ISC Safety Lore

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Key lessons from incidents involving flare systems

Introduction

The flare collects a range of gaseous emission and pipes them to a flare stack where the harmful gases are burnt and then the exhaust is safely discharged to the atmosphere. The flare is a last line of defense in the safe emergency release system in a refinery or chemical plant. It is used to dispose of purged and wasted products from refineries, unrecoverable gases emerging with oil from oil wells, vented gases from blast furnaces, unused gases from coke ovens, and gaseous water from chemical industries.

Case 1 – Oil refinery – power cut

A series of severe electrical storms caused refinery wide unit shutdowns, including the fluidised catalytic cracking unit (FCCU). The crude distillation unit was shut down as a result of a fire, which had been started by a lightning strike. A process upset in the FCCU's gas recovery section ultimately led to a high liquid level in the flare drum and several shutdowns of the wet gas compressor, together with other process anomalies. As a result of the wet gas compressor shutdown, there was a large vapor load on the FCC flare system, which led to a high liquid level in the flare drum. When the hydrocarbon liquid overflowed into the outlet line of this drum, the line ruptured due to mechanical shock and approximately 20 tonnes of flammable hydrocarbons escaped. This mixture found a source of ignition 110 m from the flare drum and subsequently exploded. This caused a major hydrocarbon fire at the flare drum outlet itself and a number of secondary fires.

Key learning points

The explosion was caused by flammable hydrocarbon liquid being continuously pumped into a process vessel that, due to a valve malfunction, had its outlet closed. The only means of escape for this hydrocarbon once the vessel was full was through the pressure relief system and then to the flare line. The flare system was not designed to cope with this excursion from normal operation and due to liquid breakthrough at the FCCU flare knock out drum, a failure occurred in the outlet pipe. The investigation revealed, that internal acidic corrosion also contributed to the pipeline rupture. Apparently, the company did not inspect the weakest points of the pipeline which were exposed to corrosion.

Case 2 – Crude oil distillation

In a crude oil distillation unit, tests showed that the flare system valve was not providing effective isolation and would require eventual removal for overhaul at a scheduled shutdown of the flare. A 'cold work' permit to work was issued two days prior to the incident. Alternate flange bolts were removed and the other bolts lubricated as a standard practice to save time. Sufficient bolts remained at all times to retain the flange seals. There was at that time no need to verify line conditions. Two contractors wearing breathing apparatus completed the work. When almost all the bolts were undone, liquid leaked from the gap between the flanges and gas escaped from the top of the joint.
The men stopped work, came down to ground level and sought advice. The supervisor checked the platform and saw gas issuing from the top and liquid leaking from the bottom of the flange. He concluded that neither was under pressure and that the quantity of liquid was small. Without any further tests assured the contractors that it was safe for work to continue. The fitters remained concerned, thus asked and received 'spark proof' tools. Liquid continued to leak as more bolts were removed then, as the last bolt was undone and the crane took the strain and started to lift the valve, the spacer suddenly sprang upwards. A large quantity of liquid was released, a flammable vapour cloud formed and ignited by the nearby compressor. Two workers died in the incident.

Key learning points

A tower scaffold with a working platform and access ladder had been erected for work on the valve but due to access restrictions, it was necessary to climb over or under it. This seriously limited the route of escape. Work on the valve should not started prior to verification of the isolation and should not have continued after the first leak occurred until all doubt about the safety of the situation had been resolved. The absence of the spark arrester on the compressor was not known of until after the incident.

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	
engineering & design, assurance	• Ensure that all relevant standards and codes are followed, including how to mitigate liquid breakthrough.
assurance, systems & procedures, culture	• Identify the hazards associated with flare systems and check that safeguards are available and adequate. Make sure that maintenance activities are considered in sufficient detail during PHA/HAZOP reviews.
engineering & design, systems & procedures	• Ensure sources of flare blockage are understood contingence plans are developed to address possible obstructions in the flare systems.
systems & procedures, knowledge & competence	• Ensure rigorous risk assessments have been undertaken prior to jobs of such a high magnitude and potential hazard such as maintenance of a flare system.
knowledge & competence, culture	• Make sure that maintenance supervisors have the competence to undertake responsibilities and to perform their activities to a recognised standard on a sustained basis.
systems & procedures	• Develop detailed procedures for drainage and isolation of lines, and opening of pipelines and flanges, and ensure they are followed.
Process Engineer/Supervisor	
systems & procedures, engineering & design	• In case of ammonia production facilities, ensure flare systems containing ammonia are segregated from the flare systems containing carbon dioxide, as the mixing can cause plugging problems.
knowledge & competence, engineering & design	• In addition to ensuring the permit to work system is used, job specific Task Risk Assessment (TRA) are needed for higher risk activities. Ensure that deviations from the PTW/TRA are risk assessed prior to execution.
knowledge & competence, assurance	• Supervise and control the work; check that the procedures are always followed. Talk through the hazards and maintenance procedure with the workforce before issuing a PTW.
human factors, systems & procedures	• Ensure flare line isolation valves incorporate valve position indicators.
systems & procedures, culture, assurance	• Process isolation and preparation plan should be clearly documented and checked. Positive isolation and drainage checks must be performed prior to work commencing.
systems & procedures, human factors	• Make sure that adequate means of escape in case of an emergency are provided, especially at elevated working platform. A single egress point is not sufficient in an emergency.
systems & procedures	• Prepare an emergency response plan to enable workers to escape or act upon in case of emergency.
knowledge & competence	• Check that all personal protection equipment that is required for the work is present and fit for purpose. Workers should wear fireproof suits until the lines are proved safe.
human factors, systems & procedures	• Check for the presence of residual flammable gas, avoiding a flammable atmosphere. The use of nitrogen to purge lines should be considered but used with caution. It could cause pyrophoric deposits to dry out, thus increasing their flammability. Working areas should be drenched in water until open pipes have been blanked or spaded.
systems & procedures, knowledge & competence	• In case of any abnormal situation (leak or rupture etc.) work must be stopped immediately and should not start again until a thorough inspection if it is safe for work to continue.
Operator	
knowledge & competence, culture	• Make sure that no flammable gas/vapour is left inside the system prior to cold/hot work activities.
systems & procedures, knowledge & competence	• In case of any emergency situation ask the supervisor for further advice on whether the work can be completed or additional checks are necessary.
systems & procedures, assurance	• Ensure that relevant PPE is available such as breathing apparatus.
systems & procedures, human factors	• When completing process isolation and draining, a positive check should be conducted to prove them.

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