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Key lessons from incidents relating to creeping changes

Introduction

Creeping changes are the accumulation of minor changes which often are ignored or accepted as the new norm, but which over time can add up to a big change and ultimately lead to a major incident. Most incidents result from a migration toward states of higher risk (Leveson, N). The well-known phenomenon, "normalization of deviance" fits into with this category too, with accepting deviations from the norm. The theory behind creeping changes is that that no industrial sites are static, there are changes made to the original design or there are changes due to ageing and degradation of equipment over time, together with organizational changes that can affect plant integrity.

Case – Oil refinery – FCCU

The Fluidised Catalytic Cracker Unit (FCCU) was shut down on the 29th May 2000 following the power distribution failure and was being restarted after an 11-day shutdown. On 10th June 2000 during start-up a significant leak of hydrocarbons was discovered, creating a vapour cloud which ignited resulting in a serious fire. Workers escaped before the blast, nobody got injured in the incident.

Key learning points

The leak was as a result of failure of a tee-piece connection at the base of the debutaniser column which found a source of ignition nearby. The tee-piece connection which had originally been installed in the 1950's was correctly specified but incorrectly fitted, and then hidden by lagging. There was no subsequent amendment to the plant layout drawings to identify that change.

Since the 1950's, sections of the FCCU had been significantly modified. Prior to the modifications in 1986, changes had been made to the pipework at the base of the column and a valve had been removed. This resulted in there being inadequate support for the remaining pipework and the tee-piece connection. Between 1996 and 1998 the FCCU had been experiencing considerable difficulties and did not operate consistently. This resulted in an increase in the number of start-up/shutdown cycles for the plant and pipework. An incident occurred in 1999 during a prolonged start-up on the FCCU. It resulted in an ignition of a torch oil vapour cloud. Contrary to plant operating instructions in the master operating manual, the torch oil had been admitted to the regenerator when the unit was at too low a temperature. As a result, ignition of the torch oil did not occur in the regenerator. Although ignition had not been verified, a considerable further quantity of torch oil was injected, and it is believed that hot spots in the slumped catalyst bed vapourised the torch oil. The provision of a temperature interlock had previously been considered and discounted, as it was decided that operating procedures alone provided enough control.

In the 11 weeks preceding the incident in 2000, 19 start-up attempts had been made and only 7 were successful. Failure of the tee-piece connection pipework was probably caused by a combination of the incorrectly fitted tee-piece connection, the inadequately supported pipework and the cyclic stresses/vibration caused by the increased number of start-up/shutdown activities on the plant. Eventually these led to fatigue failure of the pipework in the vicinity of the welded connection. The company reviewed the FCCU to find out why it did not operate properly but the findings were never implemented or communicated properly.

The safety report failed to reflect the reality of the condition of the FCCU. The 1997/98 revision concluded that "hardware and software controls in place on the FCCU are adequate to prevent the occurrence of a major accident". Incidents with vibration of the transfer line had occurred over the two years prior to the explosion. These events were not reported or investigated. There were two incidents preceded the blast on 10th June, a power distribution failure on 29th May 2000 and the medium pressure steam main rupture on 7th June 2000. Construction of a new facility had started in early 2000. The company hired a sub-contractor for the underground works and the sub-contractor sub-contracted the actual excavation work to an excavation contractor. The company also engaged a main electrical sub-contractor for the electrical and instrumentation work to be carried out. The electrical subcontractor further contracted the laying of the cable in the excavated trench to a cable-laying contractor. The schedule for the excavation and cable laying was very complicated and supervision of the excavation work was limited.

On the 25th May a cable-laying operative from the cable-laying contractor observed a damaged tile and cable in preparation for laying a cable but he did not report the damaged cable in the belief that it was dead and it had already been reported. Before that, on 20th April an excavation contractor had been found using a clayspade to the trench at a depth greater than the instructions from the toolbox talks. The earth fault was caused by physical damage to the cable from a clayspade.

This case is not a standalone event related to creeping changes. For example, the 2006 Royal Air Force Nimrod crash, Texas City refinery explosion, Buncefield, Shell Moerdijk, the Columbia space shuttle disaster, Bhopal or the Herald of Free Enterprise are cases similar in nature.

The ISC believes that leadership across six key functional elements is vital to achieve good process safety outcomes. These elements are:

- systems & procedures
- engineering & design
- assurance
- knowledge & competence
- human factors
- culture

In the *What can I do* section below you can see how each of these elements plays a part.

Figure 1: The ISC Framework

What can I do?

Management

- Be aware that changes in management or ownership can have large consequential hazards, therefore make sure that organisational changes go through a Management of Change (MoC) procedure.
- Incidents often occur after some change in the system. Make sure that changes as a result of adoption of new or altered processes, loss of skills and new knowledge brought into the operation are addressed in the MoC process.
- Ensure that audits address changing behaviour to check that the process is carried out as designed.
- Every system and its environment change over time. Make sure to apply strategies to adapt to changing environment, changing in the safety management system.
- Have the safety case or safety report kept as a living document that needs constant review to follow up the changes might occur over the years.
- There can be significant difference between the designed and the built system. If an incident scenario is not considered in the design phase but that scenario is possible, then it needs to be incorporated into the leading metrics programme.
- Signs of change are difficult to detect, therefore consider implementing a system and structured process for identifying them, detecting how the process should operate and what the current status is.
- Make sure that leading metrics are implemented in the risk management programme and responsibilities are assigned for checking the metrics and following them up in case problems are found.
- Have an action plan in place to ensure that leading metrics exist and they indicate when and how they will be checked and have an action associated with them. Periodically review and update the list of leading metrics.
- Make sure that near miss events are identified and investigated as they can be precursors of a major incident. Pay attention to cumulative causes that help to identify dramatic changes that may have been overlooked.
- Ensure that change is detected and even small changes to the system are documented in the incident investigation reports instead of simply focusing on proximal events.
- In case of an incident, check if leading metrics are in place and why they failed to identify the problem to prevent the incident, or, if they did, why effective action was not taken.
- Make sure that cost cuts do not impact safety and they do not threaten plant integrity.
- Make sure that process knowledge is maintained and transferred.

Process Engineer/Supervisor

- Make sure you record trending of the leading metrics, ensure that the process functions as it is intended based on the original design.
- Ensure that you document all changes, particularly safety critical ones and near misses immediately and these records are incorporated in the plant operating procedures.
- Starting up a process unit results in significant changes (operating temperature, pressure) on the pipework and vessels as they are brought up to the required operating conditions from ambient. Be aware that increasing the frequency of start-ups results in fluctuations in conditions and increased cyclic stresses on mechanical systems.
- Pay attention to the signs of normalisation of deviance where operators might alter from the original procedures, to make sure that safe operation is in place.
- Have up-to-date plant layout drawings and maps to follow up changes and keep record of the original design layouts.
- Report and investigate all cases of violations, unauthorised changes and workarounds in the system.

Operator

- Make sure that you follow the operating, maintenance and emergency procedures and do not deviate from them.
- Report any damage or irregular event immediately to the supervisor.
- If the procedures cannot be followed, report the situation to your supervisor for investigation and resolution.

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