

**Source :** CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD, OCTOBER 18, 2000, (<http://www.chemsafety.gov>), Disclaimer: The Chemical Incident Reports Center (CIRC) is an information service provided by the U.S. Chemical Safety and Hazard Investigation Board (CSB). Users of this service should note that the contents of the CIRC are not intended to be a comprehensive listing of all incidents that have occurred; many incidents go unreported or are not entered into the database. Therefore, it is not appropriate to use the CIRC database to perform statistical analysis that extends conclusions beyond the content of the CIRC. Also, although the CSB never knowingly posts inaccurate information, the CSB is unable to independently verify all information that it receives from its various sources, much of which is based on initial reports. CIRC users should also note that the CSB receives more comprehensive reports about incidents that occur in the U.S.; comparisons made between U.S. incidents and those in other nations should take this fact into consideration.

**Location :** St Louis, USA

**Injured :** 0      **Dead :** 0

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**Abstract**

An explosion occurred involving a medical refrigerator in a university medical school building. Fortunately no one was injured in the incident although fifteen students in the area at the time have been quarantined due to radioactive material used in medical imaging stored in the building. The cause of the explosion is not known.

[refrigeration unit]

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**Lessons**

[None Reported]

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**Source :** CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD, SEPTEMBER 11, 2000, (<http://www.chemsafety.gov>).

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**Location :** West Deptford, USA

**Injured :** 3      **Dead :** 0

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**Abstract**

A fire occurred at a refinery. It is reported that the fire occurred in a dewaxing unit used in the process of crude oil.

An investigation revealed that diesel fuel leaked from tubes that run through the heater into another heater, the fumes caught fire and released nitrogen oxides as a by-product of the fire.

Two workers and one fire fighter were injured in the incident.

[fire - consequence, gas / vapour release, refining, burns, injury]

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**Lessons**

[None Reported]

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1286823 July 2000

**Source** : BBC NEWS, 23 JULY, 2000, (<http://www.bbc.co.uk>).

**Location** : Staffordshire, UK

**Injured** : 0      **Dead** : 2

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**Abstract**

Two contractors were killed when a 100-metre kiln they were demolishing collapsed.

The incident occurred as the contractors were salvaging bricks. It is thought that they were cutting away a metal structure when the kiln collapsed.

An investigation into the incident is being carried out.

[demolition, fatality]

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**Lessons**

[None Reported]

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**Source :** CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD, JUNE 28, 2000, (<http://www.chemsafety.gov>).

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**Location :** Cadwell, USA

**Injured :** 1      **Dead :** 0

**Abstract**

A worker was injured by frigid liquid ammonia whilst trying to shut off a leaking valve during servicing of a refrigeration system. The worker was treated for a burned forearm.

Approximately twenty-four workers were evacuated from the plant.

Hazardous materials team shut off the valve.

[maintenance, burns, refrigeration unit, evacuation, injury]

**Lessons**

[None Reported]

1097415 May 2000

**Source** : CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD, 15 MAY, 2000, (<http://www.chemsafety.gov>)

**Location** : Cheshire, UK

**Injured** : 2      **Dead** : 1

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**Abstract**

One worker was killed and two others injured when scaffolding collapsed whilst they were working inside an incinerator tower.

The workers were carrying out maintenance inside the tower 40 metres up when the platform collapsed beneath them.

[fatality, fall, injury]

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**Lessons**

[None Reported]

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**Source :** CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD, MAY 8, 2000, (<http://www.chemsafety.gov>).

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**Location :** Tooele, USA

**Injured :** 0      **Dead :** 0

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**Abstract**

A leak of a harmful nerve-agent occurred due to a feed chute jam on an incinerator. The incinerator was shut down to investigate the source of the leak.

[plant shutdown, mechanical equipment failure, gas / vapour release]

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**Lessons**

[None Reported]

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**Source :** CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD, 15 MARCH, 2000, (<http://www.chemsafety.gov>).

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**Location :** Allentown, USA

**Injured :** 1      **Dead :** 0

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**Abstract**

An incident occurred at a recycling company when the door of an oven used to burn hazardous waste blew off and struck a worker knocking him unconscious.

The company reclaims mercury from a variety of materials, including fluorescent tubes, electronic switches and other hazardous material.

The incident occurred due to pressure build-up, which caused the oven's doors to blow off. It is not known what caused the pressure build-up.

An investigation is being carried out as to whether contamination of mercury occurred.

[high pressure, explosion / pressure release, injury]

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**Lessons**

[None Reported]

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**Source :** CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD, 15 MARCH, 2000, (<http://www.chemsafety.gov>).

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**Location :** New Brunswick, CANADA

**Injured :** 0      **Dead :** 0

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**Abstract**

A chemical spill at a science centre forced the evacuation of approximately 800 people.

The incident occurred when a cooler unit used to store volatile chemicals malfunctioned, causing a chemical reaction.

The refrigeration unit contained 30 to 35 containers of chemicals. The chemicals included a styrene monomer, a special alcohol used in the production of plastics and approximately 11 kilograms of initiator.

[unwanted chemical reaction, storage]

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**Lessons**

[None Reported]

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121662000

**Source :** CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD, JANUARY 25, 2000, (<http://www.chemsafety.gov>).

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**Location :** Masury, USA

**Injured :** 1      **Dead :** 0

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**Abstract**

Six propane tanks exploded at an industrial park causing approximately \$500,000 (2000) in damage. The cause was due to a leak of propane from a space heater, which ignited and caused the 50-pound cylindrical tanks to explode.

At the time of the incident workers were using the heaters for warmth as they carried out sand blasting work on a large tank inside a gas turbine.

A worker suffered second degrees burns and third degree burns in the incident.

An investigation into the explosions is being carried out.

[damage to equipment, explosion, maintenance, injury]

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**Lessons**

[None Reported]

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12497May 1999

**Source** : EVENING CHRONICLE, 21 MAY, 1999, (<http://www.evening-chronicle.co.uk>)

**Location** : Tynside, UK

**Injured** : 2      **Dead** : 1

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**Abstract**

An explosion occurred at a factory killing a worker and injuring two others. At the time of the incident repair work was being carried out on a press heat exchanger when a filter blocked. It is thought that due to the filter being blocked a pipe fracture occurred resulting in a massive release of high-pressure steam. An investigation is underway into the cause of the explosion.

[burns, fatality, flow restriction, injury]

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**Lessons**

[None Reported]

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**Source :** ICHEME

**Location :** ,

**Injured :** 1      **Dead :** 1

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**Abstract**

A worker was killed and another seriously injured during leak testing on a heat exchanger.

The workers were using inert gas when a tube bundle ejected with great force striking them both.

An investigation into the cause of the incident found the following immediate causes:

1. Use of an unsafe work procedure for leak testing of the heat exchanger, no test ring was used and the use of high risk pneumatic test method.
2. Failure to stop test when instructed.
3. Inadequate protection from the potential of tube bundle propelling outwards.

[explosion / pressure release, design or procedure error, fatality, injury]

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**Lessons**

[None Reported]

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**Source** : CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD, 2 DECEMBER, 1999, (<http://www.chemsafety.gov>).

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**Location** : Landover, USA

**Injured** : 14    **Dead** : 0

**Abstract**

A small refrigerant leak developed at an ice plant, fourteen people were taken to hospital after being exposed to the hazardous material released.

A full investigation into the incident is underway.

[gas / vapour release, refrigeration unit, injury]

**Lessons**

[None Reported]

**Source :** ICHEME**Location :** , UK**Injured :** 1     **Dead :** 0**Abstract**

Part of a benzene plant was shutdown, as part of the annual shutdown programme. As part of the preparations for maintenance the main process sections were drained, purged and steamed in accordance with the set procedures. Work then began on the stripper column reboiler circuit, including two heat exchangers. The actions required for the preparation of one of the exchangers had been highlighted, and so it was assumed these actions had been completed. Under a Permit to Work the foreman and 4 of his team commenced on unbolting the exchanger end plate and the main channel end flange. The work was not completed and was carried forward to the next shift. During the work it was noticed that the exchanger surface was still hot. This was assumed to be due to steaming operations in the shell side of the exchanger. The following day under a re-signed Permit to Work, the team continued with unbolting and the exchanger end plate seal was released. Hot condensate spilled out of the bottom section of the exchanger end channel. When the flow ceased the final bolts were removed from the end plate flange and the end plate cover was rigged ready for lifting down to ground level. Approximately 10 minutes after the end plate was removed, a fitter working adjacent to the area was hit by a large flow of hot condensate, which flowed from the exchanger, impinged on a tube baffle plate and then sprayed over the fitter. He crawled away and colleagues put him under a safety shower until the ambulance arrived. The fitter received scalds to his back and neck. Investigations showed that there had been ineffective isolation of the exchanger system from the live LP plant steam supply. There were also passing valves on the condensate system which contributed to the presence of hot condensate. The highlighted had not in fact been completed and there had been inadequate physical checking of the isolation work prior to handover for maintenance. The Permit to Work system had not highlighted potential hazards, and due to work overload was not being operated effectively.

[permit to work system inadequate, burns, isolation inadequate]

**Lessons**

The following recommendations were made:

1. Key isolation valves should be checked for passing.
2. All work packs were re-checked for proper system isolation before shutdown work recommenced.
3. The organisation and supervision for the shutdown were reviewed and clear requirements for detailed recording and handover of progress between shift teams were set.
4. A schedule was to be set up for a management review of the progress of the new coordination routine and for general safety auditing of the shutdown activities on the plant.
5. The lessons learnt from the incident were to be circulated to other plants undergoing shutdown, to identify Best Practice for the future.
6. Generic recommendations from other condensate related incidents were to be reinforced.

Source : ENVIRONMENTAL TIMES, VOLUME 6, ISSUE 3, SPRING 2000.

Location : , UK

Injured : -      Dead : 0

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**Abstract**

An explosion occurred in an incinerator. An investigation into the incident discovered serious deficiencies in the maintenance of the plant.

The company was charge with:

1. Failing to maintain good condition all plant, equipment and technical means used in carrying out the authorised process for failing to maintain the associated plant.

2. Failing to ensure that the authorised process was managed and operated by enough people who were suitably trained and supervised.

The authorised process recovers precious metals from a wide range of scrap materials.

The company was fined £30,000 and costs of £950 (2000).

[design or procedure error, management system inadequate]

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**Lessons**

[None Reported]

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Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

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**Abstract**

A cooling tower, on an ethylene plant, had been prepared for person-entry. A fitter noticed paint blistering near to the middle entry door. The emergency services played water onto the tower externals until temperatures fell to 150 degrees C then the tower was repurged with nitrogen. Prior to the incident, the tower had been purged with nitrogen, then steam purge to remove traces of hydrocarbons, and cooled. An air purge was then used to assist cooling, and the last (middle) of three entry doors removed. It was whilst removing this door that the blistering paint was noticed. [pyrophoric carbon, iron sulphide, fire - consequence, autoignition]

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**Lessons**

The tower had been shut down to investigate, and remove, blockages of coke and polymer. The coke is carried forward from upstream furnaces, and the polymer forms within the tower during normal operations. Before shutdown, several wash solutions, including xylene, were used to attempt to dissolve the polymer. None of these were successful in removing the blockage so a decision to open up the tower was taken. Laboratory tests showed that washing with xylene produced fine, sooty carbon deposits that were self-heating in air at the temperatures in the tower. There could then self-ignite at 185 degrees C. Also, traces of finely divided iron sulphide, also present in the xylene wash sampler, can be pyrophoric. Either of these mechanisms could have led to glowing-hot sooty carbon, which then ignited the larger coke particles on the tower trays. Manufacturing managers were recommended to review procedures for cleaning and opening (to air) equipment, containing material of a pyrophoric nature. An outline procedure was developed, and referred to in the Report. However, the procedure itself, was not included in the report received.

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1044022 April 1998

**Source** : CNN.COM, U.S. NEWS, 1998,  
(<http://www.cnn.com>).

**Location** : Montreal, CANADA

**Injured** : 35    **Dead** : 0

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**Abstract**

An explosion and fire occurred at an automobile brake pad plant injuring 35 workers. One person was badly burned when an oven exploded, other injured workers complained of breathing difficulties and nervous shock. The explosion did not damage the exterior of the one-storey brick building.  
[fire - consequence, burns, processing, injury]

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**Lessons**

[None Reported]

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106051998

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

An on-line crude unit heat exchanger vent line was fractured during a lifting operation. The strap/webbing sling being used to install a tube bundle into the shell of the lower of a pair of horizontal heat exchangers came into contact with the vent line and fractured it releasing approximately 32 barrels of crude oil into the area. There were no injuries or fires.

The immediate cause of the spillage was a failure in the preparations to ensure that the crane operation could not damage equipment on the crude unit. The basic cause was a failure to provide a method statement and formal risk assessment for the crane lift and ensure that the vent line was adequately protected or decommissioned.

[design or procedure error, damage to equipment]

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**Lessons**

[None Reported]

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Source : ICHEME

Location : , FRANCE

Injured : 1      Dead : 0

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**Abstract**

During the removal of one of two furnace tube header plugs in preparation for the mechanical decoking of a furnace, the plug ejected under residual nitrogen pressure and struck the contractor's face. The contractor required hospital treatment.

The furnace contains a radiation section consisting of four passes of vertical 4-inch diameter hairpin tubes. Each pass consists of 31 tubes, with a height of 20 meters arranged with plug headers at the top returns and "U" bends at the bottom. Nitrogen at 12 bar pressure through a three quarter inch hose was connected to each tube pass to push the gas oil out of the furnace to slops. This was not effective (unknown at the time) with the result that nitrogen was trapped in the top of the tube(s) between legs of gas oil. Pressure of the nitrogen in the top of the tubes being equivalent to the hydraulic pressure/height of gas oil in the tube legs. The strongback (clamp) holding the plug was removed after which a whistling sound was heard and the plug shot out of the header striking the contractor's head.

[preparation for maintenance, maintenance, furnace, design inadequate, injury]

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**Lessons**

The following recommendations were made:

1. Preparation of plant for maintenance procedures should be subject of a hazard/job safety analysis.
  2. A nitrogen purge may not clear lines of liquids and trap hidden pressure.
  3. Always have a second safeguard when breaking into process systems and communicate this requirement on the work permit.
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**Source :** ICHEME**Location :** , USA**Injured :** 0     **Dead :** 0**Abstract**

A second plug inserted into a "U" tube reactor blew out while the shell side of the Alkylation Unit's "Exchanger/Reactor" was pressurised with nitrogen at 50 psi to detect leaking tubes. The plug blew out as the craftsmen were about to drive it in, spraying a mist of liquid on to the face shield of one of the craftsmen. The reactor had been prepared in accordance with the procedure to test for leaking tubes. The reactor had been blocked in, depressurised and drained. The shell side had been caustic washed to neutralize any alkylation acid and the reactor was blinded off from the acid settler. When the front cover plate was removed, some residual liquid was found in the bottom of the channel head and fire water was used to flush the channel head and tube sheet area. Dry nitrogen at 50 psig was then used to pressure up the shell side of the exchanger in order to find the leaking tubes. As this is a "U" tube bundle, the bottom leaking tube is usually found to dribble liquid out with the nitrogen. When a plug is driven in this end, then the top end of the leaking tube has to be found by detecting the escape of nitrogen. The top plug was put in place with the nitrogen pressure still applied on the shell side and tapped into place. The craftsmen were then preparing to drive the plug in completely when it blew out, spraying a mist of liquid on to the face shield of one of the craftsmen.

There is no written maintenance procedure specifically for repairing a leaking "U" tube in the reactors at Alkylation Unit. There is a Job Aid for repairing a leaking exchanger tube and the most significant difference between the Job Aid and the typical practice at the Alkylation 2 is that the Job Aid calls for water to be used to fill up the shell side of the exchanger and then this is pressurised up (if necessary) to detect tube leaks. The investigation team discussed this at length and agreed that the use of nitrogen for the Alkylation Unit's reactor/exchanger is acceptable and can be done safely. The Job Aid, however, does specifically call for the shell side to be depressurised and drained before tube plugs are installed. Plugging a reactor tube while there is still nitrogen pressure on the exchanger shell was not typical practice. Nitrogen is normally blocked in and allowed to depressure first. The craftsman alleges that he was directed to attempt to plug the leaking tube while nitrogen pressure was still on the shell. The technique of inserting and driving home a plug does not require the craftsmen to enter the channel head area, as he uses an extension piece to reach into the tube sheet and insert the plug. This means a confined entry permit is not required. However, to detect which tube is leaking requires the inspectors to use a portable instrument which detects the sound of a leak. To use this instrument they must climb into the channel head, following the issue of an entry permit by the safety inspector. The safety inspector had been called for a confined space entry permit, and was present when the plug blew out. He had refused to issue the confined spaced entry permit, advising the operator that the nitrogen had to be blocked out and the shell depressurised.

