Improvements in incident reporting and investigation from developing a task inventory

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Introduction

Reporting and investigating incidents can help prevent their recurrence, but overall safety can only be improved if a more widespread view is taken involving the identification and removal of root causes. The trouble is that whilst active failures, especially human errors, tend to be fairly obvious, the root causes, which are usually a direct result of management failures, are far more difficult to recognise. An incident investigation needs to fully assess the whole situation surrounding the incident. A lot of important factors may not easily be identified during the investigation because they may have occurred outside the duration of the incident or at some remote location.

As an aid to investigating incidents a *task inventory* is proposed. This focuses on what actually happens on the plant in question and how failures can either introduce latent failures or be active failures. Emphasis is placed on how the people who work on the plant influence safety, both positively and negatively. Over time the inventory will be developed so that it describes how the systems operate, the types of errors people actually make and the conditions, and other factors, that affect reliability and performance.

We aim to show that developing a *task inventory* can improve incident investigation and reporting, and will ultimately be an invaluable and unique source of information for use in all reliability, safety and quality studies.

Incident model

To be able to prevent accidents we need to understand why they happen and a simple model is useful. Figure 1 aims to show that incidents rarely have a single cause but are usually the result of multiple failures that occur because of management failures[1]. These failures mean that each component in the operating system does not interact in a way that guarantees safety (underlying conditions), unwanted events are able to occur (incident causes) and if this results in an un-safe condition due to the system design (inherent safety) an incident is the likely consequence.

The system characteristics mean that the control programme allows latent failures into the system and if hazards are present the possible consequences include injury, damage to equipment and the environment or loss of production.

Everybody makes errors regardless of their skill or experience[2], however management should control conditions to ensure errors are less likely[3]; active failures trigger latent failures and, where there is no opportunity for recovery, an incident will result.

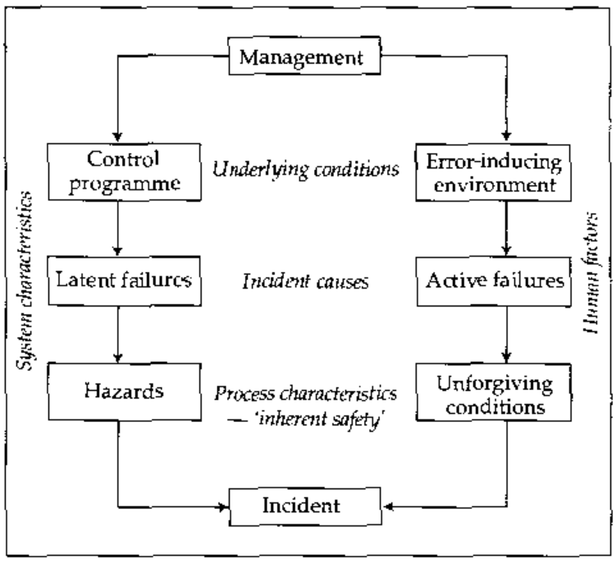

FIGURE 1: AN ACCIDENT CAUSATION MODEL

Task inventory

We propose a *task inventory* can be used as a source of data, detailing what actually happens on a plant, for use during incident investigation and reporting, along with other safety studies. Initially the plant is divided into its individual units, each with a specific objective. The way the objectives are met is described according to the characteristics of the unit's design and operation, the operator's activities, any hazardous materials or conditions and the possibilities for interaction with them. This is shown diagramatically in Figure 2

The content of the inventory is collected from plant documents such as work schedules, procedures, training manuals and handbooks but it is very important that the information recorded describes what actually happens on each unit, rather than what is supposed to, or is expected to, happen. This means that it should be reviewed with the people who actually work on each unit and that tasks should be observed where possible. At this stage, however, an obsession with total accuracy is unnecessary as the inventory is to evolve over time as information becomes available from actual operating experience.

Incident outcome

The *task inventory* is analyzed to predict the outcome of incidents based on how the control of hazards and processes can be lost or where unit objectives are not achieved, as shown in Figure 3. The aim is to highlight an outcome that may not be entirely obvious and to allow analysis of incidents to show where the event differs from what is expected. This analysis will result in a series of questions that must be answered should an incident occur.

Improved incident reporting system

The purpose of developing a *task inventory* is to ensure that an incident report results in an overall improvement in safety, rather than preventing that one particular incident from recurring in the future. This is achieved by having a reliable source of information about how the plant actually operates with a focus on how people contribute, both positively and negatively, towards safety and what factors, especially management, affect their performance.

