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OPERATIONAL MANAGERS BUILD SAFETY BY CREATING FAVOURABLE ENVIRONMENTAL CONDITIONS FOR SAFETY WORK

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ABSTRACT

The purpose of this paper is to promote a complementary myth to "compliance to rules ensures safety" namely that "operational managers build safety by creating favourable environmental conditions for safety work". By a "myth" we understand a story that expresses a partial truth about a phenomenon. "Environmental conditions for safety work" refers to conditions that influence the opportunities an organization, organizational unit, group, or individual have to control the risk of major accidents and work environment risk. Based on a literature review and qualitative interviews we elaborate on the idea that operational managers build safety by creating favourable environmental conditions by discussing two examples from the petroleum industry: 1) How a failure to create favourable conditions for safety work contributed to the explosion at BP's Texas City refinery in 2005. 2) How operational managers in the Norwegian petroleum industry actively try to prevent excessive stress and time pressure related to downtime in drilling operations. We conclude that a failure of senior management to provide adequate environmental conditions for the safety work of operational managers may indirectly contribute to accidents. Operative managers can build safety by creating favourable environmental conditions for safety work for workers at the sharp end. Safety is not ensured by a single means, such as compliance to rules, and creation of favourable environmental conditions for safety work is therefore an essential part of a more complex account of safety.

1. INTRODUCTION

In the call for papers for this conference, contributors are invited to discuss myths on safety in the information society. One of the myths that are listed in the invitation is the idea that *compliance to rules ensures safety*. The term "myth" can have different meanings. In this paper, we will use the term "myth" about stories that expresses a partial truth about a phenomenon. We do not challenge the idea that compliance to rules contributes to safety in many contexts. However, we want to argue that it is necessary to go beyond rule compliance to ensure safety and to understand how safety and accidents come by. The purpose of this paper is therefore to promote the complementary myth that *operational managers build safety by creating favourable environmental conditions for safety work*.

The term "environmental conditions for safety work" refers to conditions that influence the opportunities an organisation, organisational unit, group, or individual have to control the risk of major accidents and work environment risk (Rosness et al., 2012, in press). By "safety work", we refer to all efforts to keep the risk of major accidents and work environment risk under control. Safety work is thus not limited to tasks performed by safety professionals, but ranges from a technician carrying out his/her daily work in a safe manner to a company board allocating adequate resources to safety critical investments. The term "environmental conditions for safety work" thus draws attention to specific actors facing specific risks, and to a broad range of circumstances that facilitate or constrain the efforts of these actors to handle the risks they are facing. The concept is compatible with classic ergonomic thinking, with its philosophy of adapting the work environment to the needs and capacities of the worker. It is also compatible with an open systems view of organisations, according to which one has to take into account interactions with the environment of an organisation to understand and explain phenomena inside the organisation.

Rosness et al. (2012, in press) proposed a conceptualisation of "environmental conditions for safety work" and identified a set of theoretical resources that may help us understand how environmental conditions may constrain or facilitate safety work. The present paper aims to give the concept an empirical grounding by illustrating how it can be used to make sense of empirical material. We shall elaborate the idea that operational managers build safety by creating favourable environmental conditions by discussing two complementary examples from the petroleum industry: *Example 1* shows how a failure to create favourable conditions for safety work contributed to the explosion at BP's Texas City refinery in 2005. More specifically, the example illustrates how senior management decisions may create unfavourable environmental conditions for operational managers, and thereby trigger decisions that adversely affect the environmental conditions for workers at the sharp end. *Example 2* illustrates what operational managers in the Norwegian petroleum industry do to prevent excessive stress and time pressure related to downtime in drilling operations. The example illustrates how operational managers ensure favourable environmental conditions for workers at the sharp end.

2. "SENDERS" AND "RECEIVERS" OF ENVIRONMENTAL CONDITIONS FOR SAFETY WORK

Many environmental conditions are created, changed and maintained by the decisions and practices of other actors. For instance, higher management levels typically impose budget limits, whereas designers may determine the layout of a workplace during the design of a production facility. Rosness et al. (2012, in press) proposed the metaphors "senders" and "receivers" to convey the idea that some actors ("senders") exert a strong influence on environmental conditions that other actors ("receivers") face when they strive to keep risks under control. These metaphors can be used to highlight how decision-makers at the blunt end of organisations, remote from the physical sources of danger, may enhance or restrict the scope for effective safety work at the sharp end. Operational managers find themselves in an intermediate position. They are "receivers" of environmental conditions shaped by decisions at higher management levels, such as budget constraints, resource allocations and deadlines. At the same time, they are "senders" of many environmental conditions facing lower organisational levels. We do not claim that distinct "senders" and "receivers" can be identified for all environmental conditions; some environmental conditions, such as safety climate, are co-created, whereas others, such as oil prices, may not have a clearly identified "sender".