A safety inspector will not issue a confined space entry permit until the nitrogen is disconnected from the reactor shell. However, the corrosion inspector must have the nitrogen connected and under pressure for the instrument to "hear" the leak. Accordingly, the typical practice is for the nitrogen to be disconnected from the shell, have the shell depressurized and obtain a confined space entry permit. After this, pressurise the shell and enter the channel head area to use the instrument to detect the leak. The investigating team agreed that this was an unacceptable practice, because as soon as nitrogen is used to repressurize the shell the conditions of the confined space entry permit are invalid.

[reactors and reaction equipment, maintenance, tube, heat exchanger, reactor tube, design or procedure error, blowout, permit to work system inadequate, entry into confined space]

**Lessons**

The following recommendations were made:

1. Failure to have a detailed procedure with a task analysis and periodic observations for unusual jobs will lead to attempts to short cut normal practices.
2. Gas under pressure has a great deal of potential energy waiting to be released. Plugs under pressure whether in heat exchanger tubes or furnace tubes present a potential hazards.
3. A robust permit to work system is essential to prevent accidents.

Source : LOSS CONTROL NEWSLETTER, 1997,; ENDS REPORT 269, JUN, 1997,; ECN, 16-22 JUN, 1997.

Location : , UK

Injured : 0      Dead : 0

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**Abstract**

About 5 tonnes titanium tetrachloride leaked into cooling water system in a heat exchanger, corroding a pipe and was released into the atmosphere. A dense white cloud of hydrochloric acid and titanium oxychloride occurred. Prohibition notice issued.

[cooling equipment, gas / vapour release, corrosion]

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**Lessons**

[None Reported]

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Source : HAZARDOUS CARGO BULLETIN, 1997, AUG. LLOYDS LIST.

Location : , SINGAPORE

Injured : 0      Dead : 0

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**Abstract**

A large part of a waste treatment and tank cleaning depot was destroyed by fire due to a burst incinerator exhaust pipe igniting vapours.  
[fire - consequence]

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**Lessons**

[None Reported]

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Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

### Abstract

At 04:45 hrs., a tube leak was discovered in a naphtha treater furnace. The furnace was built in 1958 with one and a quarter percent chrome aluminised tubes. Most of the tubes were replaced with 5% chrome in the late 1950s and early 1960s because of tube failures due to overheating. The tube that failed was a 1960 replacement tube. The designed firing rate was 47.9 MM BTU/Hr. Presently, it runs at 71.5 MM BTU/Hr. This change in operating conditions went through the "management of change" procedure in February, 1997. Although the furnace would not have meet the companies recommendations for burner to tube spacing in a new installation, it was determined to be an acceptable safe operation if tube skin temperatures were monitored and kept under 925 degrees F (496.1 degrees C).

Over the past year, the refinery had started the implementation of a furnace management program on this particular furnace. Some of the items addressed were burner maintenance and adjustment, additional instrumentation and calibration with operator training. Improvement was noted in its operation since then, but the furnace tube failed anyway.

Prior to the incident, the operation of the furnace and process unit were normal. The furnace tube leak occurred in a bottom row tube of the south coil. Smoke was detected coming from the convection heater stack at 04:45 hrs. by two supervisors as they were exiting the control room's south door. The furnace tube leak was verified by a supervisor who, was able to see the smoke coming out of the naphtha treater furnace stack and the flames in the fire box. He warned others to stay away from the furnace. Several operations personnel went on to the eastside deck to verify the leak, but because of the flames in the box they were not able to see where the leak was. They went to the westside deck and were able to view inside the box, then left the furnace area. Less than a minute after their departure, at about 04:58 hrs., according to the process alarm, the tube massively failed and engulfed the furnace structure in flames. For the operations personnel who had been on the furnace deck, this was truly a "near miss" event.

The fire alarm was sounded, security was called to page the emergency response team, and the fire department was summoned. A decision was also made to shut down the other units. The furnace was quickly isolated (about 05:15 hrs.) and the fire was contained to the furnace area and under control within 20-30 minutes.

Total loss was about \$3 million (£1.7 million) (1997). Business interruption accounted for \$2.2 million (£1.2 million) (1997) and property damage \$0.8 million (£0.6 million) (1997). The naphtha treater furnace was recommissioned on May 24, 13 days later.

An investigation found that the failed tube, which was a 5 Cr tube, was coked locally in between two burners closest to the east end of the furnace (south pass). A tight adherent layer of coke, about a quarter inch in thickness, was inside the tube located on the fire side of the tube. This layer of coke could be expected to raise the temperature of the tube close to 300 degrees F. This led to longer term overheating and eventual longitudinal bulging. A crack occurred causing the initial release of naphtha into the firebox. This was followed a few minutes later by the tube being ripped open circumferentially releasing 600 psig naphtha into the furnace. This type of failure is not typical, but is more likely to occur in high pressure services.

[heating, furnace, tube, furnace tube, overheating, tube failure, fire - consequence, rupture]

### Lessons

The following recommendations were made:

Continued flame impingement on tubes in any hydrocarbon furnace will lead to localised coking and eventual tube failure. Management of change procedures must be applied when changes to materials are proposed, or when duty beyond original design is required.

Tube leaks in furnaces operating at high pressure are likely to have a sudden and catastrophic failure. Attempting to make further visual inspections is a significant risk.

Emergency response plans should be regularly tested, and include the communications and "call out" systems.

Process operators must be trained in the actions to be taken following a tube rupture.

112041997

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A tube failure on the fin fan air cooler released, over a period of 1 hour, approximately 2 tonnes of butane and 10Kg of HF (hydrogen fluoride) vapour.  
[processing, condenser, fin fan cooler, gas / vapour release]

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**Lessons**

Current monitoring of the condenser tube X radiographs, at 2 yearly intervals did not identify the fault. The monitoring program is being reviewed.

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Source : ICHEME

Location : , GERMAY

Injured : 0      Dead : 0

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**Abstract**

An explosion in the rotary kiln of a waste incinerator at a fibre manufacturing plant.

Charging of the kiln had been stopped for one hour at shift change-over. A molten salt pool accumulated in the kiln. When charging resumed, the explosion occurred.

The waste being charged had a high carbon disulphide content and was frozen due to low ambient temperatures.

The kiln had to be taken off-line for repairs and was returned to service three days later.

A similar incident had occurred in the kiln several years earlier.

[processing, process causes]

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**Lessons**

Project team set up to investigate the incineration of water material with high carbon disulphide content.

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Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

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**Abstract**

A foam and plywood "bung" was discovered in 6 inch pipework upstream of a 4 inch thermal relief valve on a refrigeration system on a petrochemical plant. The investigation concluded that the bung had been in place for the four years since the Plant was commissioned. It was believed to have been installed as a temporary isolator used while creating an inert atmosphere during construction. It was concluded that it was too flimsy to have caused a serious obstruction in the event of the valve lifting. There was no recollection on the plant of this ever having happened.  
[refrigeration unit, management system inadequate, plant / property / equipment]

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**Lessons**

The investigation concluded that the management systems for controlling both housekeeping and levels of supervision were inadequate.

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

**Abstract**

An FCC Unit was shut down for 9 days following failure of the wet gas compressor turbine. Total loss was estimated at \$4.65 million (£2,776,119) (1996). The loss was caused by water contaminating the lubricating oil of the turbine driver. Water had entered the lube oil system through a defective steam ejector system that is an auxiliary part of the wet gas compressor's steam turbine driver. The FCC wet gas compressor was installed in 1971 and had two, long operating periods (12 years and 11 years) without an incident. On September 27, 1996, a short-term lube oil bearing temperature increase of 15 degrees F on the inboard end of the turbine was followed with a 70 degrees F fall in lube oil temperature. This was possibly the first indication of some loss of bearing material, which resulted in an increase in the bearing clearances allowing more oil to flow into the bearings. This increased flow resulted in the reduction of the lube oil temperature below normal level. On September 28, a decline in the turbine exhaust vacuum was discovered. This was rectified by adjusting the sealing steam and the condenser ejector system. The decline in vacuum was probably due to the increase in bearing clearance the previous day causing some minor degradation of the turbine labyrinth seals. The turbine exhaust steam vacuum was steady throughout the remainder of the week, until Friday, October 4. Again the sealing steam had to be adjusted to maintain proper vacuum. Operations continued normally until the morning of October 5. At 05:50 hrs. a vibration alarm came on in the control room. Operator response to the turbine-compressor train found excessive vibration on the turbine. The sealing steam pressures were abnormal and the turbine exhaust vacuum had declined. Adjustments failed to correct the vibration problem or the turbine exhaust pressure. Increased vibration and "sparks" from the packing box area of the turbine resulted in the decision to shut down.

The FCC steam turbine driven wet gas compressor was shut down owing to extremely high vibration, sparking from the inboard and outboard packing box and a total loss of turbine performance. Inspections carried out afterward on the turbine and compressor found the following:

1. The radial bearings were excessively worn, all babbitt was found removed and the rotor had operated on the bronze backing of the tilt pad bearings.
2. The shaft labyrinth seals were heavily damaged.
3. There was damage to the rotor blades at the 5th stage (severe) and on the 7th and 8th stages.
4. There was evidence of heavy rust in bearing housings and the oil lubricated coupling was fouled with rust and "blocked up."
5. The compressor itself was undamaged, but there was rust in the bearing housings and minor damage to thrust bearings.

Evidence of water contaminated lube oil throughout the system caused sludge and corrosion material build up in the bearings. The water came from a defective steam ejector system. Eight out of the 12 tubes of the gland condenser had failed; and since the condenser drain was plugged, it allowed the cooling water to flow back into the turbine seals and into the lube oil system.

The refinery took a number of corrective actions that included:

1. Repair of and modification to the ejector system.
2. Development of a proper lube oil monitoring system for all rotating equipment on site.
3. A review of other machine condition monitoring systems for bearings.
4. Development of a comprehensive training program including refresher training to ensure compressor - turbine auxiliary systems are fully understood.
5. Ensuring clear communications between operations and maintenance on the priority that should be given to monitoring and maintenance of critical equipment.

The immediate cause of the failure was the presence of water in the lubricating oil system which destroyed the ability of the lube oil to support the rotating equipment. The basic cause of the contamination was the leaking tubes on the associated with the auxiliary system ejector system combined with the plugged drain. In addition, the failure to identify and/or acknowledge a number of warning signals prior to the incident was also significant. The latter was attributed to training particularly the need for refresher training on the wet gas compressor's auxiliary systems.

[cracking, turbine, mechanical equipment failure, training inadequate, plant shutdown]

**Lessons**

1. Rotating equipment lubricating oil examination to detect contaminants to be a routine operation.
2. Use condition monitoring equipment to determine critical bearing performance, but be sensitive to other early warning signals.
3. Auxiliary systems are outside operations mainstream expected performance and so are easily overlooked. Refresher training is essential for these systems.

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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### Abstract

An high pressure cooling water supply line ruptured necessitating reduced feed to the FCC. Water hammer shock coupled with bending stress is the likely cause of the failure which is estimated to have cost \$88,000 (£52,700) (1996), of which \$62,000 (£37,100) (1996) was production loss.

The line rupture was discovered when the general operator observed a temperature increase at the FCC second stage drum and sent the general operator to the cooling towers to investigate. When the operator arrived at the cooling tower to investigate the problem, he noticed that both high pressure fans were off and that a small trickle of water was accumulating in the roadway. The operator reset the vibration switches on both fans and attempted to restart them, but he was unsuccessful. After attempting to restart the fans, the operator noticed the pressure pump was also off. He was unable to restart it. By this time the flow of water in the roadway had grown substantially, so the operator began to investigate the source of the flow. Operators noticed that the flow of water returning to the cooling tower basin had significantly decreased and observed a loss in the cooling tower level. To maintain cooling and prevent damage to the low pressure cooling circuit, the high pressure cooling circuit was shut down and firewater was added to the basin. Over the next several hours, fire hoses were connected to heat exchangers in the high pressure cooling circuit to provide a temporary water supply. Once electricians were able to examine the equipment, they found that the 600 amp main electrical breaker 114 degrees C, supplying the high pressure pump and fan, had tripped. They also discovered that another fan had shut down due to vibration, unrelated to the circuit breaker tripping. Approximately half an hour after the main circuit breaker was reset, the high pressure pump started to run on its own, even though its switch was in the off position and it had to be shut off by opening its circuit breaker because it could not be shut off using its stop button. Circulation was re-established at 7:30 pm on August 27 after 64 hours.

After an investigation it was concluded that the immediate cause of the pipe fracture was probably due to water hammer combined with a high localised bending stress.

The basic cause was poor piping design and installation.

A contributory cause was probably faulty electrical equipment that caused a pump to trip off and restart automatically.

[design or procedure error]

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### Lessons

The following recommendations were made:

1. Water hammer even in large industrial systems can cause severe damage to weak points designed into a piping system.
  2. Old electrical relay equipment requires significant preventive maintenance attention if it is to continue to provide reliable service.
-

8459 25 May 1996

**Source** : EUROPEAN CHEMICAL NEWS, 1996, JUN, 3.

**Location** : Wisebaden, GERMANY

**Injured** : 0      **Dead** : 0

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**Abstract**

A fire in a cooling tower spread to two adjoining towers causing damage estimated at \$324,000 (1996).

[fire - consequence, damage to equipment]

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**Lessons**

[None Reported]

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**Source** : SEDGWICK LOSS CONTROL NEWSLETTER, ISSUE 2, 1996.

**Location** : Grannagh, Kilkenny, IRELAND

**Injured** : 4      **Dead** : 0

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**Abstract**

An explosion blew off part of the roof and a wall during maintenance. The explosion was linked to a flame arrestor in the line leading to a newly commissioned incinerator. Substance involved: paraformaldehyde.

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**Lessons**

[None Reported]

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Hydrotreater recycle hydrogen line failure at a refinery.

Localised corrosion of a FCCU (Fluid Catalytic Cracking Unit) feed hydrotreater recycle hydrogen line by-pass around a hydrogen pre-heat exchanger led to an explosion and fire. The failed part of the line had been identified by inspection as a dead leg. After investigation it was found that the mechanism of corrosion was ammonium chloride under deposit corrosion. The source of chloride has not been traced, but hydrogen from the catalytic reformer was strongly suspected. Inspection inadequate of the dead leg was identified as the cause of this incident. There was damage to equipment, material loss and product loss. [refining, fluid cracker]

---

**Lessons**

Localised corrosion mechanisms are difficult to detect with fixed point UT, and dead leg corrosion can have several different corrosion mechanisms.

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Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

---

**Abstract**

The feed effluent exchangers of a reformer suddenly caught fire. The fire was extinguished in 5 minutes and the unit safely shut down. The precise cause of the sudden fire is not known. An estimate of the total cost of the incident is \$311,000 (£177,000) (1996), including \$154,000 (£88,000) (1996) in production lost and \$154,000 (£88,000) (1996) for labour and materials.

The FCC1 operator reported seeing smoke in the direction of the reformer. Upon arrival of operators and supervisors to the scene, the feed effluent exchangers were fully involved in fire. The fire was extinguished within about five minutes, and the unit was safely shut down. There were no injuries as the result of this incident. Due to liquid carryover to the DHT make-up gas knock out drum, both DHT compressors were shut down. The unit operator at the time of the incident stated that he had just been in the area of the 4 exchangers, and that he had not observed leakage of products. Shortly after returning to the control room, he was informed that the exchangers were on fire. He estimated the elapsed time between walking through the area and being informed of the fire was approximately 5 minutes. He indicated that when he arrived at the scene, the most intense burning seemed to occur around the lower portion of the two stacked feed/effluent exchangers

The immediate cause of the fire was leaking reformer reactor effluent released to atmosphere above its auto-ignition temperature from either one of the bolted channel covers, channel head flanges, ring jointed piping connection or a threaded plug in the channel head cover.