In the event of an incident the inventory is used as a source of information whilst performing the investigation. Once the incident report is complete the findings are compared with the *task inventory*. Any discrepancies suggest that either the investigation is incomplete or the *task inventory* does represent the true situation. The aim is that, over time, investigations will improve and the inventory will become a very useful source of information because of its thorough and accurate summary of what actually happens on the plant.

Case study

A simple study was performed on the water injection unit of a North Sea oil production platform. The details below were collected during a visit to the platform; from training manuals, daily logs and reading sheets and written procedures, and backed up by observation and discussion with the unit operator at the time.

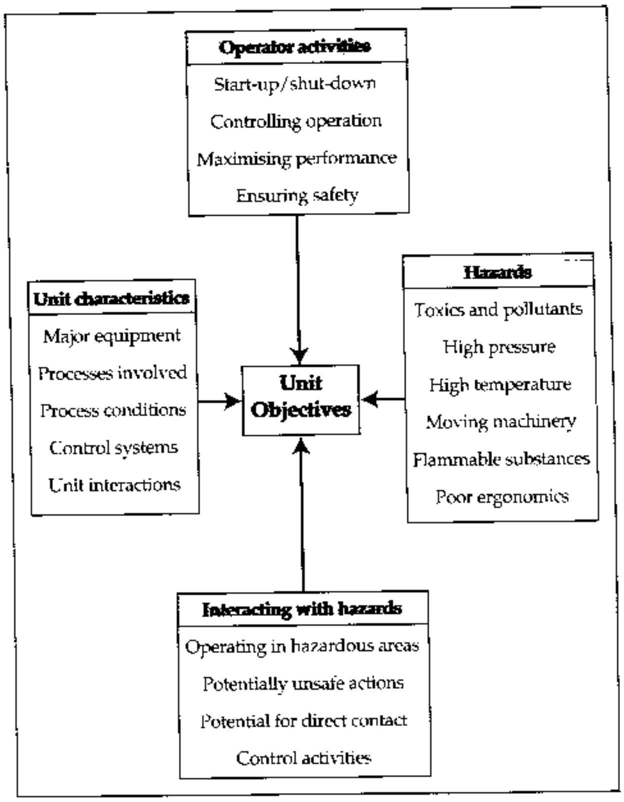

FIGURE 2: FACTORS AFFECTING EACH UNIT'S OBJECTIVES

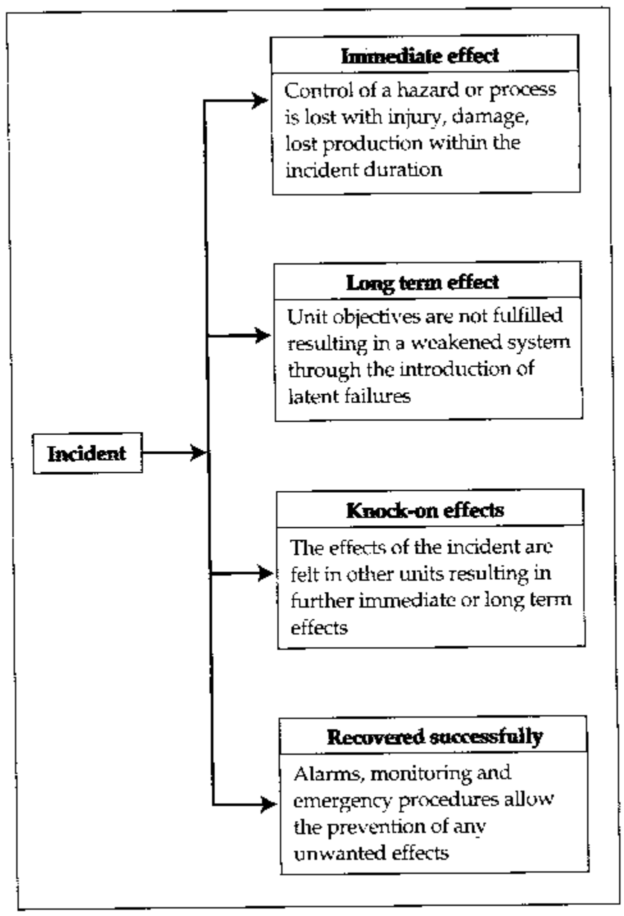

FIGURE 3: POSSIBLE EFFECTS OF AN INCIDENT

Unit objectives

The basic objective of the unit is to 'provide very clean water at the required pressure and rate' to each of the injection wells along with contributing to the overall platform objective which is 'safe, efficient and profitable oil and gas recovery.'

