ISC Safety Lore

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Key lessons from incidents relating to ageing

Introduction

Ageing of industrial facilities is a well-known phenomenon which has a broader implication that goes far beyond corrosion management. It is sometimes mistakenly believed that ageing is about how old the establishment or the equipment is. However, ageing of industrial plants has a wider meaning which indicates the degradation of the equipment in use, its overall condition and the change in its condition over time. Everything associated with a site and its processes can age, not only equipment but people, procedures and technologies. These physical states, mechanisms and organisational elements can lead to major incidents.

Case 1 – Oil refinery - corrosion

On 6 August, 2012, a catastrophic loss of containment occurred on an 8-inch diameter piping associated with the gas-oil side-draw on an atmospheric crude distillation column in a refinery. The pipe ruptured, releasing flammable hydrocarbon process fluid to the environment. The flammable liquid partially vaporized into a large vapor cloud engulfing nineteen employees. After two minutes the flammable portion of the vapor cloud ignited. All of the employees escaped, narrowly avoiding serious injury.

Key learning points

The underlying cause of the pipe rupture appears to be poor maintenance procedure in regard to mechanical integrity. Subsequent testing determined that the rupture was due to pipe wall thinning caused by sulphidation corrosion. In fact, over a period of nearly 35 years, the 52-inch long piping component had lost on average, 90 percent of its original wall thickness in the area near the rupture. Although the company employed experts in sulphidation corrosion, they were not consulted on any key decisions associated with potential sulphidation risk of the crude distillation unit. The crude distillation unit is one of the processes most associated with sulphidation corrosion in petroleum refineries. However, the process hazard analysis of the crude unit did not consider the potential for sulphidation corrosion. The pipe in question was made of carbon steel which had a tendency to corrode from sulphidation faster than typical higher chromium-containing steels. In addition to that, carbon steel also experiences significant variation in corrosion rates due to possible variances in silicon content, a component used in the steel manufacturing process. Carbon steel piping containing silicon content less than 0.10 weight percent can corrode at accelerated rates, up to 16 times faster than carbon steel piping containing higher percentages of silicon. This should be considered in the risk assessment.

Case 2 – Chemical plant – corrosion of concrete pipe

On 4 February, 2005, a storage tank containing 16,300 tons of 96 % sulphuric acid ruptured. The content of the reservoir spilled out into the bund and then the dock. The remaining 2,000 tons of acid in the bund came into contact with salt water that created an exothermic reaction, which produced an acid cloud consisting of hydrogen chloride. The vapour cloud drifted along the coastline and mostly over the sea. No one was affected by the event.

Key learning points

The incident was caused by a leak in the cooling water supply pipe passing under the tank farm. The leak undermined the ground under the foundations of a tank which then ruptured because of the uneven weight distribution resulting in the sudden release of the acid. The bund was filled with salt water when the rupture occurred and that caused the formation of hydrochloric acid. The pipe was made of concrete and came into use in the early 1960s. The only damage noted to the pipe was a leak at the pumping station in 1999. The inspection of the failed pipe following the incident detected little or no internal corrosion, but heavy external corrosion to the concrete. In certain parts of the pipe the concrete has corroded so severely that the reinforcing steel had also been exposed. It suggests that the corrosion was as a result of an acid attack on the concrete. According to the standards, a strong acid attack on concrete occurs if the pH level in surrounding water is < 5.5 and a very strong attack if the pH level is < 4.5. The company drew the conclusion that the pH level measured as 4 in the shallow groundwater in 1989 entailed risks for strong acid attack on the concrete. However, there was no risk assessment conducted.

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	
	• Ensure that lead process safety metrics are implemented to address ageing phenomenon in the operation.
	• Identify and monitor signs of ageing in particular corrosion, erosion, fatigue, creep, obsolescence.
	• Ensure that policies are in place for determining the end of equipment life. Plan a life cycle for the plant/equipment and have a date for retirement/replacement of them.
	• Make sure the company has clear, up to date procedures and instructions available to cover normal operating, emergencies and management of change.
	• Have a systematic inspection program in place that addresses ageing phenomenon in order to monitor condition of plant and equipment or handle inadequate design.
	• Have complete documentation on the history of all safety critical equipment, including use parameters, changes and additions since their installation.
	• Have up-to-date documentation of all the safety-critical mechanical equipment (tanks, pipelines, pumps) present on the site, including all component parts (replacements, additions, etc.)
	• Address ageing of critical assets such as primary containment systems, control and mitigation measures, electrical control and instrumentation systems and structures in the ageing inspection programme.
	• Ensure that key skills, knowledge and experience relevant to asset integrity management and ageing is transferred and maintained with people leave, retire, move to a new position in the company.
	• Make sure that process knowledge is maintained and transferred.
	• Make sure that incident investigation reports highlight causes and lessons learned related to obsolescence and loss of knowledge.
	• Make sure that staff and contractors engaged in maintenance and change operations have access to all relevant documentation.
	• Degradation of the equipment should be subject to hazard identification and risk assessment.
Process Engineer/Supervisor	
	• Make sure that underground piping that entail risks to foundations are inspected and measured.
	• Ensure that all safety critical equipment fit-for-purpose and that it is documented.
	• Composite materials can be subject to degradation mechanisms if not properly installed. Make sure that material selection is completed by corrosion experts reliant on service experience and advice form equipment manufacturers.
	• Pay attention to the potential ageing of safety critical electrical, control and instrumentation equipment and systems in terms of physical and performance degradation.
	• Make sure that old/obsolescent equipment and systems are recognised and managed, with special care of spares, repairs and competencies for modifying or checking older software and logic-based systems.
	• Special care is required when upgrading control and instrumentation systems to new digital standards where previously there has been a reliance on analogue equipment.
	• Report all cases where leakage was discovered and make sure these events are investigated thoroughly. Leaks are often caused by corrosion and mechanical failure or wear.
Operator	
	• Make sure that you have access to installation specifications and are knowledgeable in them.
	• Report any leaks or damage immediately to the supervisor.