The basic cause has not been determined, but seems likely to be either incorrect tightening of the heat exchanger covers, piping joints or threaded plug.

[fire - consequence, refining, heat exchanger]

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**Lessons**

The following corrective actions were taken:

1. Although an improper tensioning procedure was an unlikely cause, it is recommended that in the future all assemblies requiring hydraulic bolting be supervised by technical personnel familiar with the procedures including lubricated studs and extensometer readings to assure proper bolt tightening.
  2. If possible, all threaded plugs in critical or corrosive services (elevated temperature, hydrogen, hot oil service, etc.) should be replaced with welded connections. At a minimum, a thread gauge must be used to assure proper thread engagement during turnarounds.
  3. Consider installation of a water deluge system over the feed/effluent exchangers.
  4. Consider fireproofing of cable trays in overhead pipe racks where damage occurred.
-

Source : ICHEME

Location : ,

Injured : 0      Dead : 1

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**Abstract**

Fatality during maintenance on Fluid Catalytic Cracker Unit (FCCU) heat exchanger.

During steaming of heat exchanger shell covers, to facilitate removal, the lower cover blew off, striking an operator. The tight fit between the shell cover and floating head restricted the path of steam flow, creating an overpressurisation. This was due to the minimum clearance between the shell cover and floating head being less than that required by design.

[fluid cracker]

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**Lessons**

When using steam for heating equipment for disassembly, a free path to vents must be available and maintained; e.g., not blocked by sludge.

Personnel need to be aware of the potential force of steam, nitrogen, air, used as a maintenance aid and not build up uncontrolled pressure in equipment.

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Source : ICHEME

Location : ,

Injured : 0      Dead : 1

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**Abstract**

Contractors were attempting to unplug a blockage in a pump suction line in the bottom of a mix tank used in their process to convert hazardous waste material into cement kiln fuel. One of the contractors decided to enter the tank, contrary to instructions from his supervisor, in an attempt to expedite the work. He was wearing an air purifying respirator (canister mask) and protective clothing but quickly became disoriented and lost consciousness. He had been exposed to benzene. Fatality

[entry into confined space, asphyxiation, operator error]

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**Lessons**

There was lack of sufficient appreciation for the acute toxic hazards of petroleum hydrocarbons.

There is a need to ensure that contractors effectively carry out their written safety programmes in the field.

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Fire on crude unit stack. A carry-over of hydrocarbon from a naphtha stabiliser to the acid gas knock out pot then went to a incinerator, where it ignited. As a result, there was thick black smoke, followed by a fire, at the common stack. The unit was immediately shut down. The disposal line from the acid gas knock out pot was engineered in 1984 to enable the transfer of condensate, but due consideration was not given to accidental carry-over of entrained hydrocarbon. There was a common assumption that this was the normal route for disposal problems, i.e., to the incinerator. Production loss \$1.8 million (1995).

[fire - consequence, product loss, processing]

---

**Lessons**

Guidelines and detailed procedures need to address the handling of abnormal conditions.

---

**Source :** SEDGWICK LOSS CONTROL NEWSLETTER, ISSUE 4, 1995.

**Location :** Chicago, USA

**Injured :** 0      **Dead :** 0

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**Abstract**

A fire, which inflicted small damage, broke out in a sponge coker unit process heater and was quickly extinguished.

[fire - consequence, damage to equipment]

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**Lessons**

[None Reported]

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Source : HAZARDOUS CARBO BULLETIN, JUNE 2000.

Location : Ohio, USA

Injured : 0      Dead : 0

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**Abstract**

An explosion occurred at a commercial incineration facility. The incident involved drums containing hazardous waste. Significant damage occurred to the facility.

An investigation into the incident found that the drums contained primary and high explosive materials. The drums were not properly marked or labelled. The company was fined \$40,000 (2000).

[damage to equipment, labelling incorrect, design or procedure error, incinerator]

---

**Lessons**

Mis-classification of any hazardous material is a very serious matter because it can result in improper handling of the material by the carrier and may cause danger to emergency personnel responding to an incident.

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Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

**Abstract**

A tube suddenly ruptured in a reactor feed preheat furnace of a Resid Hydrotreater and resulted in a major fire. The mechanism of failure was creep in a relatively localised area. The incident occurred during the start-up of the unit.

The 96 Mbpd Resid Hydrotreater started operation in late 1983. It consists of three parallel modules feeding a common distillation section. Each of the modules is identical, and contains two parallel reactors, feed/effluent heat exchanger, one preheat furnace, hydrogen recycle and quench, and product separation and cooling. Each furnace has two separate radiant sections which preheat the feed to the two parallel reactors. Each radiant cell of the furnace preheats a mixture of resid feed and hydrogen to its feed temperature. Twenty-two furnace tube skin temperature indicators (TIs) are provided throughout each radiant cell. Peepholes are provided at each end of the 60 foot long firebox and at three locations along each side of the firebox. The tubes are seven inches in diameter, 0.6 inch in nominal thickness and of type 347 stainless steel.

On the day of the incident, the fuel gas valve on the furnace's north cell was fully open at a rate of 43,000 scfh from about 00:30-02:35 hrs., and the south cell was also fully open at the same rate from approximately 01:25-02:35 hrs. An operator inspected the furnace during this period and noted no obvious hot spots on the tubes or other abnormalities. Fuel gas was reduced to both cells prior to shift change to lower the skin TIs (one skin TI in the north cell reached alarm point of 1050 degrees F at 05:30 hrs.). The skin TIs cooled to 850 degrees F (454 degrees C) or less but the one TI which had alarmed remained at 950 degrees F to 1000 degrees F (510 degrees C to 538 degrees C). At no time during the startup did any TI reach the maximum design limit of 1100 degrees F (593 degrees C). surveys have revealed temperatures high enough to cause a creep failure.

Key findings from the investigation are summarized below.

1. Coke deposition occurs predominantly at or near tube welds in the furnaces.
2. The weld acts like a stiff ring - such that when creep conditions exist in the weld area the tube bulges where the resistance to stretch is less (4 inches from weld).
3. Weld thermal stabilization did not remove residual stresses from the weld to the edge of the heating blanket, test shows that after post-weld heat treatment negligible residual stresses remain.
4. The grooves found in the north cell tube 4 failure point were statistically equivalent to the grooves found in the south cell tube 12 bulge and most likely occurred from the same mechanism.
5. The grooves were not a manufacturing defect because the grooves in the south cell crossed a weld.
6. The internal grooves were a consequence of carburization and creep (very similar to boiler tube ruptures due to creep and Environmental factors such as scale).
7. There was no evidence of tube material degradation near the welds.
8. Short term stress rupture tests on tube material indicated properties at or slightly below the API 530 minimum rupture curve.
9. Due to several locations of creep characteristics being found, the overheating is most likely due to chronic conditions rather than any single event.
10. Full tube inspection, visual or IR, was not possible with the existing number of sight ports.
11. Localized overheating of the tube was not indicated by skin TIs, periodic infrared scans, or visual inspections.
12. Furnace operating policy, at the time of the incident, was to fire the furnace subject to tube skin TI, draft, CO, excess O2 and flame pattern constraints. Heat flux or fuel gas limits had not been imposed.

[reactors and reaction equipment, fire - consequence, separation equipment, cooling equipment]

**Lessons**

The following recommendations were made:

1. Decoking of furnace tubes to prevent coke build up and consequent localised heating should be undertaken at specified intervals.
2. Tube skin temperature alarm points should be set sufficiently lower than the maximum design temperature to allow for hot spots or localised heating.
3. IR imaging needs to be conducted frequently to supplement tube skin temperature measurements.

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

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**Abstract**

A leak was discovered in the discharge pipework of an ethylene refrigeration compressor. The ethylene plant was shut down, the leak isolated and the associated pipework purged, prior to full inspection and repair.

The location of the leak was discovered at a point where a 2 inch safety valve bypass joined a 10 inch safety valve header on the compressor discharge. It was identified that the failure of the 2 inch pipe had been due to vibration induced fatigue.

The plant had been recommissioned two days previously, following a shutdown brought about by a process upset. It was estimated that 400-50 tonnes of ethylene had been lost in the 48 hours following recommissioning.

[refrigeration unit, plant shutdown, excessive vibration, normal operations]

---

**Lessons**

The enquiry team identified that monitoring of the vibration levels on pipework around the failure location should continue after the installation of new pipe supports. Monitoring and analysis results should be communicated site-wide and to others.

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Sulphur pit explosion at a refinery. A flashback from the incinerator ignited an accumulation of acid gas in the sulphur pit. The cause of this accident was a previous modification to the sulphur pit design when the unit amine sump vent was connected into the sulphur pit vapour space. This allowed hydrogen sulphide to accumulate in the sulphur pit vapour space. The amine sump had originally been fitted with an atmospheric vent.  
[near miss, design inadequate, refining, contamination, modification procedures inadequate]

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**Lessons**

Allowing for understandable technical reasons, the contamination of the sulphur pit with drainings from the amine sump was undesirable, especially with the limited control over quantities being drained.

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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#### Abstract

Isocracker heat exchanger flange leak at a refinery. An Isocracker Unit was shutdown due to a small pinhole leak found in the first stage feed/effluent exchanger outlet piping. After disassembly of the piping system, the flange revealed extensive cracking.

Losses including damage to equipment, product loss, and materials and labour amounted to \$1.3 million (1995). It was found that chloride stress corrosion cracking caused the incident. All four criteria for chloride stress corrosion cracking were present: Material of cracked flange was austenitic type stainless steel, known to be vulnerable to chloride cracking. Flanges were overcompressed and the joints had not been hydraulically torqued during previous turnaround. Even low overall concentration of chlorides got into grooves and pits during cycling and went undetected for many years/cycles.

[refining, cracking]

---

#### Lessons

Chloride stress corrosion cracking propagates during start-up and shutdown periods, even in low overall concentrations of chloride, concentrating in grooves and pits.

---



**Source** : SEDGWICK LOSS CONTROL NEWSLETTER, 2ND QUARTER, 1995.

**Location** : Houston, Texas, USA

**Injured** : 0      **Dead** : 0

---

**Abstract**

Fire on a fired heater feed loop at this refinery shut one of the four crude oil distillation units for 14 days.

[fire - consequence, refining]

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**Lessons**

[None Reported]

---

**Source** : SEDGWICK LOSS CONTROL NEWSLETTER, 2ND QUARTER, 1995.

**Location** : Blue Island, Illinois, USA

**Injured** : 3      **Dead** : -

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**Abstract**

A fire occurred at a refinery which was caused by leak of gasoline additive ignited by faulty heater. Soot from the fire settled over a nearby school causing smoke inhalation injuries to students.

The accident occurred during repair work on a valve for a hydrocracking unit used in producing gasoline. Operators not trained in maintenance procedures were performing the work and did not properly lock out the equipment. Pressure in the line blew off the valve bonnet, shooting flammable liquid and vapour 70 feet into a welding shop, where it exploded into a fire that flashed back to the hydrocracking unit. The employees who were killed had been eating lunch in the welding shop. The three operators in the hydrocracking unit suffered severe burns. Fatality.

[fire - consequence, training inadequate, vapour cloud explosion, injury]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 1      Dead : 0

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**Abstract**

Improper alignment of valve. Workers began heating a tank containing an acid solution used to de-scale heat exchangers. The tank was unintentionally filled to 100 percent and, when an operator was in the process of removing the inspection port, the pressure in the tank forced the port off the tank and the operator was sprayed with the acid solution. Extreme pressure had built up under the inspection port, and the steam supply by-pass valve to the heating coil was not aligned. The basic cause was the improper installation of by-pass valve, which increased the amount of steam going to the coil.

[installation inadequate]

---

**Lessons**

When working with high energy sources, such as steam, ensure that extreme care is exercised, repairs double checked, and that system valves are correctly identified/labelled.

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Fired heater tube failure. A heater tube failed during the start-up of a naphtha hydrotreater unit, causing damage to equipment and product loss. It was found that a liquid seal stopped flow while heater was firing and the tube failed due to ductile overload/severe overheating (blockage). The incident was caused by changes to process conditions and modifications to unit that led to the development of liquid seals.  
[tube failure, design or procedure error]

---

**Lessons**

Modifications to process design conditions and equipment must be subject to technical assessment and safety review.

Fired heaters require adequate instrumentation to ensure that overheating/uneven heating of tubes does not occur, e.g., individual pass flow and temperature monitoring, skin thermocouples, etc.

---

1196013 November 1994

**Source :** ICHEME

**Location :** , GERMANY

**Injured :** 0      **Dead :** 0

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**Abstract**

An explosion occurred in an incinerator. The incident occurred when a big lump of ash fell into the quench bath causing a large quantity of the water contents being spilt. There was no damage to equipment nor any injuries.

[near miss]

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**Lessons**

[None Reported]

---

6747 31 October 1994

**Source** : HAZARDOUS CARGO BULLETIN INCIDENT LOG, 1995, JAN.

**Location** : Trebister Ness; Shetlands, UK

**Injured** : 0      **Dead** : 0

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**Abstract**

Fish factory grounded, broke in two, fuel oil spilt and ammonia from refrigeration unit released.

[marine transportation, ship ran aground, spill, gas / vapour release]

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**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 1      Dead : 0

---

**Abstract**

Maintenance work was being carried out on a benzene reactor product heat exchanger tube bundle. The tube bundle for a similar heat exchanger had already been lifted out without difficulty. However, the tube bundle on this heat exchanger would not pull out, so two 50 ton hydraulic jacks of different makes and styles were used between the exchanger shell and the jacking frame to try to jack the bundle out of the shell. The craftsmen had been given verbal directions on how to carry out the work and were reminded to exercise caution during jacking. The craftsmen had noticed some of the bolt threads were worn and had added extra locking nuts to the bolts. One of the four stud bolts suddenly sheared, hitting one of the workers in the chest. He had a notebook and newspaper in the top pocket of his overall which absorbed much of the impact. The injury was minor. Following a study it was determined that:

1. The jacking operation overloaded the bolts such that one of them failed.
2. This type of failure had not been anticipated.
3. The strength of the stud bolts had been assumed to be adequate.
4. The workers were more aware of the hazards associated with lifting than with using the jacks.
5. The worker who was hit was standing in a high risk area, with the potential for a serious injury.
6. The jacks gave no indication of the load being exerted by them. As one jack was easier to operate than the other the load exerted was probably unequal.
7. If the load had subsequently lifted out, there was the potential for either jack to fall and injure personnel.
8. Jacks had been used before for similar operations.

[material of construction failure, injury]

---

**Lessons**

The lessons learnt were as follows:

1. Everyone using jacking equipment should be aware of the possible failure modes and place themselves in a position of safety.
  2. In such operations either a protective shield should be put in place or an exclusion zone set up.
  3. Equipment used in jacking operations throughout the factory should be designed and certified for a specific maximum safe working load.
  4. Each pulling or jacking operation should have a specific engineering instruction and personnel should be aware of the maximum permitted load.
  5. A safe method of checking the movement of the tube bundle is required.
-

**Source** : SEDGWICK LOSS CONTROL NEWSLETTER, 2ND QUARTER, 1994.

**Location** : Kaohsiung, TAIWAN

**Injured** : 0      **Dead** : 0

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**Abstract**

Fire on a cracker in a furnace and was put out in 5 minutes. Caused thought to be due to cracked furnace tube. Substance involved naphtha.  
[tube failure, fire - consequence, cracking]

---

**Lessons**

[None Reported]

---



Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

An explosion occurred in a waste incinerator, used to dispose of waste from acrylic and viscose plants. Damage was sustained by the incinerator and associated equipment. Immediately prior to the incident, fourteen drums, originating from a viscose making plant, had been discharged into the furnace. The explosion followed a couple of minutes later.

Although the precise circumstances of the explosion are not clear, it was considered that molten salt residues within the incinerator were involved and that the explosion was due to the rapid evaporation of water. Salts (sodium sulphate and sodium hydroxide), entering the incinerator with waste would form a molten pool in the kiln section.