Rosness et al. (2012, in press) suggested that theory development and empirical research on environmental conditions for safety work may draw on a broad range of theoretical resources. In this paper we shall take Erik Hollnagel's (2004, 2009) concept "Efficiency-Thoroughness Trade Off" (ETTO) as a starting point. Hollnagel suggests that organisations, groups and individuals frequently have to balance efficiency requirements and quality requirements directed at their work. The output of their work will typically display increased variability when thoroughness is sacrificed to gain efficiency. Under unfortunate circumstances, for instance when variability from different sources interact in an unforeseen manner, such variability may contribute to an accident. The variability is then likely to be labelled "human error" when investigators construct a post-hoc account of the accident.

We propose that adverse environmental conditions for safety work may increase the likelihood that actors will trade off thoroughness in order to gain efficiency. The variability produced by actors trading off thoroughness for efficiency may create adverse environmental conditions for actors further down in the production sequence or command chain. For instance, less than thorough planning work may lead to a deficient plan and create dilemmas for the actors implementing the plan. Hollnagel thus drew attention to conflicting demands and variability of input from other actors as environmental conditions for safety work. In the present paper we shall follow this lead by exploring the following research issue: How do environmental conditions for safety work created by senior management influence the safety work of lower level managers and operators at the sharp *end?* This issue will be explored in Example 1.

Hollnagel (2004, 2009) provided lists of ETTO rules to illustrate the rationales typically given by actors when they trade off thoroughness to achieve efficiency, e.g. "it has been checked earlier by someone else" or "it looks like a Y, so it probably is a Y". However, he did not give a similarly elaborate account of episodes when actors chose a thorough course of action when facing incentives or pressures to choose efficiency. This paper will therefore address the following research issue: How do operational managers act to create environmental conditions that influence their subordinates towards selecting a thorough course of action? This issue will be explored in Example 2.

3. MATERIAL AND METHODS

The research design for this paper relies on two complementary case studies, referred to as "Example 1" and "Example 2". The case studies are complementary in several respects:

1. Example 1 concerns environmental conditions that contributed to a serious accident, whereas Example 2 concerns normal work practices that are intended to create favourable environmental conditions for safety work;
2. Example 1 concerns a US refinery, whereas Example 2 is based on an oil production platform on the Norwegian continental shelf;
3. Example 1 is based on a literature review, whereas Example 2 is based on qualitative interviews;
4. Example 1 reflects analyses and judgements made by outsiders (independent accident investigators and researchers), whereas Example 2 presents the accounts of insiders, i.e. personnel that are themselves involved in safety work and the creation of environmental conditions for safety work.

The choice of complementary cases enabled us to explore the implications of the concept of "environmental conditions for safety work" in a broad range of contexts. We chose this approach because we are in an early stage of empirical research concerning environmental conditions for safety work, where our main concerns are to give the new concept an empirical grounding (Strauss, 1987) and illustrate its application and implications in a variety of settings.

Example 1 is based on literature concerning the explosion at BP's Texas City refinery, in particular the investigation report of the Chemical Safety and Hazard Investigation Board (CSB, 2007), the Baker Panel Report (2007) and Hopkins (2008). This accident was selected for study because the available documentation provides rich information on the effects of senior management actions and practices. We used an iterative analysis approach. We looked for decisions and practices that had an impact on the accident sequence or on the environmental conditions of actors whose actions had an impact on the accident sequence. Each decision or practice was analysed in two ways. First we looked for its impact on the accident sequence and on the environmental conditions of other actors ("receivers"). Secondly, we looked for decisions and practices of "senders" that influenced the environmental conditions that contributed to the decision or practice in question. This analysis allowed us to construct plausible paths of influence that encompassed actions and practices of BP senior management, the Texas City refinery management, and the operators at the sharp end. The results are summarised in the diagram shown in Figure 1.

