ISC Safety Lore

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Issue 1

Key lessons from incidents during startup operations

Introduction

Start-ups are non-routine, transient and sometimes be quite cumbersome operations; these periods require intense activity and attention from the operators. Starting up a process unit results in significant changes (operating temperature and pressure etc.) on the system as it brings the pipework and vessels up to the required operating conditions from ambient. Under such recurring extreme conditions pipework and different safety instruments can experience fatigue or other deterioration. These can develop as a result of the rapidly changing parameters (pressure, temperature) during start-up. These mechanical failures coupled with the lack of routine, competency and inadequate training can lead to major incidents.

Case 1 – Petrochemical plant

Mid way during a night shift while personnel were performing post-maintenance heat exchanger restart operations, a heat exchanger on an adjacent bank catastrophically ruptured. Employees were in the final stages of a startup activity to put three (A/B/C) heat exchangers back in service following cleaning. The adjacent three (D/E/F) heat exchangers remained in service during this operation. While the operations staff was performing the startup operations, the E heat exchanger in the middle of the operating D/E/F bank catastrophically ruptured. The rupture of the E heat exchanger was the result of the carbon steel exchanger being severely weakened by a damage mechanism known as High Temperature Hydrogen Attack (HTHA). As a consequence of the explosion seven employees were fatally injured.

Key learning points

The start-up of heat exchangers within the unit was a hazardous, non-routine operation. The unit had a long history of flange leaks and occasional fires during start-up in the past that were never investigated. They had just used steam to mitigate leaks, rather than address heat exchanger design issues. Their start-ups commonly required additional staffing to manage issues, resulting in more personnel on site than under routine operations. The company's lax safety culture led to a "complacent" attitude towards flammable leaks and occasional fires; the workers knew about the problems at start-up but it became the new "normal". The Process Hazard Analysis of this activity did not provide effective preventive methods to eliminate the hazards. The investigation revealed that the effectiveness of safeguards to prevent HTHA was neither evaluated nor documented in the process hazard analysis study. The consequence was also increased due to the additional staff on site when the incident occurred.

Case 2 – Ammonia plant

During a summer day a violent storm hit an ammonia production plant. The thunderstorm caused the failure of the external power supply and trip of the plant at 15:20. After safely isolating the affected unit, operators prepared the start-up during the night shift. First steam had to be imported to be able to start the primary furnace the following day. However, at 00:55 the top fired reformer blew up. The procedure required many valves to be in the closed position and for these to be verified. The shift leader, however, did not ask the workers to check the valves because he was convinced that the valves were closed following his site walkaround. Even though the display in the control room showed that the valves were open, he insisted that the reading was wrong and continued the start-up. With that, he opened the natural gas supply valve, resulting in triggering a series of alarms and a minute later, the explosion occurred. The explosion injured two workers and destroyed the steam reformer.

Key learning points

The shift leader was convinced that the valves were closed and that was never double checked. To confirm that all safety critical equipment are in the correct position prior to start-up is a crucial step. It should be included in the operating procedures and those procedures should always be followed. There was no redundant system in place to prevent operators from introducing natural gas in the process while the valves were open. The investigation revealed that no log book entry indicated the positions of the valves and any readings from the display. The start-up procedure was used sometimes as a check list but no signature or approval was requested. It was, however, not used this time to check the valves for the arch burners. Lack of training and competence were also factors that could contributed to the accident. Start-ups are rare, and as such, regular refresher training is necessary. In case of emergency shutdown, a risk assessment should be undertaken to understand any changes or issues prior to starting up. This may include a formal Management of Change.

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

- Make sure that procedures are clear and that they are always followed by personnel.
- Identify the hazards associated with the procedure and check that safeguards are available and adequate. Make sure that start-ups are considered in sufficient detail during PHA/HAZOP reviews.
- In case of experiencing anomalies during start-up, immediately investigate what happened instead of normalizing such hazardous situations.
- Use inherently safer design where possible to control the damage mechanisms rather than inspection strategies.
- If you work in the petrochemical industry, for more information about turnaround activities see the IChemE BP Process Safety Series "Safe Ups and Downs for Process Units" available at http://www.icheme.org/bp-safety.

Process Engineer/Supervisor

- Make sure that start-up operating procedures are up-to-date and adequate. They should be in checklist format and signed off at each step. Such procedures should cover all possible operating modes.
- Prior to start-up make sure that all critical safety devices are in the right position (valves closed or open depending on the procedure).
- Make sure that adequate staffing and competence are available before starting up.
- At shift change, talk through the procedure with the team and check the upcoming steps. Ensure the status is recorded in the log book and check it before shift change.
- Communicate to all personnel, including contract workers in the vicinity of the process unit about start-up and evacuate the affected areas during critical steps.
- A number of the losses relate to poor control of work during the shutdown maintenance period but this is somewhat out of the hands of the operations team once it has been handed back. A pre-start-up safety review should be completed (see www.marsh.com)
- Start-ups are rare operations, therefore plan refresher training for personnel; best carried out just before start-up.
- In case of emergency shutdown or before modifying the start-up procedures, complete a Management of Change review.
- Report and investigate incidents and near-misses which are clear indicators of future occurrence of hazardous events.
- Alarm management should be in place for start-up operation, too.
- Process control instrumentation should be carefully designed to be able to function in non-steady state operations when it is necessary to bypass safety critical instrumentation to enable start-up.

Operator

- If you are unsure about what is written in the start-up procedure, ask your supervisor.
- Check that no foreign particles are left in the system that can block pipes or cause vibration in compressors.
- Always follow the start-up procedure using it as a check list to cover each step in the right order.

The information included is given in good faith but without any liability on the part of the IChemE or the IChemE Safety Centre.
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