[damage to equipment, normal operations]

---

**Lessons**

A number of recommendations were made. These included:

1. The kiln to be operated in such a way that molten salt pool formation is minimised.
  2. A number of routine jobs are carried out in the vicinity of the kiln. These are to be minimised and access to the area should be prohibited if the presence of a molten salt pool is present (and for a period of time after charging waste to the incinerator).
-

Source : ICHEME

Location : , GERMANY

Injured : 0      Dead : 0

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**Abstract**

A series of three explosion occurred within a few seconds in the waste incinerator of a chemical site during a night shift. There were no injuries and the damage sustained was slight. The incinerator burns waste from acrylics and viscose plants. The incinerator was operated for 20 years without any significant incidents. Salts (sodium sulphate and sodium hydroxide) were being charged and collecting as a molten pool in the rotary kiln section. A quantity of this residue had been allowed to build up. The explosion occurred within 2 minutes of a 14 drum charge being made to the system. On-site inspections suggested the damage caused was greater than that consistent with mild over-pressure but there had been no equipment failure. A Rapid Phase Transformation (or Physical explosion) caused by very hot molten salt entering the quench bath (containing water) from the kiln was seen as the most likely cause. This might have been triggered by a small transient over-pressurisation.

[charging, processing, overpressurisation, damage to equipment, accidental mixing]

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**Lessons**

1. Inventories of molten salt to be minimised within the incinerator. The best means of achieving this is not to change salts containing metal ions to the system.
  2. A programme of regular inspections of the kiln should be instigated to ensure that residues are not allowed to build up.
  3. Restrict access to the area at the bottom of the kiln, especially during and after charging.
-

6448 04 March 1994

**Source** : SEDGWICK LOSS CONTROL NEWSLETTER, 1ST QUARTER, 1994.

**Location** : North Sea, UK

**Injured** : 0      **Dead** : 0

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**Abstract**

Smoke alarm due to smouldering lagging on a fuel gas heater on an offshore platform.

[lagging fire]

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**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

During a spading operation on a pair of exchangers, some straight run naphtha was released and ignited on hot residue exchangers located directly underneath. It was found that no checks were made after steaming to verify the system as empty. Naphtha was admitted to the pipeline from passing valves and overflowed at outlet valve onto heat exchangers below. In addition, during prolonged steaming of the system, dirt had collected and piled up in front of the outlet valve.

Losses: approximately \$24,000 (1994).

[operator error]

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**Lessons**

Adequate drainage facilities and safe procedures need to be used to avoid spillages of oil from equipment being prepared for isolation.

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Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

A section of utility piping failed in a new distillate desulfurization unit at a refinery. The failure was as the result of internal overpressure generated from water freezing in a dead leg section of piping.

There was a release of hot product from the stripper section of the hydrotreater. The resulting vapour cloud ignited, and fire damage to nearby equipment released additional hydrocarbon.

The fire was brought under control in approximately one hour, and it was extinguished in 2 hours.

There were no injuries to personnel. Although the unit was quickly isolated, there was extensive damage to pumps, several air coolers, analysers, instrumentation, electrical conduits, and process piping. Direct damage to the unit was \$5.9 million (1994), and the unit was down for 52 days.

The dead leg piping was a result of improper piping design and inexact project execution.

[overpressurisation, cold weather, mechanical equipment failure, vapour cloud explosion, gas / vapour release, damage to equipment, design or procedure error, fire - consequence, processing]

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**Lessons**

1. Ensure that design teams identify expertise needed at an early stage; e.g., cold weather design experience was needed.
  2. Resolve HAZOP issues, not items, making sure that the group which resolves actions communicates back to the HAZOP team, to ensure that true concerns are adequately addressed.
  3. The Pre-Startup Safety Review (PSSR) should not only verify installation detail but that systems will function as intended. Piping configurations and other construction detail can sometimes cause systems to work poorly, or not as designed.
  4. Ensure that new plant has an adequate provision of fire protection, both in terms of equipment and emergency response.
-

124091994

Source : ICHEME

Location : ,

Injured : 2      Dead : 0

---

**Abstract**

A fire occurred on one of the charge pumps of the debutaniser section of a hydrocracker unit, resulting in severe damage to pumps, heat exchanger, air coolers, surrounding pipework, steel structure and the debutaniser column.

The cause of the fire was attributed to failure of the screwed drain connection of the pump casing.

Fortunately, there were no severe casualties, and only two minor injuries occurred during the fire-fighting operation. Repairs took six months to complete and cost approximately USD 7.5 million (1994).

The cause:

It was found that, in addition to the blown-out pump drain, some process lines had ruptured and a number of flanges had failed. However, since these lines and flanges showed no signs of significant corrosion, it was concluded that their failure was due to the heat of the fire.

[fire - consequence, damage to equipment, material of construction failure, flange failure, hot surface, injury]

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**Lessons**

[None Reported]

---

**Source :** ICHEME

**Location :** ,

**Injured :** 0      **Dead :** 0

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**Abstract**

Hydrocracker heat exchanger failure at a refinery.

Two occurrences of tube failures in an exchanger in the reactor effluent circuit each resulted in the hydrocracker being shut down. There was damage to equipment, and product loss. It was found that erosion, corrosion stress was brought on by velocities in the reactor effluent exchangers which were in excess of the licensor's recommendations.

The inadequate identification of both the corrosion risk to reactor effluent circuit exchangers and the appropriate mitigation strategy caused this incident.

[reactors and reaction equipment, refining, cracking]

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**Lessons**

Management of Change (MOC) techniques could have improved the timeliness of identifying both the corrosion risk to the reactor effluent circuit exchangers and the appropriate strategy to mitigate.

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6193 18 August 1993

**Source** : EUROPEAN CHEMICAL NEWS, 1993, 4 OCT.; LLOYDS LIST, 1993, 20 AUG.; CHEMICAL ENGINEER, 1993, 16 SEP.

**Location** : Charleston; West Virginia, USA

**Injured** : 30    **Dead** : 1

---

**Abstract**

Explosion in reactor cooler in plant making insecticide and nearby chemicals were ignited. Cloud of irritant fumes. Fire-water runoff contaminated river. One victim inhaled hydrogen cyanide gas thought to have been produced when chlorine acetoaldoxime and hydrochloric acid came into contact. Debris from explosion slightly damaged storage tank containing methyl isocyanate. Fatality.  
[heat exchanger, cooling, pollution, methyl isocyanate, acetoaldoxime]

---

**Lessons**

[None Reported]

---



Source : ICHEME

Location : ,

Injured : 0      Dead : 0

**Abstract**

A SCOT Unit at this refinery was scheduled for shut down on 3 August, to screen catalyst, as a high pressure drop across the reactor was limiting sulphur production. The shutdown procedure had been issued the week before, and it was re-issued again over the weekend in preparation for the shutdown. At 11.30 hours on 2 August, in preparation for the unit shutdown, and in order to stabilize the unit operation, the 16" start-up blower suction valve on the absorber overhead line, was cracked open. This move lowered the back pressure on the No. 2 Sulphur Train, allowing more process gas and air flow into the sulphur train. While the air to the train was being adjusted the heater outlet temperature dropped slightly. Fuel gas flow was increased to compensate for this temperature drop. Outside operators checked heater firing and reported the flames as slightly hazy. Additional fuel gas flow cleared this haze. Heater outlet temperature stabilized and unit operation looked okay. At about 15.30 hours the 16" blower suction valve on the absorber overhead line was opened further, and shortly afterwards, at about 16.00 hours, the SCOT heater inlet line was reported to be "cherry red". This line is insulated and has no temperature indication installed on it. Hydrogen to the SCOT unit was cut off immediately, the heater shutdown, and unit feed (Claus tail gas) diverted to the incinerator. Nitrogen flow was started through the heater via the blower suction line.

After the heater inlet line began to cool, additional nitrogen was added to the heater hydrogen supply line and later to the start-up blower discharge piping to aid in cooling. The 16" blower suction valve on the absorber overhead line was closed to prevent drawing heat back from the inlet line towards the incinerator. The heater outlet temperature dropped steadily and no further problems were noted.

An Incident Investigation Committee was set up and came to the following conclusions and recommendations.

1. The normal loop used for the blower operation was suspected to be plugged based on previous blower operation and the use of x-rays, it was recommended that the normal loop (Quench Tower Bypass) be insulated (this has been done).
2. The pressure drop across the SCOT reactor was too high for stable operation of the Sulphur Train; therefore develop shutdown guidelines based on plant performance, sulphur dioxide emissions versus allowable.
3. The lack of temperature indication on the inlet of the SCOT heater provided no early warning of an abnormal condition in the inlet line, so local skin couples should be installed on the line. Temperature sensitive paint will also be evaluated.

Other factors and recommendations arising from the incident:

1. There is a need for control room indication of the SCOT reactor pressure drop.
2. Operators responding to the incident should have worn self-contained breathing apparatus; this requirement will be incorporated into the Emergency Response Manual, other guidance.
3. A backflow prevention device on the blower is required and a request for a check valve should be submitted.
4. The ability to divert tail gas and the use of nitrogen purge could be hampered by the location of equipment; therefore, an engineering request will be submitted to specify the use of equipment needed for both the manual and automatic systems for nitrogen purge and for remote switches on the diverter valves.

[refining]

**Lessons**

Operators must frequently be reminded of the hazard presented by high concentration hydrogen sulphide found particularly in sulphur plant areas and the need to wear PPE when responding to emergencies or breaking equipment containment in any way which can lead to escape of gas or sour liquids.

Overheating of lines due to uncontrolled combustion/sulphur pockets is not uncommon on such units, and operators must be aware of the rapid actions to take to prevent line or vessel rupture, as was done successfully in this incident.

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

Crude distillation unit heater explosion in a refinery. During attempt to re-light crude furnace, following an emergency shut-down due to instrument air failure, an explosion occurred. Contributing to the incident was the urgency to re-light the furnace to prevent shutdown of the FCC (Fluid Catalytic Cracker) unit and related equipment. The cause was failure to follow safe-out and start-up procedures on the fired heater. There was damage to equipment and the total cost was estimated at \$8 million (1993).

[instrumentation failure, human causes]

---

**Lessons**

Supervisors should increase the awareness of all personnel, particularly operators, to the potential for explosions during non-routine situations such as hot and cold heater light-offs. Personnel need to develop a healthy respect of situations and to proceed with caution. Done correctly, such operations pose minimal dangers. Done incorrectly, these operations can prove to be hazardous to personnel as well as destructive to equipment.

---

6152 16 July 1993

**Source** : SEDGWICK LOSS CONTROL NEWSLETTER, 3RD QUARTER, 1993.

**Location** : Laporte, Texas, USA

**Injured** : 0      **Dead** : 0

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**Abstract**

Lightning disabled refrigeration units. An attempt was made to transfer material but peroxide in containers decomposed and ignited.  
[decomposition, fire - consequence, cooling]

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**Lessons**

[None Reported]

---

6137 02 July 1993

**Source** : CHEMICAL HAZARDS IN INDUSTRY, 1994, MAY.

**Location** : Fukuoka, JAPAN

**Injured** : 13    **Dead** : 0

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**Abstract**

Explosion at an aluminium plant when water seeped into smelter.

[unwanted chemical reaction, smelting furnace, processing]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A cooling tower brominator failure. A rapid overpressurisation of a brominator resulted in the PVC cap and exit piping to be blown free from the brominator's fibreglass shell.

Overfilling of the brominator with product minus the proper accompanying water level together with a higher than specification process additive content created an environment for exothermic product decomposition leading to generation of gases and subsequent pressure build-up. There were inadequate procedures for delivery and for verification of water level. The impact of incorrect levels in the brominator and change in chemical additive were not assessed. [cooling equipment, overflow, design or procedure error]

---

**Lessons**

Routine operations, if not done properly, can be a link in a chain of events leading to an incident.

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6072 17 May 1993

**Source** : HAZARDOUS CARGO BULLETIN INCIDENT LOG, 1993, JUL.; OIL AND GAS JOURNAL, 1993, 24 MAY.

**Location** : Catlettsburg; Kentucky, USA

**Injured** : 0      **Dead** : 1

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**Abstract**

Failure of a heater in no 2 crude unit caused a flash explosion and release of heated oil. Fatality.

[heating]

---

**Lessons**

[None Reported]

---

Source : PROCESS SAFETY PROGRESS VOL 16, NO 2, 1997.

Location : Goth Machhi, PAKISTAN

Injured : 0      Dead : 0

---

**Abstract**

A step increase in recycle gas flow and synthesis loop pressure was observed to occur in an ammonia synthesis loop. Leakage was suspected in the converter feed/effluent hot heat exchanger. The heat exchanger was of single pass floating internal head type with the bellows connecting the floating head to inlet nozzle. The internal bellow was considered the most vulnerable component, although other failure modes were possible. To locate the leakage, insulation was removed from the cold end of the exchanger and shell temperatures mapped. This indicated that leakage could be from the upper part of the bellows in the form of a high velocity jet.

Investigation and repair necessitated a plant shutdown. Replaced the bellows would have involved cutting through a 56mm thick head. Other options involved a sleeve inside the bellows connecting the inlet nozzle and floating head with a dynamic packing rings and gland.

The repair was carried out with an estimated saving of 10 days downtime.

As the bellow was not removed no metallurgical analysis of the failure was carried out. A typical reason for the failure could have been hydrogen attack combine with fatigue loading.

The repaired exchanger has subsequently been operating satisfactorily for a number of years without detectable leakage and with several shutdowns / start-ups.

[mechanical equipment failure, ammonia]

---

**Lessons**

Internal failure of a heat exchanger was located by indirect methods.

Bellows units are potentially vulnerable components.

An acceptable repair scheme for the failed bellows was devised which did not require cutting thick wall material and which saved significantly on downtime.

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6024 08 April 1993

**Source** : SEDGWICK LOSS CONTROL NEWSLETTER, 2ND QUARTER, 1993.

**Location** : Port Arthur, Texas, USA

**Injured** : 0      **Dead** : 0

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**Abstract**

Tube ruptured in crude oil heater. Damage extremely severe and heater collapsed.

[fire - consequence, heating]

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**Lessons**

[None Reported]

---



6005 29 March 1993

Source : ICHEME

Location : , FRANCE

Injured : 0      Dead : 0

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**Abstract**

Fire on ethylene oxide plant. Heat exchanger was open during plant shutdown when sludge caught fire.

[fire - consequence, processing]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , UK

Injured : 12    Dead : 5

---

**Abstract**

A major release of combustible gases and liquids took place on the gasoline treater unit of an ethylene plant. Severe damage occurred to pipework, an 8 inch line positioned underneath two heat exchangers surrounded by a platform ruptured. Ignition occurred after the release of gas, 80% hydrogen and 20% methane causing a massive fire. The radiation from this fire scorched the paint on the flat slab side panels of the cold box on the ethylene cracker. The works fire brigade and public fire services attended with speed and prevented any major escalation of the damage.

[burns, gas / vapour release, damage to equipment, fire - consequence, fatality]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

Isocracker air cooler failure at a refinery. Shortly after discovering a minor tube leak in a tube of an air cooled heat exchanger bundle on the isocracker, the tube ruptured. The tube failed due to acid corrosion.

Due to the collapse of the trays in the Recycle Splitter 12 months previous, the bottoms temperature of the first-stage stripper was lowered by 15-25 degrees F (8-14 degrees C) from its normal operating temperature. This "subtle" change caused an increased water content in the stripper bottoms and, as a consequence, normally dry conditions in the second stage air cooler became wet and accelerated ammonium chloride corrosion.

Losses total of \$1.6 million (1993), \$1.1 million (1993) in lost opportunity and \$0.5 million (1993) in maintenance and repairs.

[cooling equipment, tube failure, damage to equipment, cracking]

---

**Lessons**

Beware of small changes in operating conditions/modifications to plant, small changes in feedstock composition, etc. can produce accelerated corrosion conditions which may occur between inspection periods.

Regular removal of deposits from air cooled heat exchanger bundles/header boxes is recommended. Ensure any water flushing is done with chloride free water, and the bundle thoroughly air dried before return to service.

---

5970 March 1993

**Source** : LLOYDS LIST, 1993, 19 MAR.

**Location** : Horne; Quebec, CANADA

**Injured** : 0      **Dead** : 0

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**Abstract**

Explosion in copper smelter.  
[smelting furnace, heating]

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**Lessons**

[None Reported]

---

5969 28 February 1993

Source : SEDGWICK LOSS CONTROL NEWSLETTER, 1ST QUARTER, 1993.

Location : , SINGAPORE

Injured : 0      Dead : 0

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**Abstract**

Small fire within a visbreaker caused 2 day disruption. Equipment involved: heat exchanger.