The second study is based on semi-structured qualitative interviews with 12 persons involved in drilling operations on a production platform on the Norwegian continental shelf. The informants come from a strategic sample of interviewees in a research program on environmental conditions in the Norwegian petroleum funded by the Petroleum Safety Authority Norway (Forseth et al., 2011). The interviewees included persons from the operator, the drilling contractor and a well service contractor. We paid particular attention to operational managers offshore, e.g. drilling supervisor, toll pusher and driller.

The analysis proceeded as an iterative process: First, we read and coded the interview protocols with regard to main topics, using a pre-established set of categories roughly corresponding to the main sections of the interview guide. Second, we selected and coded the narratives, text elements and the quotes that seemed most relevant to specific research issues, devising categories on the spot to reflect the main content or message of the coded protocol segment (open coding). As important concepts and patterns emerged and our scope of analysis was narrowed, we went back to our sources for additional empirical data. We use quotes and narratives in order to let the voice of the interviewees come through more vividly and portray how they try to create favourable environmental conditions for their subordinates.

4. EXAMPLE 1: THE TEXAS CITY REFINERY EXPLOSION: A FAILURE TO CREATE FAVOURABLE CONDITIONS FOR SAFETY WORK

4.1 The explosion

The explosion at BP's Texas City refinery occurred on March 23 2005. The operators were filling a 170-foot distillation column at the isomerisation unit after a maintenance shutdown. They overfilled the column, and a mixture of liquid and gas flowed out of the gas line at the top of the column, travelled through emergency overflow piping, and was discharged from a tall vent (Hopkins, 2008). The geyser-like discharge built up a vapour-cloud at or near ground level, which was ignited by a vehicle that had been left in the area with its engine idling. The explosion killed 15 persons in and around mobile offices that had been located close to the explosion. In addition, 180 persons were injured (CSB, 2007).