Unit characteristics

Source water pumps draw water from the sea which is injected, via injection wells, into the oil reservoir. As water is more dense than the oil, it occupies the bottom of the reservoir filling the void left by the removed oil whilst also forcing the remaining oil towards the surface to allow its recovery. The system, shown in Figure 4, is essential for good oil production.

Sea water has a number of properties that are undesirable for injection into the oil reservoir and so it has to pass through a number of treatment stages.

Bacteria in the water can cause severe corrosion and fouling problems and so the water is first treated with chemicals to destroy the bacteria. The temperature then has to be raised by passing it through the coolers of pumps, compressors and other units. Filters are used, aided by coagulant chemicals, to remove suspended solids which can block rock pores in the reservoir. Dissolved oxygen must be removed as it causes the water to be highly corrosive. This is achieved by injecting oxygen scavenging chemicals and passing the water through deaeration towers held under vacuum. Booster and injection pumps are used to take the water to the required pressure. In addition to the stages mentioned, the conditions on the unit have to be controlled so that they do not allow scale to form. This generally means the water temperature should not exceed 40°C, but on occasions scale inhibiting chemicals are added.

Operator activities

Performance of the unit is ensured by controlling the equipment to maintain the required conditions and through monitoring the water quality. Not all the injection wells are generally used at any one time and the operator has to select a combination that will maximise performance according to the water pressure and flow-rate available. Filter backwash timings are set according to the condition of the source water. The injection pump recycle is controlled, chemical tanks are restocked and changed over, and chemical dosing rates have to be set according to source water quality and unit performance. Less routine tasks include changing items of equipment in and out of service and isolating them for maintenance, cleaning chemical filters and sand washing injection wells. The general condition of the unit is monitored by the operators

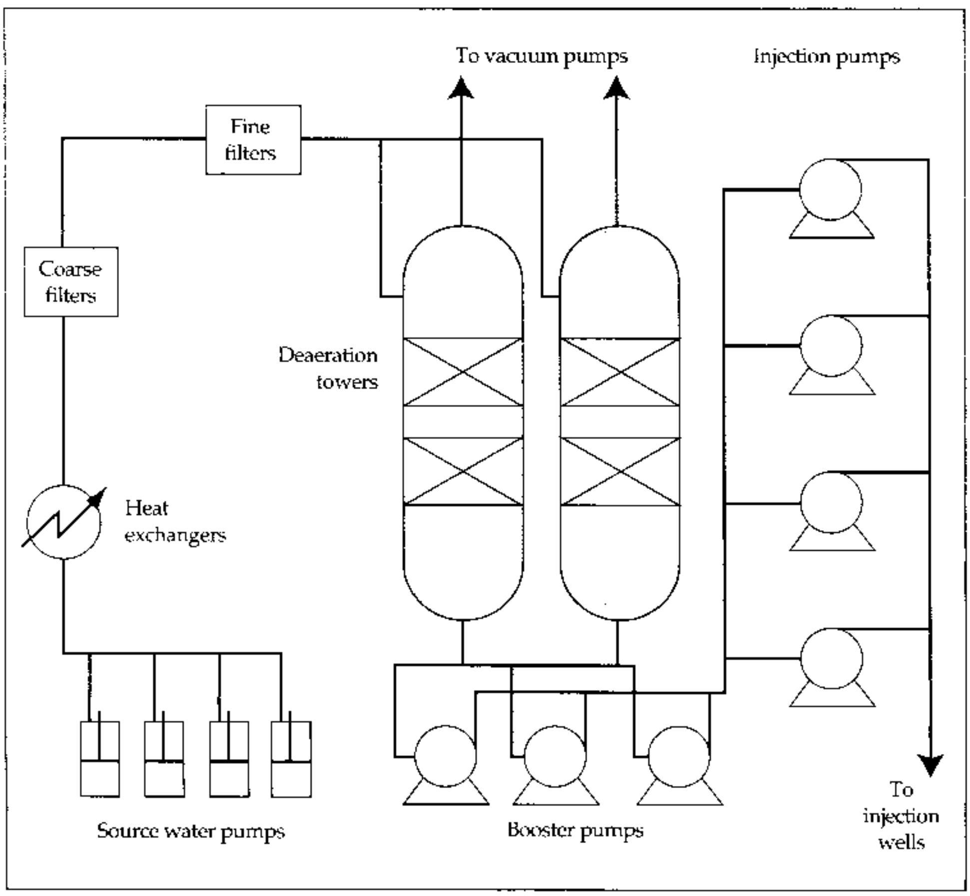

FIGURE 4: THE WATER INJECTION SYSTEM

who spend a lot of their time on the unit and complete readings and status sheets at regular intervals during each shift.