[fire - consequence, cracking equipment]

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**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A refinery suffered a serious near miss incident when with-drawing a corrosion probe from a 14 inch live piping system on a Crude Distillation Unit. Unknown to the inspection engineers, the outer probe holder had suffered stress corrosion in service and had broken completely about 14 inch from the tip during the withdrawal operation.

There was a significant release of light hydrocarbon gases through the annular space between the probe holder and the probe when the broken part of the holder passed the retaining gland.

It proved impossible to close the valve on the tapping into the process line as the piece of the probe holder that had broken away was still lying in the valve body. The piping and associated heat exchanger had to be isolated to stop the release. Fortunately, no ignition occurred, and there were no injuries.

[gas / vapour release]

---

**Lessons**

The report stated the following recommendations:

1. When working on pressure circuits on-stream, thought must be given to the possibilities of accidentally breaking containment, e.g. changing corrosion probes, inadvertent removal of thermowells etc,
  2. Materials for all components in a system subject to corrosion must be such that sudden failure will not occur leading to release of hazardous materials.
-

5926 16 January 1993

Source : SEDGWICK LOSS CONTROL NEWSLETTER, 1ST QUARTER, 1993.

Location : North Sea, UK

Injured : 0      Dead : 0

---

**Abstract**

Sea water cooling water system failed due to bad weather on this offshore platform.

[weather effects]

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**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A small fire developed on the Waste Gas Incinerator of a FCCU Complex. The supply to the incinerator was shut off and the fire was left to extinguish itself under controlled conditions. At 00.04 hours on 8 January, a gas cloud escaped through the explosion doors of the incinerator. This time the major fire alert was given, the refinery fire brigade attending, with the local fire brigade on stand-by.

The cause of the fire is most likely to have been Vacuum Distillation Unit gasoil being carried forward with sour water from the sour water feed drum which was in open connection to the incinerator.

The Vacuum Distillation Unit start-up was in hand but nearly completed at the time of the incident.

The "all clear" signal was given at 01.50 hours. There were no injuries sustained in the incident and the FCCU remained on stream.

[fire - consequence, gas / vapour release, contamination, gas oil]

---

**Lessons**

The report stated:

1. Inspection/maintenance frequency for instrumentation alarms is a critical item, especially where fouling is a problem.
  2. Operational start-up procedures for units should consider possibilities of overloading/carryover of hydrocarbons in effluent disposal streams to incinerators. How to avoid and what remedial actions are needed.
  3. Adequate draining of pump suction is critical before commissioning, especially where the pump discharges to a vacuum column where immediate flashing of water/light hydrocarbons will occur which can lead to extensive tray damage.
  4. Slops disposal pump filters need regular attention and are to be checked for cleanliness before unit start-ups.
-



Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

Cracking unit kiln temperature excursion at a refinery. Temperature excursion encountered during start-up of a catalytic cracking unit.

The investigation team concluded that there were, actually, three separate incidents being realised at the time of the temperature excursion. An immediate and basic cause is provided for each of the three incidents.

Immediate cause

1. Deviation from normal operating procedures during start-up (Operating (equipment) without authority).
2. Leaving plate (blind) in the kiln outlet hopper after maintenance (Failure to secure).
3. Faulty board level instrumentation (Warning system).

Losses: catalyst damage, loss on margins, maintenance, environmental fines, for a total of \$3.25 million (1993).

[damage to equipment, refining, human causes, catalytic cracker]

---

**Lessons**

1. Clear, written instructions covering all operating phases, operating limits, safety systems and their functions.
  2. Safe work practices and mechanical integrity program to assure the integrity of plant and instrumentation prior to start-up.
  3. Thorough training of operators.
-

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

Fire at waste gas incinerator. A small fire developed on the waste gas incinerator of a Fluid Catalytic Cracker Unit (FCCU) complex. Shortly thereafter, a gas cloud escaped through the incinerator's explosion doors. The immediate cause was product carry-over that created a fire hazard, the basic cause was instrument alarm failure and suction filters of slop oil pump were blocked. Contributing was the incorrect execution of VDU start-up. Damage repairs: \$137,000 (1993) (U.S.).

[fire - consequence, instrumentation failure, operator error, gas / vapour release, heating]

---

**Lessons**

Operational start-up procedures for units should consider possibilities of overloading/ carryover of hydrocarbons in effluent disposal streams to incinerators. Address how to avoid and what remedial actions are needed.

Slops disposal pump filters need regular attention and should be checked for cleanliness before unit startups.

---

1091216 October 1992

Source : ICHEME

Location : ,

Injured : 7      Dead : 10

---

**Abstract**

An explosion and fire took place at a refinery, at 15.52 hours on October 16, 1992, resulting in 10 fatalities and 7 injured. It was caused by the failure of a breech-lock closure on a high pressure heat exchanger on a unit (Heavy Oil Indirect Desulphurization Unit).

Part of the refinery facilities were lost, as well as part of the storage tanks and lubricant manufacturing plant located next door. The total amount of direct property loss is 2.4 billion yen (about £15 million, or \$22 million) (1992).

The incident occurred during shutdown for catalyst replacement work, the process was being returned to operation. At about 15.52 hours, when the process was nearing normal operating conditions, the lock ring, the channel cover and a few other parts of one of the Feed/Reactor Effluent Exchangers burst apart, projecting to more than a hundred meters away. There was a simultaneous explosion of released hydrogen and fire developing near the exchangers.

A few minutes before the explosion, a major emission of hydrogen, probably accompanied by VGO liquid, noisily arose from vent and drain holes and other locations. The explosion took place while plant operators and site workers were taking measures to stop the emission.

During the shutdown for catalyst replacement, the feed/reactor effluent exchangers (including the failed one) were not opened for inspection.

[fire - consequence, fatality, mechanical equipment failure, processing, leak, injury]

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**Lessons**

[None Reported]

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Source : LOSS PREVENTION BULLETIN, 116, 9-13; ASAHI NEWSPAPERS; LLOYDS LIST, 1992, 17 OCT.

Location : Sodegaura; Chiba, JAPAN

Injured : 8      Dead : 9

---

### Abstract

An explosion and subsequent fire took place at an oil refinery following shutdown for catalyst replacement work. The accident occurred when the process was returned to operation and approached normal operating conditions. The lock ring, the channel cover and a few other small parts of the feed/reactor effluent exchanger burst apart throwing debris more than a hundred metres, followed by a simultaneous explosion of the spouted hydrogen and a subsequent fire near the heat exchangers. A few minutes prior to the explosion, a loud major emission of hydrogen arose from the vent and drain holes and other locations of the failed exchanger. During shutdown for catalyst replacement, the feed/reactor effluent exchanges, including the failed unit were not subjected to internal inspection. Fatality.

After investigation the causes of this accident were found to be:

1. The gasket retainer had not been replaced in spite of diameter reduction to such an extent that it could over-ride the gasket groove.
2. The grinding repair performed on the gasket retainer at the last maintenance shutdown in 1991 was not appropriate and made over-riding easier.
3. There were no technical standards for the replacement of the internal flange set bolts that took into consideration the effects of bolt wear on the force and deformation of the lock ring.

As a background to 1,2, and 3, above, it has been emphasised that there was no clearly defined role for management of equipment maintenance between the user of the equipment and its fabricator, who conducted in-shop maintenance. This resulted in inadequate technical judgement.

[inspection inadequate, refining, fire - consequence]

---

### Lessons

On the basis of knowledge obtained through this investigation, the committee has recommended measures to prevent recurrence of similar accidents.

These are:

1. Users of the same kind of exchanger shall carry out inspection of the gasket retainer and lock ring and whether the gasket groove and relevant parts were subjected to repair in the past. This shall be conducted at next temperature/pressure down (by internal inspection, even if there are no plans for open inspection at the next shutdown). The most appropriate maintenance control of these items shall be made.
  2. Users of the same kind of exchanger shall clearly specify role sharing for maintenance management when they place an order of inspection and maintenance to an equipment fabricator. This shall establish adequate maintenance organisations so as not to overlook any problems that could adversely affect safety.
  3. Fabricators of the same kind of exchanger shall review existing criteria for replacement of the internal set bolts and shall make the results of the review available to users of the exchanger.
  4. When conducting maintenance inspections, the exchanger fabricator shall clarify respective scope of work between the fabricator and the user so that the users are aware of their safety management responsibilities.
-

5811 05 October 1992

**Source** : SEDGWICK LOSS CONTROL NEWSLETTER, 4TH QUARTER, 1992.

**Location** : Los Angeles, USA

**Injured** : 1      **Dead** : 0

---

**Abstract**

A fire in a desulphurisation unit also affected reformer unit. Equipment involved: heat exchanger. Substance involved: naphtha.  
[fire - consequence]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 7      Dead : 10

---

**Abstract**

Heat exchanger failure results in fatalities. An explosion and fire occurred at the high pressure heat exchanger on a heavy oil indirect desulphurization unit. A reduced diameter of gasket retainer overrode the edge of the gasket groove, allowing a major emission of hydrogen during the period of rising temperatures and pressures just prior to the incident. The gasket retainer had not been replaced in spite of the diameter reduction to such an extent that it could override the gasket groove. Grinding repairs performed on the gasket retainer during a previous shut-down were not appropriate, in an attempt to extend the gasket's service life.

Total amount of property loss \$22 million (1992).

[high pressure, high temperature, fire - consequence, fatality]

---

**Lessons**

Particular care is needed in regular inspection and necessary repair of plant which is the subject of significant temperature cycles with possibilities of thermal fatigue.

---

**Source** : THE CHEMICAL ENGINEER, 1992, 15 OCT.

**Location** : St Fergus; Peterhead; Scotland, UK

**Injured** : 1      **Dead** : 0

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**Abstract**

During commissioning of a process heater a rise in gas pressure extinguished the flame by blowing it off the burner. This allowed a build-up of gas which was ignited by the pilot light. The resulting explosion badly damaged the heater. Substance: oil.  
[overpressurisation, damage to equipment]

---

**Lessons**

[None Reported]

---

5736 02 August 1992

Source : LLOYDS LIST, 1992, 8 AUG.

Location : Pickering; Lake Ontario, CANADA

Injured : 0      Dead : 0

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**Abstract**

3000 litres of radioactive heavy water leaked from a cracked tube in a heat exchanger system causing shutdown of water treatment plant.

[tritium, radioactive release, plant shutdown, spill, heating, drains & sewers]

---

**Lessons**

[None Reported]

---



**Source** : LLOYDS LIST, 1992, 2 JAN.

**Location** : Mount Isa; Queensland, AUSTRALIA

**Injured** : 0      **Dead** : 0

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**Abstract**

Steam explosion occurred at a lead plant when molten slag was discharged from a smelting furnace after a refractory failure and mixed with water in spillage pits.

---

**Lessons**

[None Reported]

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**Source** : SEDGWICK LOSS CONTROL NEWSLETTER, 1ST QUARTER, 1992.

**Location** : El Segundo; California, USA

**Injured** : 0      **Dead** : 0

---

**Abstract**

A fire broke out in a smaller crude unit. Equipment involved: heat exchanger.

[fire - consequence]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A tube burst in a hot oil heater resulting in a fire inside the heater at a refinery. The incident occurred during a start-up of the heater after a programmed electricity supply interruption to the area. The fire completely destroyed the heater coil with damage estimated at £750,000 (1991). There were no injuries sustained as a result of the incident. The loss of the heater caused a one week delay in bitumen deliveries.

A preliminary investigation was carried out on the day of the incident by the Operations Manager. A formal investigation team with written terms of reference was later set up by the Refinery Manager.

The Investigation Team found that the basic cause of the incident was that the heater burner was inadvertently put into operation.

Other causes which contributed to the incident were the bypassing of the protection systems and the absence of operating procedures for the heater burner.

[tube failure, fire - consequence]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

Failure of a tube in the 2nd stage effluent air cooler of the Isocracker Unit at a Refinery caused an unscheduled shutdown. There was no fire and there were no injuries. The maintenance and repair costs were \$223,000 (1991) with a production loss of \$278,000 (1991).

The basic cause for the incident was due to acid corrosion accelerated by water entering this normally dry system from a number of possible routes; e.g., a leaking stabiliser reboiler, carryover from the HP Separator, water washing of the stabiliser tower.

[piping & fittings, mechanical equipment failure, plant shutdown, product loss, damage to equipment]

---

**Lessons**

The report states th following recommendations:

1. Even small changes in operating conditions/modifications to plant, small changes in feedstock composition, etc. can produce accelerated corrosion conditions which may occur between inspection periods and hence lead to unexpected plant failure.
  2. Regular removal of deposits from air cooled heat exchanger bundles/header boxes is recommended. Ensure any water flushing is done with chloride free water, and the bundle thoroughly air dried before return to service.
  3. Wash water injection systems to be carefully monitored so as to avoid any chance of them producing adverse corrosion effects.
-

5210 1991

**Source** : CHEMICAL ENGINEERING NEWS, 1991, 29 JUL.

**Location** : Stockton; California, USA

**Injured** : 0      **Dead** : 0

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**Abstract**

Explosion of a bottle containing cuprous chloride solution used in the monitoring of carbon monoxide in lime kiln gas.

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**Lessons**

[None Reported]

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Source : HAZARDOUS CARGO BULLETIN INCIDENT LOG, 1991, FEB.

Location : Ufa, USSR

Injured : 8      Dead : 2

---

**Abstract**

An explosion and fire occurred in a plant producing high octane gasoline fuel at refinery. Repairs were being carried out at the time to stop a small leak in a heat exchanger element. Fatality.

[fire - consequence, refining]

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**Lessons**

[None Reported]

---

**Source** : SEDGWICK LOSS CONTROL NEWSLETTER, 1ST QUARTER, 1991.

**Location** : Wilton; Teeside, UK

**Injured** : 0      **Dead** : 0

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**Abstract**

During maintenance work on 1 of 4 feeders alternators, a power trip occurred. All steam supply was lost resulting in tubes being damaged in the furnaces of the olefins plant. Subsequent damage to offsite lines occurred as a result of pipe supports fracture caused by a surge effect of condensing vapours.  
[power supply failure, maintenance, damage to equipment, steam failure, furnace tube]

---

**Lessons**

[None Reported]

---

5171 15 November 1990

**Source** : LENOIR E.M & DAVENPORT J.A, A SURVEY OF VAPOUR CLOUD EXPLOSIONS SECOND UPDATE, PROCESS SAFETY PROGRESS, 1993, 12, (1), 12-33.; HAZARDOUS CARGO BULLETIN INCIDENT LOG, 1991, JAN.

**Location** : Leixoes, PORTUGAL

**Injured** : 7      **Dead** : 0

---

**Abstract**

Propane leaked from plug from heat exchanger in propane deasphalting unit. Explosion and fire followed.  
[fire - consequence, processing]

---

**Lessons**

[None Reported]

---



Source : LOSS PREVENTION BULLETIN, 129, 8.

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A vapour cloud explosion occurred in the hydrocracker unit of this 160,000 barrels-per-day refinery. A mechanical equipment failure involving the shell of a heat exchanger in this unit resulted in the formation of a vapour cloud, which was ignited by a heater. The subsequent fires in this unit burned for 10 to 12 hours before they were extinguished by the refinery fire brigade with mutual aid assistance.

As a result of this incident, the hydrocracker unit was shutdown for approximately three months for repair. However, the fire damage was limited to the hydrocracker unit and the refinery was brought back online within one week.

[refining, fire - consequence, damage to equipment, cracking]

---

**Lessons**

[None Reported]

---

4992 24 May 1990

**Source** : OIL AND GAS JOURNAL, 1990, 4 JUN.

**Location** : Edmonton; Alberta, CANADA

**Injured** : 2      **Dead** : 1

---

**Abstract**

An explosion in process heater in the crude oil processing area. Fatality.

---

**Lessons**

[None Reported]

---

4915 05 March 1990

**Source** : SEDGWICK LOSS CONTROL NEWSLETTER, 1ST QUARTER, 1990.

**Location** : Aubette, FRANCE

**Injured** : 0      **Dead** : 0

---

**Abstract**

An explosion occurred on an ethylene unit. Equipment involved heat exchanger.

---

**Lessons**

[None Reported]

---

**4897 20 February 1990**

**Source** : SYDNEY DAILY TELEGRAPH, 1990, 3 APR.

**Location** : Port Kembla, AUSTRALIA

**Injured** : 14    **Dead** : 0

---

**Abstract**

LPG gas leaked from oven and collected underneath before ignition.