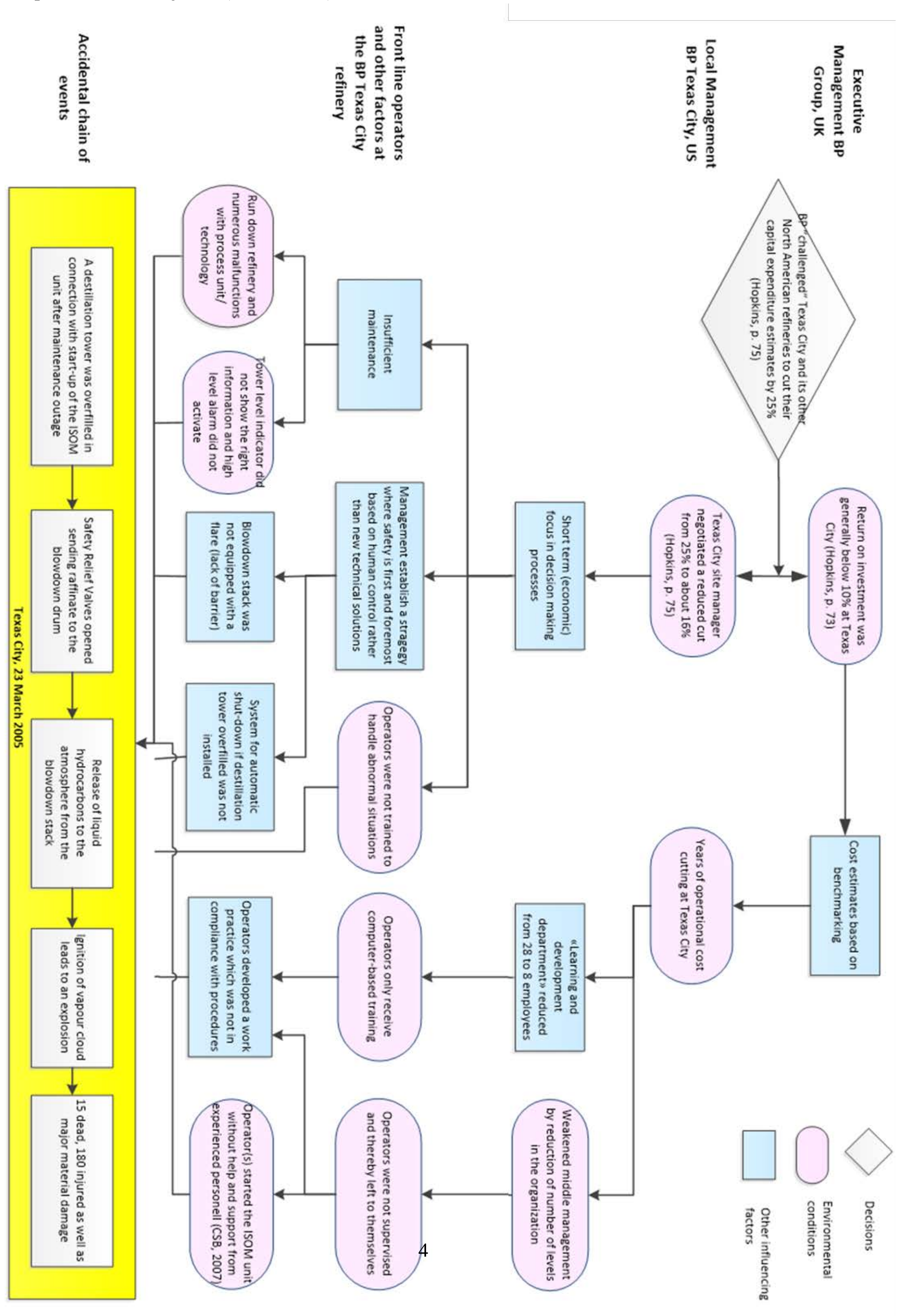

Figure 1. Decisions and conditions that contributed to the BP Texas City refinery explosion.

In this paper we shall analyse how cost reductions decided by BP senior management influenced the environmental conditions for the safety work of Texas refinery management, and how decisions made by the refinery management influenced the state of barriers and the environmental conditions for safety work for operators at the sharp end. The analysis is summarised in Figure 1. Environmental conditions are shown as rounded rectangles, decisions that influenced the environmental conditions of other actors are shown as diamonds, and other conditions that contributed to the accident are shown as rectangles.

4.2 Reduction of the Texas City investments budgets

According to Hopkins (2008: 73-75), BP senior management used *return on investment* as their main criterion for deciding on the Texas City investment budget. This was based on the idea that the capital should be spent where it gave best returns for the owners. According to an internal memo from 2003, Texas City was projected to consume 18 % of the capital available for all BP refineries, whereas it was projected to contribute only 15 % of the total profit from the refineries. Consequently, BP senior management "challenged" the Texas City management to reduce their investment budget for the following year (2004) by 25 %.

The Texas City refinery management decided to renegotiate this investment reduction, and succeeded in reducing the investment cut from 25 % to 16 %. In this way, they managed to improve the environmental conditions for their own safety work to some extent.

However, the 16 % investment cut came after several years of underinvestment at Texas City (Hopkins, 2008). The refinery was deteriorating due to inadequate maintenance. It appears plausible that the investment cuts motivated the policy of the refinery management to rely on operational controls rather than technical solutions to maintain safety:

In the face of increasing expectations and costly regulations, we are choosing to rely wherever possible on more people dependent and operational controls rather than preferentially opting for new hardware. This strategy [will place] greater demands on work processes and staff to operate within the shrinking margin for error.[1]

In accordance with this strategy, which was formally established in 2004, BP did not follow the recommendation from various authorities to install automatic shutdown devices to prevent overfilling of their distillation columns (Hopkins, 2008:16). Small investment budgets may also have contributed to the failure to install a flare system on the vent where the overflowing gas and liquid was discharged. Investment cuts may also have contributed to the failure to follow a recommendation from the British authorities to highlight on the control room displays imbalances between what was going into the columns and what was going out.

Investment cuts may also have motivated the failure of the Texas City refinery management to invest in training simulators for the process operators. BP thus missed this opportunity to improve the competence of the operators and put them in a better position to handle a plant with few technical barriers against major accidents.

As a consequence of insufficient investments, the process operators faced a deteriorated production system that lacked vital barrier functions such as automatic shutdown by overfilling of the distillation columns and flaring of discharges from the overflow vent. The level indicator of the distillation column only covered the range from four to nine feet, whereas the liquid level reached 158 feet prior to the explosion. Thus the operators had no way to know how much the column was overfilled. Prior to the explosion the level indicator indicated that the fluid level had gone *down* from about nine feet to about eight feet, whereas the real level was rising far above nine feet. A sight glass that would have allowed the operators to directly observe the liquid level had been useless for years due to build-up of residue.