Hazards present

The unit is regarded as relatively safe compared to other units on the platform because it handles relatively non-hazardous sea water. The above description, however, has uncovered a number of hazards present including chemicals that are toxic and polluting, very high pressure water, near total vacuum and a lot of moving machinery. In addition there is a large number of tripping hazards and areas which are difficult to access, high noise levels, exposure to adverse weather and, if flammable hydrocarbons escape, explosive atmospheres can be formed in parts of the unit.

Interaction with hazards

The platform in question is of quite an old design and so most of the equipment is operated locally. This means operators often have to enter high risk areas. A lot of the tasks also involve climbing and entering areas with poor access. Some tasks involve handling chemicals and the operator is required to wear appropriate protective clothing because of the possibility of direct contact. Isolation of moving equipment is required to ensure that equipment can not be started when maintenance work is being carried out.

Incident outcomes

By considering the hazards present and the types of tasks performed by the operators we can determine the types of incidents that may occur.

Likely immediate incidents include:

- the injury of people working on the unit if required equipment isolations are incomplete, if equipment held under high pressure or vacuum fails whilst people are in the area;
- if chemicals are splashed onto the skin; or
- vapours are inhaled.

Oil production can be affected by errors made in selecting injection wells, or may be lost altogether if the plant is shut-down because of a loss of water injection capacity.

The long term effects result because the unit objectives are not met. This can result in increased corrosion due to poor control of dissolved oxygen and bacteria, or fouling problems due to bacteria or scale deposits. These situations increase the chance of equipment failure and add to the maintenance workload, which is likely to involve greater risks than during normal, steady operation. Suspended solids injected into the reservoir will block the rocks pores which can seriously effect production over time and requires chemical treatment or explosive fracture to rectify.

The unit does not operate in total isolation hence knock-on effects are likely. The source water is used to cool pumps and compressors on other units and so any loss of water will effect other units. The source water pump suction is in the sea below the platform where divers may be working and their lives are at risk if the wrong pump is started due to incomplete isolation or poor communications. The platform is on a number of levels hence spilt chemicals, oil or hot fluids can affect people or equipment below.

Recovery from certain incidents is possible. Alarms warn that process conditions are unusual, equipment such as pumps and compressors will shut down automatically if conditions deviate significantly and the operators job involves a lot of general, routine monitoring of the conditions on the unit.

Incident investigation and reporting

Compiling the task analysis has resulted in a clear statement of the unit objectives and identified the main components of the system including major items of equipment, hazards present and tasks performed. It is based on what actually happens on the platform. This required a review of the unit's documentation backed up by discussions with the operators and observing them at work. Analysis of this data has suggested a number of possible incident outcomes that should be considered in the event of an incident. A number of questions are listed below that should be asked during any incident investigation and the answers should be included in the report so that they can be compared with the details included in the *task inventory*. Any discrepancies suggest that either the investigation is incomplete or the *task inventory* requires updating.

- Which of the unit's objectives were not met during the incident and did this affect the platform's performance?
- At which item of equipment or area of the unit did the incident initiate and how were other areas or units affected?
- Which of the chemicals or hazardous conditions mentioned were present during the incident, and was their control lost?
- Did the incident increase the probability of corrosion, rock pore blockage, scaling or fouling?
- Which of the tasks, from the inventory, were being performed before and during the incident?
- Were all the routine checks performed before the incident and do they indicate any abnormal conditions?
- Were any errors made before or during the incident and were they caused by access or tripping hazards, high noise levels or adverse weather conditions?
- Did the incident occur in a high risk area of the unit?
- Did the alarm and shut down devices function as required?

- Did any of the observed abnormal conditions cause problems before or during the incident?

Conclusion

The aim of this study has been to show how safety can be improved through more effective incident reporting systems. Based on a simple incident model, highlighting the fact that system characteristics and human factors are directly influenced by the quality of plant management, a *task inventory* is developed identifying the critical elements of the system, including human activities and hazards. The information recorded in the inventory is analyzed to predict possible system failures which may introduce latent failures or events that act as active failures.

The advantages of such an approach is that it is focused on what actually happens during all operations on the plant. The information collected is used to suggest how incidents occur, the likely consequences and how the effects can spread. A set of critical elements for each unit are highlighted. These must be considered when investigating incidents, and a list of questions are developed that must be answered when reporting those incidents.

Such a *task inventory* is simple to perform, using plant documentation backed up by brief discussion and observation on site, but can provide a valuable source of information to be used during any studies of the plant. Combining it with the incident reporting system ensures that it is kept up to date and accurate.

References

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