[fire - consequence]

---

**Lessons**

[None Reported]

---

**4875 09 February 1990**

**Source :** LLOYDS LIST, 1990, 10 FEB.

**Location :** Schkopau, EAST GERMANY

**Injured :** 25    **Dead :** 5

---

**Abstract**

Two explosions in calcium carbide producing oven. Intense heat prevented fire fighters reaching site. Fatality.

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A depropaniser heat exchanger had been cleaned. The polymer that was removed was put into drums labelled "Aluminium Chloride". The cleaning team asked the shift manager to arrange for disposal of the drums.

However, there was a delay of several months in removing the drums. They were left on a gravelled area close to passing traffic.

The situation was brought to the attention of the shift manager when an instrument supervisor noticed that one of the drums was pierced.

It was realised that events of this kind could lead to serious consequences if the waste material could react with remains of the substance left in an uncleaned drum or if the waste material were itself hazardous.

[near miss, storage, design or procedure error]

---

**Lessons**

The following recommendations were made:

1. A procedure is needed to cover all aspects of depropaniser cleaning.
  2. All drums must be correctly labelled.
  3. Provide labels for all materials put in drums.
  4. Drums awaiting disposal to be stored in a cordoned off area.
  5. Expedite the removal of drums. They should be removed within one week after completion of the cleaning operation.
  6. Drums supplied to the cleaning team must be clean.
-

4877 01 February 1990

Source : WORLD LOSS REPORT, 1990, 23 FEB.

Location : Punta Cardon, VENEZUELA

Injured : 0      Dead : 0

---

**Abstract**

Leak on hydrofluoric acid recovery column ignited and burned out fin fan coolers. Fire burned for 55 hours because of difficulties in isolating an isobutane accumulator and flare system. Also stated that safety relief valve lifted and ignited. Note that world loss report gives date as 31/1/90.  
[fire - consequence]

---

**Lessons**

[None Reported]

---

**Source :** SEDGWICK LOSS CONTROL NEWSLETTER, FIRST QUARTER, 1990

**Location :** California, USA

**Injured :** 0      **Dead :** 0

---

**Abstract**

A series of explosions in a natural gas heater at the world's largest solar powered power station caused extensive damage.  
[damage to equipment]

---

**Lessons**

[None Reported]

---



**4706 12 September 1989**

**Source** : LOSS PREVENTION BULLETIN, 094, 16; CHEMICAL WEEK, 1989, 20 SEP.; LLOYDS LIST, 1989, 20 SEP.; HAZARDOUS CARGO BULLETIN, 1989 OCT., 91.

**Location** : Morris; Illinois, USA

**Injured** : 18    **Dead** : 1

---

**Abstract**

A fire and explosion occurred in an ethylene cracker days before it was due to restart following another accident three months earlier. A blockage occurred in the acetylene heat exchanger, and a valve opened by mistake led to a release of ethylene. This cooled the heat exchanger down to a very low temperature and caused brittle fracture of the heat exchanger. The gas was then ignited. Fatality.

[fire - consequence, gas / vapour release, cracking]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

Damage to a heat exchanger, caused thermal shock, at a petrochemical styrene plant.

[damage to equipment]

---

**Lessons**

[None Reported]

---

**Source** : OIL AND GAS JOURNAL, 1989, NOV.

**Location** : St. Paul; Minnesota, USA

**Injured** : 0      **Dead** : 0

---

**Abstract**

Naphtha reformer damaged when gasoline, leaking from a heat exchanger, ignited and started a fire.

[fire - consequence, damage to equipment]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , FRANCE

Injured : 0      Dead : 0

---

**Abstract**

A flashback occurred inside a firebox of an incinerator when an operator attempted to re-light what seemed to be a badly lit burner.

The minor damaged occurred to the incinerator in the incident and the was operator slight shocked and injured.

It is thought that the cause of the incident was due to when the operator increased the gas flow by opening fully the manual valve, it was possible that this lifted the flame off its burner and may have completely extinguished it, being re-light by the introduced ignitor.

There was also a possibility that the operator may have turned the manual cock gas valve, first off, then by reflex action back again, followed by re-ignition by the ignitor.

The design of the incinerator was considered as satisfactory.

[damage to equipment, fire - consequence,

---

**Lessons**

The following recommendations were made:

These included:

Redefining and completing the ignition procedures for all furnaces including purging requirements, fitting pilots to the incinerator, improve training for operators, installing new gas testing sample points on the incinerator and Improvements to ignitors and their maintenance.

---

Source : ICHEME

Location : , JAPAN

Injured : 3      Dead : 0

---

**Abstract**

Corrosion inside one of the outlet headers of an air fin fan cooler was caused by iron sulphide scale deposits accelerated by increased chloride content of fluid which itself was caused by a process modification which had resulted in decreased flow rate. Corrosion caused release of hydrogen rich gas with oil which ignited giving an explosion which caused 800 window glass damage.

[solids deposition, modification procedures inadequate]

---

**Lessons**

There is a technical lesson to be learnt about the corrosion of carbon steel under iron sulphide scale deposit in fluid containing hydrogen sulphide, ammonia and water.

1. Corrosion is fairly accelerated by iron sulphide scale deposits.
2. Corrosion is accelerated by chlorides which are concentrated in the scale.
3. Corrosion speed increases under tensile stress.

Safety management system

1. For such desulphurisation plant, management system of operation and equipment should be intensified to discover early and to measure any abnormal condition such as local corrosion.
  2. Safety examination system should be reinforced for modification or new installation facilities.
-

**Source :** LOSS PREVENTION BULLETIN, 129, 14.

**Location :** ,

**Injured :** 0      **Dead :** 0

---

**Abstract**

A fire occurred near a quench tower in the reactor area of this synthetic fuels plant. The main process equipment, such as the quench tower and associated heat exchangers, was not seriously damaged by the fire, however, the piping, instrumentation and electrical equipment in the process area experienced substantial damage. The tower skirts and pipe rack supports were protected by three to four hour rated fireproofing, which prevented the failure of these structures and limited the amount of property damage.

The fire resulted when a 6-inch carbon steel pipe, which is the return line of the recycle system for the quench tower that cools and separates the synthol reactor product stream, failed as a result of corrosion/erosion. Iron particles in the oil stream, subjected to a zone of turbulence, were a contributing factor in the pipe failure. The failure of the pipe caused a release of hydrocarbon product that spontaneously ignited under the high pressure and high temperature operating conditions.

[spontaneous combustion, fire - consequence, pipeline failure, processing, damage to equipment]

---

**Lessons**

[None Reported]

---

1211912 January 1989

Source : ICHEME

Location : ,

Injured : 0      Dead : 1

---

**Abstract**

Whilst working on the demolition of a cooling tower, a contractor was fatally injured when he fell from a working platform.

An investigation into the incident concluded that the contractor had fallen while attempting to cross a gap between two working platforms. There were no witnesses, however circumstantial evidence indicated that the contractor had fallen when a poor quality scaffold board bridging the gap gave way under his weight.

[fall, scaffolding, fatality, safety procedures inadequate]

---

**Lessons**

[None Reported]

---

**Source :** CLAYTON W E, GRIFFIN M L, CATASTROPHIC FAILURE OF A LIQUID CARBON DIOXIDE STORAGE VESSEL, AICHE 28TH LOSS PREVENTION SYMPOSIUM, ATLANTA, 21 APRIL 1994,; LOSS PREVENTION BULLETIN, 125, 3-10.

**Location :** Worms; Frankfurt, GERMANY

**Injured :** 10    **Dead :** 3

---

**Abstract**

A catastrophic failure of a liquid carbon dioxide storage vessel in a citrus process caused 3 fatalities and \$20 million (1988) in property damage. An investigation showed that the vessel had been overpressured due to ice formation in the safety relief valve and heater failure in the heating on mode. A list of other carbon dioxide vessel ruptures is given. Fatality.

[safety relief valve failure, overpressurisation, storage tanks, mechanical equipment failure, vessel failure, damage to equipment]

---

**Lessons**

1. Elimination of the use of carbon dioxide in many non-critical applications.
  2. Leased or rented equipment must be to the same standard of safety as owned equipment.
  3. Carbon dioxide storage tanks should not be heated with an internal heater.
  4. Development and adoption of specific company design requirements for liquid carbon dioxide storage systems into standard practice.
-



Source : ICHEME

Location : ,

Injured : 2      Dead : 0

---

**Abstract**

Dichloroacetophenon is made from 1,3-dichlorobenzene and acetylchloride. Cooling is provided by means of a 3-stage glass reflux cooler which is installed above the kettle.

For cooling, 1,3-dichlorobenzene of -5 degrees C is used in a closed circuit.

On the day of the incident, gas bubbles had formed in the cooling spirals, which prevented the normal circulation of the cooling medium. In an attempt to restore normal circulation, an employee closed and reopened the cooling medium inlet valve several times. Suddenly, a cloud of hydrochloric acid/acetylchloride vapours and liquid 1,3-dichlorobenzene escaped from the cooling medium inlet nozzle of the reflux cooler.

An employee was hit by a small splash, and a fireman inhaled vapours and sustained irritation of the respiratory system. The reaction kettle was immediately cooled, and the vapours were removed by the ventilation system and its scrubber.

Cause:

The glass nozzle of the heat exchanger had to bear the weight of the flexible steelpipe connected to it. The superimposed pressure shocks caused by the repeated closing and opening of the valve eventually led to the rupture of the nozzle.

[processing, gas / vapour release, material of construction failure, injury]

---

**Lessons**

The rupture of glass installations can never be excluded with certainty. Therefore, a special aspiration system with a steel ejector was installed, with remote control, to facilitate the aspiration of vapors in case of a rupture of the glass cooler

---

4265 26 August 1988

Source : HEMPSEED J W, ORMSBY R W, EXPLOSION WITHIN A HELIUM PURIFIER, PLANT OPERATIONS PROGRESS, 1991, 10, (3), JUL., 184-187.

Location : , BELGIUM

Injured : 0      Dead : 0

---

#### Abstract

A cryogenic charcoal adsorber used to purify helium for cylinder filling suffered an explosion. The feed gas contained only 1.4 percent, calculations confirm that a liquid phase containing approximately 85 percent oxygen could have formed at the inlet to the bed and soaked into the charcoal. This explosive mixture was probably ignited by the flow surge when the bed depressurized to allow change over from a full to an empty bank of cylinders.

Parts of the vessel were recovered up to 250 metres from the installation and windows were cracked by the shock wave at approximately 60 metres.

[unwanted chemical reaction, purification, cryogenic purifier, adsorption, separation]

---

#### Lessons

Other adsorbents, such as silica gel, can be substituted for carbon which can make the system more inherently safe.

Incorporation of a condenser/separator prior to the adsorber unit to ensure that condensed air is separated and removed prior to adsorption.

An in-line filter and sump arrangement to collect frozen liquid oil droplets and allow blowdown prior to entering the condenser/separator.

More rigorous hardware and procedural requirements for inlet gas stream impurity analysis.

Less pressure differential between bed operating pressures and settings of the back pressure valves to reduce any effects of bed depressurization.

Increased preventive maintenance procedures for the oil removal systems to minimize any potential of oil carryover into the bed.

Use of hot nitrogen purge through the adsorbent bed during the reactivation cycle.

---

**Source :** COMMUNITY DOCUMENTATION CENTRE ON INDUSTRIAL RISK, MAJOR ACCIDENT REPORTING SYSTEM LESSONS LEARNT FROM ACCIDENTS NOTIFIED, INSTITUTE FOR SYSTEMS ENGINEERING AND INFORMATICS, COMMISSION OF THE EUROPEAN COMMUNITIES JOINT RESEARCH CENTRE, 1991, ISBN 9282622894.

**Location :** ,

**Injured :** 0      **Dead :** 0

---

**Abstract**

During maintenance, an attempt was made to free a heater in the chlorine transfer circuit from residual liquid chlorine by introducing pressurised air. Due to an operator error, the chlorine evaporated and entered into the process air system. From this system it leaked at various points of the factory causing also nuisance to the neighbourhood (several complaints recorded by the local police which gave alarm face 2: annoyance, no danger).

[maintenance inadequate]

---

**Lessons**

1. Preparation of written maintenance procedures.
  2. Better training of personnel.
-

4060 1988

Source : ICHEME

Location : , BAHRAIN

Injured : 0      Dead : 0

---

**Abstract**

A fire occurred involving an aluminium smelting furnace and a rectifier. Source of ignition was electrical.

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

---

**Abstract**

A major release of HF (hydrofluoric acid/hydrogen fluoride) vapour occurred on an alkylation unit. The plant, which was shutdown, held some 120 tonnes of HF in the acid storage tank. A crane was lifting a 60 tonne heat exchanger unit over the acid storage tank when the crane became unstable and the load was dropped onto the tank shearing off a 3" or 4" NB relief valve stub. A jet of white HF vapour was released, with the fume extending 50ft vertically.  
[gas / vapour release]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

An explosion and fire occurred involving a furnace and molten aluminium. Aluminium smelter.

[fire - consequence, smelting furnace]

---

**Lessons**

[None Reported]

---

**Source** : PIPELINE AND GAS JOURNAL, 1987, DEC., 22-23.

**Location** : Brink Station; Maryland, USA

**Injured** : 0      **Dead** : 0

---

**Abstract**

Lightning struck an external natural gas pipeline heater and blew a hole in the fuel inlet valve and ignited the gas from the pipeline. Fire.  
[fire - consequence]

---

**Lessons**

[None Reported]

---

3916 30 May 1987

Source : ICHEME

Location : , SINGAPORE

Injured : 0      Dead : 0

---

**Abstract**

A fire occurred involving an exchanger at a refinery plant.

[fire - consequence, heat exchanger, refining]

---

**Lessons**

[None Reported]

---



Source : ICHEME

Location : , BELGIUM

Injured : 1      Dead : 0

---

**Abstract**

During plant maintenance a removed heat exchanger cover plate fell over, causing injury to one man's foot. The cover plate had been lodged against pipework, without any securing, and fell when the pipework was subject to vibration.

[operation inadequate, management system inadequate, injury]

---

**Lessons**

The lessons recorded in the report were:

1. The accident should never have happened, both Maintenance and Operations departments should have avoided the accident.
  2. The management system was inadequate.
  3. The actual operation was inadequate, as the individuals involved had not followed standard site practice.
-

Source : ICHEME

Location : ,

Injured : 1      Dead : 0

### Abstract

A fitter was struck by falling scaffolding poles. The poles fell from a load of scaffolding material which was being lifted by a crane up to an elevated walkway during a major overhaul. The fitter received severe bruising to his right elbow.

In order to perform a modification to instrumentation a scaffolding platform had to be constructed adjacent to an elevated walkway (30ft above ground) at fin-fan headers. All scaffolding required for the overhaul was being handled by a contractor and a foreman arranged for the use of a crane working in the area lifting heat exchangers to lift scaffolding tubes and boards up to the fin-fan walkway. In all four scaffolding boards and ten poles were required to build the scaffold.

When the crane became available to make the lift a rigger went in search of short slings as those already on the crane were too long and too highly rated for the lift and he doubted if they would be able to "bite" the scaffolding adequately. Whilst he was searching for the correct slings he noticed that the scaffolding gear had started to be lifted as a single bundle.

It transpired that while the rigger was away two of the scaffolders and a supervisor had rigged the scaffolding equipment as a single load using one of the long slings already on the crane hook with half hitches at the end of the load.

The load was lifted having checked for stability but the crane jib was too short to be able to land the load on the walkway.

While the crane driver was lowering the load for re-rigging it hit the underside of the walkway. This tilted the load and the scaffold poles fell vertically. The fitter working underneath, who was unaware of the lift, ran clear of the area when he heard a "clanging sound" from above. Nevertheless he was hit directly on the elbow from a falling pole and received glancing blows on the head and buttock from other falling poles. A scaffold board on which he had been working was pierced through by a falling pole.

The following conclusions were made:

1. The load was inadequately rigged.
2. The wrong types of slings were used both to allow the lift to be successfully completed and to bind all the equipment tightly.
3. Two slings should have been used.
4. Scaffold boards and poles should not be lifted together.
5. Lifting both allow the boards to assume a diamond arrangement or other similar patterns to be set up in the load which prevents the poles being held tightly.
6. Checks to ensure that all personnel were away from the area were not carried out.
7. The rigger who was designated to carry out the work was overstepped by other personnel, who used equipment which the trained rigger had deemed unsuitable.