4.3 Reduction of operating costs

BP senior management also "challenged" the North American refineries to cut their operating costs (CSB, 2007; Hopkins, 2008). In 1999, shortly after taking over the refinery from AMOCO, BP imposed a 25 % reduction in operating costs. In 2002 BP senior management urged the refineries to make new reductions of operating costs wherever possible, to defer training programs to the New Year, and to freeze all hiring of personnel.

The refinery management was in doubt about whether the 25 % cut in operating costs in 1999 were sustainable (Hopkins, 2008). They thought that the cuts would have to be compensated by budget increases during

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[1] BP internal ”Compliance Strategy document”, quoted from CSB (2007).

the following years. However, their understanding was that the cost cuts were not negotiable. They decided to reduce the number of employees by 15 %, to reduce the number of management levels, and to reduce the training of operators.

The reduction of management levels implied that the control span for the remaining middle managers increased and their capacity to follow up on operators and first line supervisors deteriorated. This made the refinery vulnerable to drift, i.e. to an accumulation of work practices that deviated from the procedures. It was, for instance, an established practice to fill the ISOM-unit to higher level than prescribed by the procedures during start-up. The reason was that liquid levels fluctuated wildly during start-up, and the operators feared that equipment in the unit could be damaged if the liquid level fell to zero. Such routine violations were not detected by management because they lacked the capacity to monitor the operations effectively. The violations might have been detected if BP had defined safe operating limits and installed a system that generated an automatic alert to management when the operating limits were exceeded. However, no safe operating limits had been defined for this operation.

Reduction of training costs was achieved by replacing classroom training of operators by computer-based training that emphasized memorising facts rather than development of problem solving competence (Hopkins, 2008:79-80). As a consequence of staff reductions, the staffing of the control room was insufficient according to BP's own analyses during start-up of the ISOM unit (CSB, 2007; Hopkins, 2008:22-23).

4.4 A failure to create favourable conditions for safety work

This analysis shows that the notion of "environmental conditions for safety work" allows us to pinpoint connections between the actions of BP senior management, the actions of local management at Texas City, operator practices, the state of refinery, and the event sequence leading to the explosion (Figure 1).

The analysis may be extended vertically by examining the conditions for safety work at the BP senior management level. It may also be extended horizontally by examining other conditions with relevance to the explosion, such as incentive systems and the absence of a strong central HSE (health, safety and environment) organisation (Rosness et al., 2011).

If we accept the idea that a failure to create favourable environmental conditions for safety work, then the natural next question is: How do managers and employees create favourable conditions for safety work? We shall address this issue in our second example.

5. EXAMPLE 2: ENSURING FAVOURABLE ENVIRONMENTAL CONDITIONS FOR WORKERS AT THE SHARP END

5.1 Time pressure related to downtime as a safety challenge

In this part the data stems from a case study in oil drilling on the Norwegian continental shelf. For offshore production licenses, an operator is appointed, who is responsible for the daily management of the petroleum activities on behalf of the licensees. Offshore drilling entails significant risks of accidents related to loss of well control (blowouts), fires and explosions, and injuries related to handling of heavy equipment.

Drilling may take place on an installation owned by the operator, or on a drilling rig that is hired by the operator. Although drilling is a core activity in the petroleum industry and an important part of operations, the work is extensively outsourced. Many routine activities related to drilling and maintenance of drilling equipment are performed by employees of a drilling contractor, whereas other tasks are outsourced to well service and other specialist contractors. On a hired rig, the drilling supervisor (also called "company man") may be the only operator representative, and even the drilling supervisor may be hired rather than permanently employed by the operator.

Due to the high cost of drilling operations, economic incentives are manifest in a detailed contract where the economic conditions are negotiated in advance. Every day and night during operation the hours are recorded and logged according to type of operation such as full rate, standby rate, repair rate, zero rate, rate for moving the rig, "contractor rate" (to be used if the contractor commits serious faults resulting in extra operations). In this way the contractor company is set under pressure when deviances occur (Osmundsen et al., 2006, 2008).

Our informants agreed that both operators and contractors consider downtime undesirable. Drilling contractors consider downtime a threat to their reputation even when the operator carries the cost of downtime.

