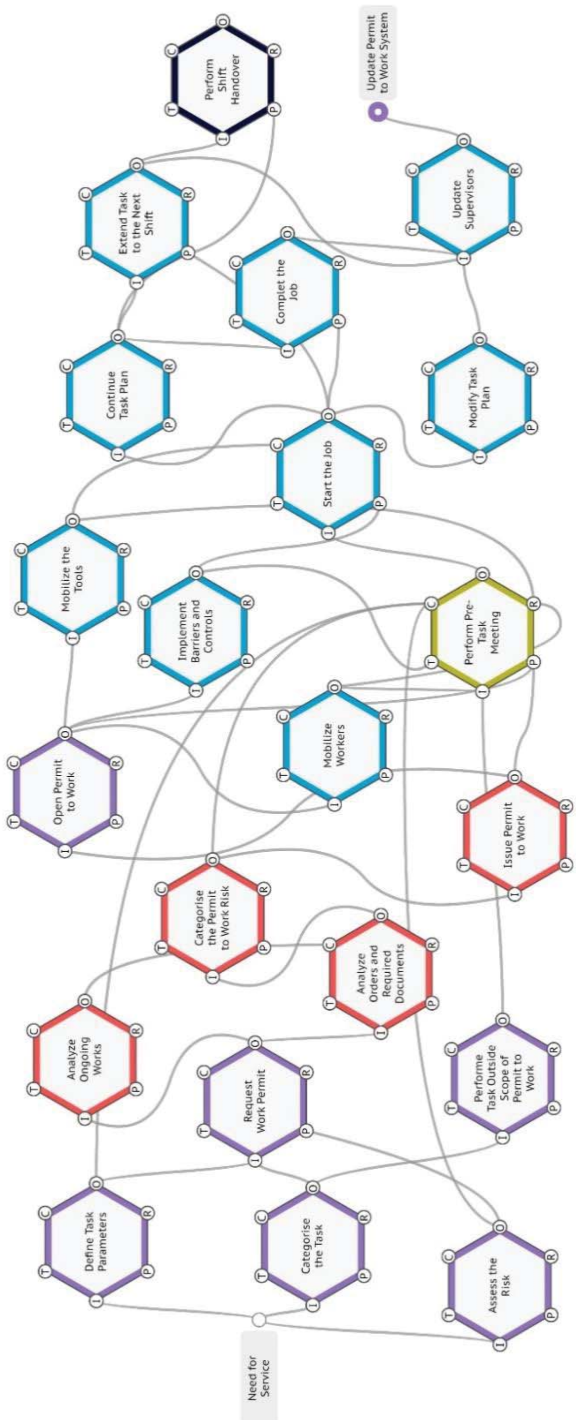
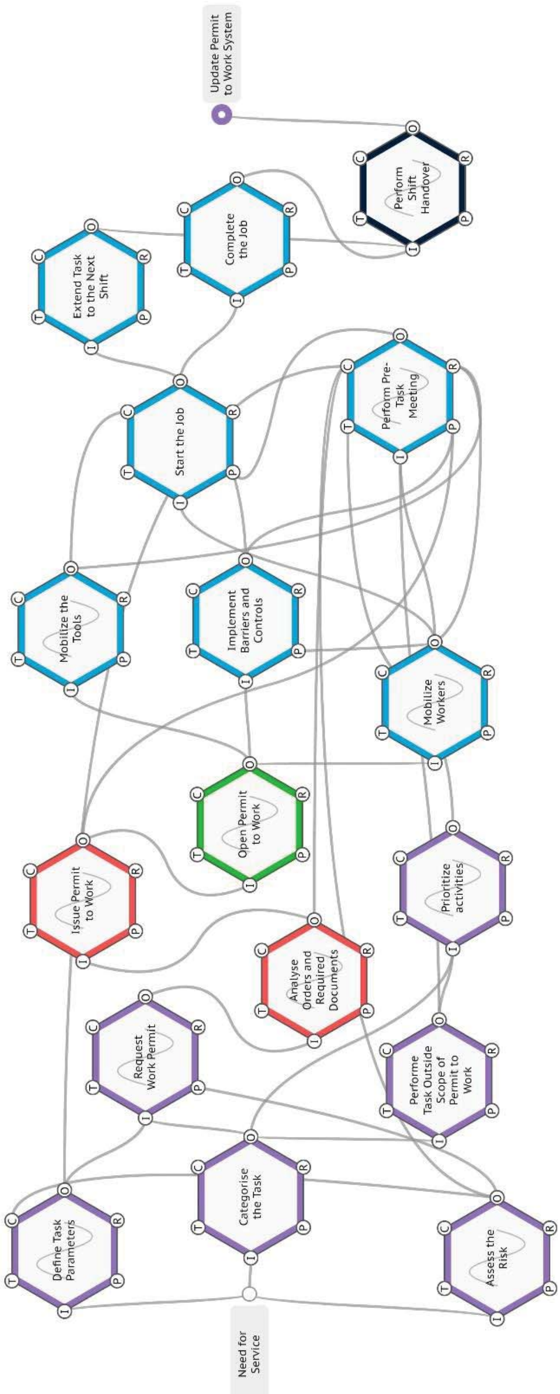
**Appendix A.1 - WAI of the PTW process**



**Appendix A.2 - WAD of the PTW process**



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