[maintenance, safety procedures inadequate]

### Lessons

The following recommendations were made:

1. Only suitably qualified and identified personnel must be allowed to rig materials for lifting.
2. Scaffold boards and poles must not be lifted together.
3. Areas below lifts must be thoroughly checked to ensure they are evacuated.

**Source :** COMMUNITY DOCUMENTATION CENTRE ON INDUSTRIAL RISK, MAJOR ACCIDENT REPORTING SYSTEM LESSONS LEARNT FROM ACCIDENTS NOTIFIED, INSTITUTE FOR SYSTEMS ENGINEERING AND INFORMATICS, COMMISSION OF THE EUROPEAN COMMUNITIES JOINT RESEARCH CENTRE, 1991, ISBN 9282622894.

**Location :** ,

**Injured :** 0      **Dead :** 0

---

**Abstract**

An ice plug in a pipe downstream of a product heat exchanger, caused the pipe to be blocked. The heat exchanger being under pressure, leaked the product to the cooling water. As part of the cooling water was discharged into the environment (sea), part of the product was released with the water. As soon as no product delivery to the storage tank had been detected, the operators stopped the plant. As the removal of this heat exchanger had been planned during the next scheduled shut-down, this product exchanger was permanently removed after this accident.

After this accident, the installation of a closed-loop cooling water system will be recommended for plants where accidental leaking of products into the cooling water may be harmful to the environment.

[storage tanks, environmental]

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**Lessons**

[None Reported]

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**Source :** COMMUNITY DOCUMENTATION CENTRE ON INDUSTRIAL RISK, MAJOR ACCIDENT REPORTING SYSTEM LESSONS LEARNT FROM ACCIDENTS NOTIFIED, INSTITUTE FOR SYSTEMS ENGINEERING AND INFORMATICS, COMMISSION OF THE EUROPEAN COMMUNITIES JOINT RESEARCH CENTRE, 1991, ISBN 9282622894.

**Location :** ,

**Injured :** 0      **Dead :** 0

---

**Abstract**

The rupture of a purge valve, installed at the outlet of a heat exchanger for heating the phosgene solution, was the cause of the release. In about 15 minutes the leaking valve was isolated. The plant was shut down and the internal emergency plan put into operation. No people were injured outside the establishment. Some operators experienced minor irritation from phosgene exposure. Neighbouring plants, the fire brigade and the hospital were alerted.

---

**Lessons**

After this accident, the following measures have been established to prevent similar accidents to occur in the future:

1. The material of which the bolts of the valve was made, has been changed from B6-ANSI 410 to B7-ANSI 410.
  2. For this and similar services, valves to be replaced by new.
    - (a) globe valves bellow-sealed with a leak detector.
    - (b) ball valves with double-stem sealing.
-

**Source :** THE SAFETY PRACTITIONER, OCT, 1986.**Location :** ,**Injured :** 0     **Dead :** 2

---

**Abstract**

An LPG explosion in a garage killed two people, seriously injured two others and caused minor injuries to a number of members of the public who were nearby. Several months before the incident a 60 litre LPG vehicle, which was approximately one third full, had been removed from a transit van and placed in a storeroom in the back corner of the ground floor of the premises. During a clean up of the premises the on-off tap of the tank was accidentally struck with a sweeping brush allowing LPG to escape. This formed a cloud of aerosol droplets which evaporated and could be seen pouring into the garage and the heavy gas spread over the floor and into the vehicle pit. The premises were evacuated and about 5 minutes later the foreman managed to turn the tap off. The garage employees stayed on the forecourt for 20 minutes and then returned. They could no longer see the aerosol cloud as it had vaporised and could not smell gas.

Shortly after they re-entered the garage one of the men went to wash his hands in the toilets. There was an explosion which destroyed the whole building. It was thought that the gas fired water heater was the source of ignition.

[evacuation, gas / vapour release, hot surface, fatality, damage to equipment, cleaning, storage]

---

**Lessons**

The following recommendations were made:

1. LPG-fuelled vehicles should not be serviced over or near pits as LPG may build up in the pit.
  2. When tanks are removed from vehicles they should be kept in a safe place in the open air or in a properly constructed store.
  3. If a tank is not being replaced on a vehicle consideration should be given to emptying it by a safe method and purging it of residual LPG vapour.
-

Source : THE SAFETY PRACTITIONER, OCT, 1986.

Location : , UK

Injured : 0      Dead : 1

---

### Abstract

A security guard on a motorway construction site was killed on the night shift by carbon monoxide poisoning. He and his alsation dog were found dead in an office. A propane-filled radiant heater, which had been provided by his employer, was also in the office. The heater had an output of 11.8 kW and was designed to be used outdoors or in very large well ventilated buildings.

The ventilation in the office was inadequate for the heater. The gas inlet nozzle was partially blocked and the surrounding area was encrusted with mud. The result was incomplete combustion of the propane and build-up of carbon monoxide. The man's employer was prosecuted and fined £1500 (1986).

[safety procedures inadequate, fatality]

---

### Lessons

The following recommendations were made:

1. Heaters used in small offices must be designed to be used in such rooms.
  2. Heaters used in small offices should be properly maintained.
  3. Small rooms containing heaters should be adequately ventilated to ensure that the oxygen content does not drop.
  4. Permanent ventilation openings in a room should never be blocked up.
-

Source : ICHEME

Location : , UK

Injured : 1      Dead : 0

---

**Abstract**

A scaffolder entered the plenum chamber of a finned fan heat exchanger of a plant after being issued with a handover certificate (cold work permit) and an entry permit for the confined space. While the scaffolder was placing boards over the air aperture the steel deck plate on which he was standing gave way and he fell 37 feet on to the hardcore ground. No bones were broken, but the scaffolder was hospitalised.

The following conclusions were made:

The accident was a case where initial design weaknesses coupled with a deteriorating condition resulted in the deck plates becoming unsafe for use as a walkway. Access to the area was infrequent and was controlled by an Entry Permit. The hazard had gradually worsened due to adverse operating conditions.

[entry into confined space, fall, design inadequate, safety procedures inadequate, scaffolding]

---

**Lessons**

1. All activities in plenum chambers, ducting etc. which utilise the deck plates as a walkway should be reviewed to ensure that the design is adequate and that the condition of the deck plates, etc. makes for safe entry and where not suitable, appropriate alternative methods are made available and warning notices employed.
  2. Consideration should be given at the design stage to improvements of chamber, plenums and ducts, either to avoid the need for entry or where necessary, to ensure incorporation into the structure.
  3. Review site practices with respect to checking the structural condition of walkways/access ways before the issue of Entry Permits.
-

Source : PETROLEUM REVIEW, JULY 1986.

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

An LPG screw compressor was being test run using air when the high speed coupling burst explosively. The gearbox shaft end hit a heat exchanger 20m away. There was significant damage to the compressor. Several similar units had been tested in this way but this compressor had an extended shaft that was designed to reduce oil loss through the seal. Apparently the gearbox manufacturer could not achieve the required vibration limit on testing so he unilaterally reduced the weight of the high speed coupling.

[testing, coupling failure, damage to equipment, design or procedure error]

---

**Lessons**

1. Compressor manufacturers to demonstrate successful experience on an identical machine. If this is not possible then a detailed system dynamics check should be carried out.
  2. Better co-ordination between compressor/gearbox/driver manufacturers for a given application.
  3. Running speeds should not be closure than 15%-20% from critical speeds. (10% was predicted for this application)
-



**Source :** LOSS PREVENTION BULLETIN, 099, 14; EVENING SUN BALTIMORE. 1986, 16 JUN.

**Location :** Pascagoula; Mississippi, USA

**Injured :** 0      **Dead :** 0

---

**Abstract**

A batch still used to separate aniline product from its reaction by-products was shut-down on a Saturday due to a leak on the bonnet of a valve on the discharge side of a steam-heater reboiler. The reboiler served the still and its feed drum. Since repairs were not to be made until Monday, the circulating feed pump was shut down and valves were closed to isolate the reboiler, the steam supply to the reboiler, and the leaking valve. Cooling water to the condenser and operation of the reflux pump continued for several hours to lower the temperatures on the tower to a satisfactory level.

About eight and a half hours later, operators observed a high level in the reflux drum and high temperature at the bottom of the idle still. During the next hour, operators attempted to reduce these levels and temperatures but for unknown reasons, pressures increased. A relief valve at the top of the tower lifted, a vent at the reflux accumulator released liquids, and the tower bottom temperature went to 550 degrees F. Shortly after the area was evacuated, several explosions were heard. The explosions, the cause of which have not yet been determined, damaged structures and broke piping in an adjoining nitration unit. Flying fragments punctured two 2,000 barrel atmospheric tanks and a 15,000 gallon pressure tank which contributed fuel to a large ground fire. The still and its feed drum were destroyed, making the investigation into the cause of this accident most difficult.

[separation, high temperature, damage to equipment]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A release of LPG occurred on an HF alkylation unit in a refinery. The gas was released over a period of one and a half hours. Fortunately the gas cloud did not ignite. There were no injuries to personnel.

An investigation into the incident concluded that the LPG had been released from a hole caused by excessive localised internal corrosion of the outlet pipework of one of the two parallel isobutane recycle heat exchangers. A build up of iron fluoride deposits over a period of time in the outlet pipework had set up an environment which had allowed rapid localised corrosion to take place which had not been identified.

[leak, gas / vapour release]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A redundant heat exchanger was being cut up as part of a demolition programme, using oxy-propane burning equipment. The exchanger was titanium-tubed and some of the tubes caught fire. The fire was doused with water. This is a potentially very hazardous procedure, as burning titanium can react with steam, to evolve hydrogen, with possible ignition and explosion consequences. It would appear from the incident report, that this had not been appreciated prior to the incident. An explosion followed the fire.

[torch, fire - consequence, design or procedure error, maintenance]

---

**Lessons**

The main recommendation for future work of this kind, was to "cold cut" the exchangers.

In the event of fire, an alternative to water as the quenching material must be used, although the report did not mention this.

---

**Source :** SAFETY MANAGEMENT, MARCH 1987.

**Location :** , UK

**Injured :** 0      **Dead :** 0

---

**Abstract**

An explosion occurred on a spray drying plant used for production of non-dairy creamer, used in drinks. The explosion occurred due to failure to properly maintain equipment. The company was fined £1000 (1987).  
[human causes, processing, spray drier]

---

**Lessons**

[None Reported]

---

**3550 18 February 1986**

**Source :** NITROGEN, NO. 160, 1986, MAR/APR., 14.

**Location :** Arkansas, USA

**Injured :** 0      **Dead :** 0

---

**Abstract**

Failure of high pressure heat exchanger during start-up following a 4 month shutdown led to fire and explosion. Ammonia and urea units damaged.  
[fire - consequence, damage to equipment]

---

**Lessons**

[None Reported]

---

3511 15 January 1986

**Source** : INSTITUTE OF INSURERS

**Location** : Habshan, ABU DHABI

**Injured** : 0      **Dead** : 0

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**Abstract**

An operator in a control room noticed that there had been an automatic shutdown of two of the four burners in the base of a heater tower, on an oil plant. He tried to re-ignite one of the burners without success. He then left the control room to carry out a manual inspection, when there was an explosion and fire. [fire - consequence, heating equipment]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

**Abstract**

A fire occurred in a crude oil heater after it had been shutdown to remove a redundant section of pipework on a relief valve manifold.

The fire was extinguished within ten minutes, and there were no injuries to personnel. Damage to the heater consisted of a split heater tube.

During the afternoon of the previous day, the coil outlet pipework to be worked on was spade isolated and the line was steam purged. At 03.30 hrs on the day of the incident an increase in production demand necessitated the recommissioning of the gas turbine set. Prior to start up of the turbine the operators checked the status of the inlet and bypass dampers on the heater but did not check the position of the heater outlet damper. In addition they did not check the status of the heater coil but assumed that it was either full of water or empty.

Later on during the day, the control operator recorded the following temperatures on the heater system 154 degrees C for the coil tube skin 72 degrees C for the heater arch 159 degrees C for the crude oil outlet from the coil 425 degrees C for the heater flue gas stack temperature.

Both the crude oil outlet temperature and the flue gas stack temperatures were to be expected since one indicated the steam purging temperature in the coil outlet pipework and the latter showed the temperature of the flue gas in the flue gas outlet duct downstream of the bypass connections. The inside operator did not realise the significance of the high heater arch temperature nor the high tube skin temperature in relation to the shut down heater and therefore did not prompt any investigation.

At 15.30 hrs on the same day, yellow/brown smoke was seen coming from the common heater stack. This was reported to the control room and immediately checks were carried out on all on-line burners for any upset condition - none were found. The smoke continued to emit from the stack but had turned black in colour, a recheck was carried out on all heaters. As a result of these checks a pool of burning liquid was discovered inside the firebox of the shut down crude heater.

Snuffing steam was immediately introduced into the firebox, the outlet damper shut and the gas turbine taken off-line.

The fire was extinguished within ten minutes.

Subsequent inspection of the heater revealed that a tube had burst.

Cause of the Incident:

Oil was released into the firebox following the rupture of an overpressured heater tube. The fire resulted from ignition of hydrocarbons by hot turbine gases.

[fire - consequence, tube failure, overpressurisation, damage to equipment]

**Lessons**

Several important lessons can be learned from this incident:

1. That prior to embarking on a planned unusual or unfamiliar mode of operation for whatever reason, it is essential that a critical analysis and a feasibility study of the operating mode to be undertaken is carried out. All operating procedures, monitoring procedures, control procedures and communication systems to be employed must be thoroughly examined to ensure that satisfactory measures have been taken to maintain the integrity of the unit throughout the planned work programme.
2. The shutting down of a crude oil heater and its preparation for maintenance is a complex operation that demands care and attention throughout all stages. It is essential that well structured and comprehensive shut down procedures, systems and check lists are provided to ensure that the numerous complex tasks associated with such an operation are completed in a safe, efficient manner to maintain the plant integrity. This would have been particularly beneficial had it been applied to the operations associated with taking the crude oil heater off-line and preparing it for maintenance.
3. It is equally important that the operating workforce, including supervision are made fully aware and understand the particular hazards associated with the work involved. It is imperative that they appreciate the significance of maintaining good effective control at all stages, in order that all potential problems are recognised and identified as early as possible, so that their relative significance to the overall safety of the unit can be assessed and corrective measures taken if required. No deviation from the procedures are to be permitted unless authorised through a modification procedure.
4. Similarly, the success of such an operation depends on the installation and use, by all parties (supervisors and workforce), of an effective formal communications system (i.e. written and verbal). This ensures that any deviations from plan, for whatever reason, are immediately communicated formally to the appropriate level of authority for consideration and action.
5. In this incident the communications between the operating workforce and their supervision were far from ideal and were a major contributory factor leading to the incident.
6. The success of any work programme such as that undertaken above, depends on the effectiveness of the isolation of equipment from all process streams. In the case of this incident it is evident that the isolation procedures adopted were inadequate in that they failed to positively isolate the unit from all its process streams. Had systems been set up to check and monitor the effectiveness of the isolation carried out on the unit following its shut down, then the problem of the passing inlet flue gas damper would have been discovered at an early stage and alternative isolation methods could have been adopted.
7. The attention of refineries is drawn to the problems associated with having the tube skin temperature alarm of a heater coil being set so high that it fails to alert operating personnel sufficiently early of a potential problem, similar to that experienced in this incident which led to the rupture of the tube. Refineries, with similar installations, are advised to review their equipment in relation to adjusting the tube skin temperature alarms to avoid a similar incident.

**Source** : GLASGOW HERALD, 1986, 7 JAN.

**Location** : Mossmorran; Fife, UK

**Injured** : 0      **Dead** : 0

---

**Abstract**

An explosion and fire occurred in a heat exchanger on an ethylene plant.