The informants also said that a sense of time pressure during downtime can lead to a rush to get back to normal operations, sometimes accompanied by stress and violations of safety procedures:

This is a source – I do not claim it is the cause – but a source of people sometimes gambling with safety. You take shortcuts, not always deliberately, but unintentionally, because you do not want to inflict heavy losses on your employer. (Interviewee from the drilling contractor)

A tool pusher illustrated how challenging this task can be:

It is often very demanding to maintain your equipment and, at the same time, avoid standstills in the production. The operator wants the operation to keep running 24 hours a day, but then – to make a comparison: If you drive a car from Stavanger to Oslo and have a puncture, then you have to stop the car to do something about it. The operator wants you, to put it ironically, to change wheels while driving at full speed.

None of our informants denied or trivialised the potential tensions between safety and the desire to resume normal operations as quickly as possible. We were also told that this issue had received increased attention during the recent years:

When you go a few years back, then it was the case that when you had downtime, then there was an enormous pressure to get the machinery into motion and resume operations, and perhaps a little more of a notion internally that it was more OK to cut corners. … During the recent years I would say that there has emerged, by clients and suppliers … emerged an understanding by management on both sides that "OK, we have downtime, that is not to anybody's benefit, but everything is to be done safely and according to the procedure." The recognition has been much more entrenched that you take the time you need to do things safely. (Interviewee from the drilling contractor)

At the same time, several interviewees at different management levels were convinced that good HSE performance was essential for winning new contracts. One interviewee from the land organisation of the drilling contractor stated:

For us who negotiate contracts, HSE performance is more important than anybody realises. … We have to use a lot of resources to convey this down to the lowest level that HSE is inconceivably important for us who negotiate contracts.

The importance of good HSE performance might thus act as a counter-pressure against the rush to get back to operations during downtime.

5.2 Strategies to prevent downtime

Based on the recognition that nobody benefitted from downtime, and that perceived time pressure during downtime could lead to increased risk, operational managers mentioned two strategies to prevent downtime. The first strategy was to keep tasks on the critical path of the operation in reserve. They crew could then switch to such tasks if the planned operations had to stop. The total time to perform the drilling programme would thus not be influenced, and the halt in planned operations would not count as downtime. A drilling supervisor gave the following example:

It may, for instance, be a common job, what we call "picking pipes". When we get deliveries of drill pipes, then they are bundled on the pipe deck, and then we screw them together by threes and stack them in the derrick. When we get a delivery of drill pipes, we never pick up more pipes than we need then, for the next job, even if we are going to drill further down later in the operation. Then we can save this until we get trouble with something, or have to wait for some equipment, or something that breaks down. Then we can start picking pipes, and perhaps we have enough pipes to keep going for 24 hours without having downtime.

The second strategy was to keep the equipment in good condition through carefully planned preventive maintenance in order to prevent breakdown during operations. This required not only careful monitoring of the equipment, but also systematic utilisation of the time windows that occurred when maintenance could be carried out without conflicting with other operations. The two strategies are related, since time windows that occurred because the planned operations had to stop, could sometimes be used to perform necessary maintenance work.

These strategies actually eliminated the dilemma associated with downtime. The crews did not have to accept more downtime in order to take the time they needed to perform their work in a safe manner. However, these strategies did require an investment in foresight. The operational managers had to maintain an inventory of tasks that they could turn to if the operations had to stop, and they had to monitor the condition of the equipment carefully in order to exploit available timeslots for preventive maintenance work.

5.3 Measures to shield sharp end personnel from time pressure during downtime

It was not always possible to avoid downtime. Operational managers such as tool pushers, drillers and drilling supervisors were then caught in the dilemma between downtime and safety. In particular, they had to find ways to communicate about this dilemma with their subordinates. A drilling supervisor handled this by paying careful attention to the planning and safety analysis of tasks to get out of a downtime situation, but at the same time avoid being conspicuously present on the drill floor when the crew worked their way out of the downtime situation:

What I usually do is to go with the tool pusher and gather where the job is to be done, and then discuss the job and what is to be done, have a little talk about it before they start and make sure that the paperwork is in good order and that they follow the procedures, and just make it totally clear that there is no stress from our side. And then I think it is important not to hang over them all the time when they do the job, because that can often stress them even more, that we should rather let them do their job without interference, but of course keep an eye on it now and then to make sure that they follow their plan. There are people who hang over them all the time when they do such a job, but then people often end up getting more nervous, and then other things happen…

This drilling supervisor was concerned with compliance with procedures, but he considered this in a broader context, where the over all aim was to create environmental conditions that are conducive to safe work.

