ISC Safety Lore
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Key Lessons from Incidents involving Corrosion

Introduction

Corrosion is one of the largest causes of plant and equipment breakdown in the process industries and is a dangerous and extremely costly problem which can result in loss of primary containment and even electrical fires due to corroded electrical contacts.

Corrosion is an electrochemical reaction that appears in several forms such as chemical corrosion and atmospheric corrosion. When acidic substances come in contact with metals such as iron or steel rust begins to form. Rust is the result of corroding steel after the iron particles have been exposed to oxygen and moisture and if not managed effectively can have catastrophic consequences.

Case 1 – Flammable Vapour Release Leading to Fire;

On 6 August 2012, a refinery experienced a catastrophic pipe rupture on a 52-inch long component of the 4-sidecut 8inch line. At the time of the incident light gas oil was flowing through the line at a rate of approximately 10,800 barrels per day. The ruptured pipe released flammable high temperature light gas oil which then vaporized into a vapor cloud that engulfed 19 employees. The incident resulted in around 15,000 people from the surrounding communities seeking medical treatment.

The rupture was the result of sulfidation corrosion which causes thinning in iron containing materials due to a rection between sulfur compounds and iron at temperatures ranging from 450 – 1000DegsF. The pipeline that ruptured was constructed of carbon steel which corrodes at a much faster rate from sulfidation than other typical alternative materials due to variances in silicon content.

Key Findings:

The organisation did not follow the subject matter experts (SME's) recommendations to help prevent pipe failures due to sulfidation corrosion – 10 years prior SME's of corrosion recommended an internal inspection take place or that the pipeline that ruptured be upgraded to more suitable material.

The senior management rejected the SME's proposal for turnaround work due to a due to a historical integrity document that stated the pipeline should retain integrity until circa 2016. This resulted in the organisation believing there was a lack of data to justify the work or support the profit improvement project even though they had a Sulfidation Failure Prevention Initiative in place. An upgraded inspection programme was then implemented for materials subjected to sulfidation corrosion. Emergency response refresher training was required for personnel due to lack of understanding of procedures.

Case 2 – Chlorine Release

On 20 July 2003, a release of chlorine gas occurred from a chemical plant which resulted in seven plant workers being injured and a shelter in place advisory warning being issued for residents within a 0.5mile radius of the plant. During the investigation, the heat exchanger was cut open for inspection which showed three holes in the tubes and a build-up of corrosion products at the bottom. It is believed that a historical arc welding process in the year 2000 was a major contributor to the heat exchanger failing. After a matter of years the natural corrosivity of the brine thinned the welded metal resulting in small amounts of chlorine being able to contaminate the brine. Chlorine induced chemical attack then occurred, enlarging the holes and allowing more chlorine into the brine, leading to the coolant pump seals failing which released chlorine to the atmosphere which was then able to enter the control room through the air ventilation route. The release to atmosphere was prolonged due to the requirements for manual valves to be close to isolate the system.

Key findings:

The organisation had a culture of risk normalization due to multiple plant leaks, continuing to operate and not learning from a similar incident two years prior. There was a lack of consideration into automated shutdown systems on the plant including isolation valves as it was still reliant on manual operation. The heating, ventilation and air conditioning design was inadequate to protect safe areas such as control room from hazardous substances. Management of change failures, inadequate risk assessments and poor emergency response onsite and for the public where all key findings.

Figure 1: ISC Framework

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.

What can I do?

Management

	• Ensure that there are written procedures on the requirements to be in place to ensure continued corrosion monitoring occurs.
	• Ensure that an emergency response team and equipment are available within the organisation.
	• Ensure that changes to scope are adequately assessed and approved prior to any work taking place.
	• Conduct a full review of SME advice.
	• Ensure there is a maintenance management system that defines how work is identified and scoped.
	• Have in place an effective Management of Change (MOC) process to adequately record changes from normal operations such as weeps and seeps. This is a deviation from normal operations.
	• Ensure risk assessments are reviewed and updated at adequate time intervals to reflect current conditions.
	• Liaise with local residents on the risks associated with the plant/process and steps to take in an emergency.

Process Engineer/Supervisor

	• Make sure to follow company rules and operating procedures to protect workers.
	• Complete simulated emergency response exercises.
	• Ensure site personnel concerns for ‘stop activity’ are addressed and suitable feedback provided.
	• Ensure that all scope changes are adequately risk assessed and documented. Any changes must be reviewed to ensure the conditions are suitable for ongoing operations.
	• Ensure plant is designed to allow automated isolation in an emergency situation including safe areas such as control rooms.
	• When issuing a permit to work, ensure at all hazards specific to the task are identified and that controls are implemented to manage these hazards. Such as nearby weeps and seeps, passing valves etc.
	• Perform adequate HAZOP, HAZID, LOPA studies etc into enhancing plant and equipment within a suitable review period.
	• Have daily or shift briefs to ensure site teams are aware of issues associated with the plant and process.

Operator

	• Complete start and end of shift plant checks for abnormal conditions.
	• Report all abnormal conditions and if safe to do so take the appropriate action.
	• Ensure worksite visits and effective pre job risk assessment discussions take place.
	• Perform regular plant checks on all work to ensure it is being performed as required and following the permit to work controls. Audit if required.
	• Stop the job and report any deviation from the permit to work system including change in surroundings.
	• Ensure sufficient handover’s are in use documenting all activities.

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