Another strategy for shielding sharp end personnel during downtime was to resolve discussions between operator and contractors about downtime and money issues in the onshore organization:

We have received clear and distinct instruction that if there is an issue concerning downtime and money issues, then nothing is handled offshore. That shall only be handled by management on land. (Interviewee from the well service contractor)

An interviewee from the onshore organisation of the drilling contractor emphasised the need for repeatedly communicating that nobody will experience negative reactions for taking the time they need to do the job in a safe manner. The drilling company did not communicate the specifics about rates during downtime to the organizational levels below the tool pusher. A driller thus commented:

We are not specifically informed about [rates during downtime and repair], but it is in that connection that I hear talk about the contract. With regard to if there is much downtime during one month, for instance, and such matters. But I think they are rather good at it. They try not to stress us for that reason. It is clearly dependent on the person, on who is on the rig just then. The biggest problem is perhaps self-imposed stress.

This comment shows that the driller was aware of the intention of the company to avoid stress during downtime, and he was also aware of the challenges of communicating about this dilemma. Several informants noted that operational managers differed in their ability to shield their subordinates from time pressure during downtime.

6. DISCUSSION

6.1 How do operational managers act to create environmental conditions that influence their subordinates towards selecting a thorough course of action?

The proposal (or myth) that "compliance to rules ensures safety" suggests that the safety work of operational managers is restricted to ensuring that they and their subordinates follow the safety rules. The results of the present study show that the safety work of operational managers is more complex. They make significant efforts to create favourable environmental conditions for safety work for their subordinates, or to reduce the impact of potentially adverse environmental conditions.

Example 2 highlights two important aspects of the work that operational managers do to create favourable conditions for safety work for their subordinates and themselves. The first aspect, which we may label *preventing dilemmas through foresight*, involves not only the task of envisioning what problems may occur. It also involves maintaining a repertoire of responses that can be put in action if a problem occurs. Foresight implies that operational managers need to maintain a longer time perspective than the common "fire-fighting" metaphor suggest. Staying within the fire-fighting metaphor, we may say that operational managers work on anticipating where the next fire will occur, prevent it from occurring, and making preparations for handling the next fire, all while fighting the fires that are currently burning.

The other aspect of the work that operational managers do to create favourable conditions for safety work concerns *resolution of dilemmas*. This occurs each time the organisation faces tensions between the need to work safely and competing demands such as completing a job within schedule, minimising downtime or reducing costs (Hollnagel, 2004, 2009; Rosness, 2009). The resolution of dilemmas involves much more than just choosing between two given options. Dilemmas have to be recognised as such. This is not trivial, because many dilemmas are resolved tacitly, by following established practice or carrying on according to the normal procedure or the logic of the task. By recognising a dilemma, the operational manager takes on responsibility to make a choice, gain the necessary commitment from the people that are to implement the choice and possibly from his or her superiors, follow up through its implementation, and be prepared to defend the choice irrespective of its consequences. The resolution of dilemmas is also part of a long term process of establishing norms through words and actions.

This discussion does not present a comprehensive overview of the safety work performed by operational managers. However, it is sufficient to challenge the myth that "compliance to rules ensures safety". It should also help us recognise the scope and complexity of the safety work performed by operational managers.

6.2 How do environmental conditions for safety work created by senior management influence the safety work of lower level managers and operators at the sharp end?

The analysis of the explosion at Texas City illustrates and substantiates the complementary argument, that adverse environmental conditions for safety work can be detrimental to safety. Adverse environmental conditions for safety work created by BP senior management cascaded down the organizational levels and towards the sharp end of operations, going through significant transformations at the level of the refinery management. At this point, budget cuts were translated into organizational change, reduced maintenance, and reduced training of operators and reliance on operational rather than technical barriers against major accidents. This analysis does not introduce any new facts beyond those already reported in the literature on the Texas City explosion, but it highlights processes by which senior management decisions may contribute to an accident.

The analysis of Texas City also hints at the significance of power games in the relations between "senders" and "receivers" (LeCoze 2008). On one occasion, the Texas City refinery management was able to renegotiate a budget reduction, whereas on another occasion, they did not believe that the budget reduction could be renegotiated. Hopkins (2008) provides several examples of how BP executive management and the Texas City refinery management used rhetorical devises to avert resistance against their cost reductions. Conversely, Skarholt et al. (2011) provide examples of how safety representatives on a Norwegian oil production installation used rhetorical devices and other power tactics to promote their initiatives to resolve safety problems.

6.3 What can be gained by studying environmental conditions for safety work?

Based on the analyses in this paper, we propose that safety work and safety research may be enriched in several ways be considering environmental conditions for safety work:

1. The concept provides a conceptual tool for exploring and understanding *how senior management decisions at the blunt end of organisations may indirectly influence safety* by influencing the environmental conditions for safety work at lower levels of the organisation. This was illustrated by the analysis of the explosion at Texas City. Such knowledge is necessary for senior managers to act in a responsible manner, and for making senior management accountable for the consequences of their decisions for safety.

2. The concept allows us to build a *richer understanding of the safety work of operational managers*, i.e. of what they do or can do to promote safety. The efforts of operational managers to create favourable conditions for safety work goes beyond the idea that "compliance to rules ensures safety". It also transcends the direct implications of conventional control loop models of safety management.

3. The concept can be used to *explore the production of negative as well as positive outcomes*, i.e., accidents as well as accident-free performance, as illustrated by the two cases presented in this study.

4. The concept can be used both *retrospectively*, to accounting for events in the past, as illustrated by Example 1. It can also be used *proactively*, to identify conditions that contribute to or help to prevent future accidents, as illustrated by Example 2.

5. In the context of accident analysis, *an exploration of environmental conditions facing the actors can help us understand their actions and help us avoid scapegoating*. This is not only a matter of being fair to the actors involved in the accident. By making their actions more intelligible, we are less likely to dismiss an accident as

the result of negligent or irresponsible behaviour and more likely to recognise the potential that other persons could act in a similar manner when facing a similar situation.

6. The "sender" and "receiver"-metaphor highlights the importance of the *interaction between actors* at different management levels and between designers and users, planners and "doers" etc. It thus helps us overcome the common bias towards considering individual actors in isolation when investigating accidents and planning measures to promote safety.

6.4 Implications for practical safety work

The results of the present study have several implications for safety work and safety management:

1. Senior executives need to explore how their decisions influence the environmental conditions for safety work at lower levels in the organisation.

2. This perspective points to the need for creating open and balanced dialogues between "senders" and "receivers" of environmental conditions for safety work. This also implies a need to consider what environmental conditions promote or restrain such a dialogue.

3. Accident and incident investigators should strive to identify the environmental conditions that of actors involved in accidents or to successful recoveries, and, if feasible, explore how these conditions were created and maintained.

4. Organisations should pay attention to practices that create favourable conditions for safety work and promote specific practices as well as the rationales that support such practices.

5. Organisations need to ensure that operational managers are provided with environmental conditions that enable them to ensure favourable environmental conditions for the safety work of their subordinates. This implies that operational managers should have the time to practice foresight and the necessary backing for resolving dilemmas in a manner that promotes safety, even when this comes at the cost of inferior performance on other parameters such as production, compliance with deadlines or economic results.

6.5 Methodological strengths and limitations of the present study

Due to the complementarity of the two cases, the present study demonstrates the relevance of the concept of "environmental conditions for safety work" both in accounting for an accident and in characterising efforts to prevent accidents.

For reasons of space, the analysis of the explosion at Texas City is confined to the impacts of BP senior management decisions to cut costs. This analysis can be extended to other decisions and environmental factors, as shown by Rosness et al. (2011).

The results in Example 2, concerning how operational managers act to prevent negative impacts of reduced rates during downtime, may reflect conditions that are specific to the Norwegian petroleum industry. It is therefore of interest to explore how similar tensions are handled in other industries and in other national and organizational cultures. Such studies may even provide opportunities for experience transfer and learning between cultures and industries.

7. CONCLUSIONS

We conclude that operational managers in the Norwegian petroleum industry build safety by creating favourable environmental conditions for safety work. Further research is needed to determine to what extent this finding can be generalised to other industries and other national cultures. A failure of senior management to provide adequate environmental conditions for the safety work of operational managers may indirectly contribute to accidents. Safety is not ensured by a single means, such as compliance to rules. The creation of favourable environmental conditions for safety work is an essential part of a more complex account of safety. Our data material illustrates the dilemmas and complexities in creating, sustaining and improving safety. It is our hope that these examples and our analysis can serve as food for thought in developing more nuanced frameworks for safety and more safe work practices.

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