[fire - consequence]

---

**Lessons**

[None Reported]

---



Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A large quantity of dense smoke was seen to be coming from the chimney of an acrylonitrile plant incinerator. Investigation showed that there was an accumulation of residues in the incinerator firebox. The plant was shutdown to test for hydrogen cyanide downwind but none were found.  
[plant shutdown, heating]

---

**Lessons**

The following recommendations were made:

1. Provide a means of flow control and measurement, with provisions to ensure that this is maintained within the rated capability of the burners.
  2. Provision should be made for circulating the residues storage drums in order to avoid layering.
  3. A regular routine of inspection of the burner tips should be carried out.
-

3346 06 July 1985

**Source :** 100 LARGEST LOSSES 9TH EDITION, MARSH & MCLENNAN PROTECTION CONSULTANTS, 1986; LLOYDS LIST, 1985, 8 JUL.

**Location :** Clinton; Iowa, USA

**Injured :** 8      **Dead :** 0

---

**Abstract**

A fillet weld failure on a 2 inch recompressor cylinder discharge line in an ammonia plant released synthesis gas at 5000 psi. The 50 ft by 350 ft compressor building rapidly filled with gas before ignition took place 30 - 45 secs later. One of the electric motors driving the four compressors was the probable source of ignition. The explosion caused widespread damage to the buildings, the cooling tower, and to an acid plant. A blast resistant control building sustained no damage.

[damage to equipment]

---

**Lessons**

[None Reported]

---

9692 01 July 1985

Source : ICHEME

Location : , SWEDEN

Injured : 0      Dead : 0

---

**Abstract**

A contractor's hut was burnt out, probably due to an electric heater that has been covered by clothing.

[fire - consequence, human causes]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

An explosion occurred in a firebox of a Vacuum Distillation Unit fired heater. The force of the explosion lifted the radiant section roofs and scattered brickwork up to 10 metres from the heater structure. Damage costing an estimated £25,000 (1985) resulted. No injuries are reported.  
[damage to equipment]

---

**Lessons**

The report stated the following recommendations:

1. The foul gas burners to be fitted with their own pilot gas burners to ensure prompt ignition of any foul gas generated.
  2. The stability of the pilot gas burners and main gas burners to be checked on start-up, both for various settings of the fan dampers and main gas burner louvre openings.
  3. Highly paraffinic residue stocks are prone to cracking. Extra attention is to be given to furnace firing. The process of such feed stocks to be minimised or avoided during start-up.
  4. An expert view of the furnace firing control, linked to the vacuum system and foul gas relief system to be instigated with a view to future recommendations.
-

3313 16 May 1985

**Source** : LLOYDS LIST, 1985, 6 JUN.

**Location** : Stenungsund, SWEDEN

**Injured** : 0      **Dead** : 0

---

**Abstract**

Ethylene cracker put out of operation due to collapse of cooling tower.

[cracking]

---

**Lessons**

[None Reported]

---

3300 29 April 1985

**Source :** INSTITUTE OF INSURERS

**Location :** Bosnanski Brod, YUGOSLAVIA

**Injured :** 0      **Dead :** 0

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**Abstract**

Failure of an 8 in steel outlet pipe from a gas heater which ruptured and allowed hydrogen to escape with ensuing rapid ignition. Leak.  
[fire - consequence, pipeline failure]

---

**Lessons**

[None Reported]

---

1156910 April 1985

Source : THE GUARDIAN, 11 APRIL, 1985,; THE TIMES, 11 APRIL, 1985,; THE GUARDIAN, 12 APRIL, 1985.

Location : , UK

Injured : 20    Dead : 0

---

**Abstract**

An explosion at an automotive factory, in a department used to prepare cars for motor shows. It is believed that the cause was due to petrol being accidentally left in the tank of a new car that was being prepared for an exhibition. The process involved the vehicle being placed into a gas-fired oven.

The explosion shattered the glass roof to the building which fell on the men working below. Approximately 20 were injured, 2 of them seriously.

[processing, heating, road transport, design or procedure error, gasoline, injury]

---

**Lessons**

[None Reported]

---

3282 10 April 1985

Source : GUARDIAN, 1985, 12 APR.

Location : Cowley, UK

Injured : 24    Dead : 0

---

**Abstract**

Gasoline left in car put through a spray oven causing explosion.

---

**Lessons**

[None Reported]

---



3255 09 March 1985

Source : ICHEME

Location : Aceh, INDONESIA

Injured : 0      Dead : 0

---

**Abstract**

A fire occurred involving a heat exchanger on fertiliser plant.

[fire - consequence]

---

**Lessons**

[None Reported]

---

9678 08 March 1985

Source : ICHEME

Location : , SWEDEN

Injured : 0      Dead : 0

---

**Abstract**

During the draining of a level gauge on the amine treater, liquid hydrocarbon was carried to a heated sump where it vaporised and was ignited by the adjacent sulphur unit tail gas incinerator. The flash fire caused damage to instruments and cabling costing £2,870 (1985).  
[fire - consequence, damage to equipment, gas / vapour release]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

Laggers were working around heat exchangers on the visbreaker which was to be shutdown the following day.

A pressure gauge became unscrewed from a spigot in a pipeline and started to leak, the scaffolders moved quickly away, ignition occurred and a fire covering an area of some 15m<sup>2</sup> developed. Damage to small bore pipework, cables and control equipment cost £100,000 (1985).

The laggers denied touching the pressure gauge. The gauge had been changed a couple of months ago and may have been cross threaded or incompatible threads offered.

[fire - consequence, damage to equipment, maintenance]

---

**Lessons**

[None Reported]

---

3202 13 January 1985

Source : LLOYDS LIST, 1985, 28 JAN.

Location : Dayto; Cleveland; Ohio, USA

Injured : 0      Dead : 0

---

**Abstract**

A build-up of methane gas in a trash pit at an incinerator ignited and set fire to a building.

[fire - consequence, heating]

---

**Lessons**

[None Reported]

---

**3196 06 January 1985**

**Source :** LLOYDS LIST, 1985, 9 JAN.

**Location :** Ciudad Juarez, MEXICO

**Injured :** 27    **Dead :** 0

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**Abstract**

Transportation. Natural gas leak from a pipeline ignited by a heaters pilot flame caused explosion.

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**Lessons**

[None Reported]

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**Source :** COMMUNITY DOCUMENTATION CENTRE ON INDUSTRIAL RISK, MAJOR ACCIDENT REPORTING SYSTEM LESSONS LEARNT FROM ACCIDENTS NOTIFIED, INSTITUTE FOR SYSTEMS ENGINEERING AND INFORMATICS, COMMISSION OF THE EUROPEAN COMMUNITIES JOINT RESEARCH CENTRE, 1991, ISBN 9282622894.

**Location :** ,

**Injured :** 0      **Dead :** 0

---

**Abstract**

The reactor was used to oxidise a pyridine compound with hydrogen peroxide using a maleic anhydride catalyst to form a pyridine-n-oxide. The reaction was recognised to be exothermic, therefore, hydrogen peroxide was added at controlled rates. Safety features included, circulation of the reactor content through 2 heat exchangers, a 200 cm pressure relief line to the atmosphere with a 0.7 bar bursting disc, a water quench tank situated 3 m above the reactor, which should dump automatically its content into the reactor should a sudden rise of temperature occur.

The peroxide addition pump should not operate if the quench tank was not full, the circulation pump was not operating or the reactor vent was not open to the atmosphere.

Probably due to an error of the operator, an accelerated rate of hydrogen peroxide (estimated to be about one order of magnitude higher than the normal addition rate) through the manual by-pass led to a sudden temperature increase. Although the quench tank was automatically activated, an explosion occurred a short time later and the entire reactor content was emitted either to the process area through the reactor manway, which was covered with an aluminium foil disk which should burst at 0.14 bar, or to the atmosphere through the pressure relief line.

[reactors and reaction equipment, operator error, high temperature]

---

**Lessons**

1. The closure of the reactor manlid during oxidation.
  2. The removal of the by-pass on the peroxide transfer line.
  3. The provision of an emergency dump tank on the reactor 200 cm vent line.
-

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

The chloride activated catalyst in a naphtha reforming unit has to be regarded by burning off coke. Shortly after coming back on stream after a regeneration, a leak development in the reactor effluent air cooler. During regeneration a bicarbonate solution was injected to the inlet of this cooler to prevent hydrochloric acid corrosion. It was found that the control for maintaining the composition of this solution for the whole regeneration period were inadequate. This was corrected and the injection point was modified to improve distribution of the solution.

[hydrochloric acid, start-up, fin fan cooler, blowout, cleaning inadequate, inspection inadequate]

---

**Lessons**

[None Reported]

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---

**Source :** ICHEME**Location :** ,**Injured :** 0      **Dead :** 0

---

**Abstract**

An explosion occurred within the crude oil heater and its economiser. The unit had been shut down about half an hour earlier due to foaming in the crude pre-flash column which resulted in liquid carry-over into the fuel gas system. No damage was caused to the process tubes inside the heater but the economiser shell was deformed, the refractory damaged and the flue gas ducting expansion joints were ruptured. No fire ensued and no personnel injuries are reported as a result of the explosion. Repair costs were about £20,000 (1984) and plant downtime about 60 hours.

**Cause of the Incident:**

The violent fluctuations of level in the preflash column and overhead vessels is considered to be due to foaming resulting from the presence of stripping steam condensate in the upper part of the column.

The main cause of the fire and explosion was the failure to close the individual gas burner valves on closing the main isolating valve 'A'.

The incident took place on night shift after a process upset during the afternoon and it would appear that the nightshift staff were not aware that the gas burner valves were open when they first cracked open the 6 inch isolating valve to permit drainage. This would have allowed liquid hydrocarbon to pass into the furnace causing the early fire. Initially it had been thought that this burning liquid dripping from the heater base had originated from the pilot gas burners. However, with hindsight since the pilots were being fed from the regasser this could not have been the case.

Since the night shift did not realise this, they opened the 6 inch isolating valve a second time after shutdown and purged with steam in order to drain liquid from the gas header. However, this hydrocarbon liquid would have entered the heater through the open burner valves.

The reduction in steam out rate mentioned earlier would have resulted in the heater being inadequately purged. The hot heater would have vaporised the naphtha/crude oil and the explosive mixture would have been ignited by hot refractory in the firebox or economiser.

[design or procedure error, heating, fire - consequence]

---

**Lessons**

[None Reported]

---



3169 20 December 1984

Source : HAZARDOUS MATERIALS INTELLIGENCE REPORT, 1985, 1 FEB.

Location : Akron; Ohio, USA

Injured : 7      Dead : 3

---

**Abstract**

Sawdust mixed with waste oil, toluene, xylene and other solvents, was put into an incinerator and an explosion occurred. Fatality.  
[heating]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A frozen steam line ruptured releasing 230 degrees C steam into a chlorine storage building. The steam heated up the building and the chlorine storage cylinders to at least 71 degrees C at which the cylinders' fusible plugs melted, releasing 3 tonnes of chlorine gas.

The actuation of the chlorine gas detector, the use of water fog to knock down the chlorine gas clouds, the mutual aid received, and perhaps most significantly the cooling tower updraft, all contributed to minimising the impact of the release. There were no injuries.

[gas / vapour release, high temperature]

---

**Lessons**

[None Reported]

---

**Source** : FIRE PREVENTION, JUL, AUG, 1985, NO. 181, PAGE. 42-44.; HAZARDOUS CARGO BULLETIN, FEB, 1986, PAGE 55-56.; HAZARDOUS CARGO BULLETIN, FEB, 1985.; THE GUARDIAN, DEC 4, 1985.

**Location** : Sheffield, UK

**Injured** : 30+ **Dead** : 0

---

**Abstract**

A steel framed warehouse with asbestos clad internal walls and roof was destroyed by fire. Investigation showed that the fire was probably started by an office heater in a unit used to store polyurethane foam furniture. The fire was able to spread rapidly through the building due to undivided wall and roof cavities, by pieces of burning asbestos falling from the roof and by heat conducted through the steel internal walls. Fire appliances also experienced difficulties with access to the building and to water supplies. The fire was brought under control around 15 hours after starting, but damping down operations were delayed until the toxic and highly toxic chemicals stored in the warehouse could be identified. Asbestos particles were carried up to 16km away by the wind. 31 local schools were closed and a public warning was issued. Between 30 and 70 firemen later suffered symptoms of exposure to a mixture of smoke and chemical fumes.

[warehousing, fire - consequence, storage, people, hot surface, design or procedure error]

---

**Lessons**

The investigation report made the following main recommendations:

1. More firemen should have been issued with breathing apparatus.
2. Warehouse users should obtain appropriate information about the hazards associated with the materials they are storing, and arrangements should be made for this information to be readily available to emergency services.
3. Toxic, corrosive, highly flammable or potentially explosive materials should be stored in dedicated fire-proof compartments, segregated from other goods. Locations of all stored materials should be recorded on a site plan.
4. The availability of private water supplies for fire fighting should be checked by owners.

Other recommendations and suggestions included:

A review of procedures for routine site inspections by the fire service, review of building regulations to reduce the risk of fire spread in large single storey buildings, owners of similar buildings to monitor tenant's compliance with relevant legislation, owners & occupiers to install smoke detectors, partition large buildings into fire-resisting compartments, provide fire vents in roofs and check private water supplies, BSI to review test procedures for roof & ceiling materials.

---

Source : THE GUARDIAN, 20 SEP, 1984.

Location : , UK

Injured : 82    Dead : 0

---

**Abstract**

A release of gas from a chemical works affected over eighty workers of an adjacent plastics factory. Two workers from the plastics factory were sent home and eighty others complained of headaches and sore eyes after a gas emission from the chemical plant lasting two and a half hours. It is thought the gas was hydrobromic acid gas, believed to have been caused when a bromine contaminated solvent was mistakenly used as fuel to start-up an incinerator after the weekend break.

This is believed to have produced eye-sensitive by-products not produced at normal operating temperatures. The fuel consumption figures showed that the emissions were at a low concentration, and capable of causing irritation.

[gas / vapour release, contamination, processing, people]

---

**Lessons**

Immediate steps have been taken to prevent a recurrence.

---

3019 07 June 1984

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

---

**Abstract**

Fire occurred on a cooling tower a refinery Fluid Catalytic Cracker Unit (FCCU) plant.

[fire - consequence , refining, fluid cracker]

---

**Lessons**

[None Reported]

---

2955 26 March 1984

Source : INSTITUTE OF INSURERS

Location : , PHILIPPINES

Injured : 0      Dead : 0

---

**Abstract**

Explosion of an asphalt mix heater due to human error. Operator fired 2 burners which were not in operation unaware of the fuel vapour.  
[human causes]

---

**Lessons**

[None Reported]

---

**2940 08 March 1984**

**Source :** LOSS PREVENTION BULLETIN, 106, 9-13; LLOYDS LIST, 1984, 9 MAR.; 100 LARGEST LOSSES, 9TH EDITION, MARSH & MCLENNAN PROTECTION CONSULTANTS, 1986. LOSS PREVENTION IN THE PROCESS INDUSTRIES, PAGE 2-5.

**Location :** , INDIA

**Injured :** 0      **Dead :** 4

---

**Abstract**

This incident occurred in a fuel refinery commissioned in 1966. It is believed that light ends from a leak in a heat exchanger entered the return cooling water lines and travelled to the cooling towers where they were released. Ignition was probably from the adjoining utility plant. The explosion occurred involving storage tanks subsequently causing a fire. The explosion was heard and felt two kilometres away. Refinery personnel who went to the site immediately and reported that three tanks, two containing naphtha and the other containing aviation fuel were involved in the fire.

Fire fighting operations were made difficult because naphtha from one of the tanks had spilled through a damaged pipeline into the dyke which was on fire.

Another tank developed a leak in the bottom and its contents were spilling into the dyke. As cooling water to the tanks was being applied in larger quantities than could be drained out, water levels in dykes continued to rise. In fact pumps had to be used to dewater the dykes.

The damage to the property inside the refinery was spread over a large area. The utilities area, the chemical warehouse and three storage tanks were damaged by the explosion and fire.

[fire - consequence, refining, fatality, burns]

---

**Lessons**

[None Reported]

---

2939 06 March 1984

Source : INSTITUTE OF INSURERS

Location : Grimsby, UK

Injured : 0      Dead : 0

---

**Abstract**

Incombustible gas extinguished flame in heater then fuel gas entered causing explosion.

[flameout]

---

**Lessons**

[None Reported]

---



2914 10 February 1984

Source : INSTITUTE OF INSURERS

Location : , SOUTH AFRICA

Injured : 0      Dead : 0

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**Abstract**

Instrument air failure caused shock to 2 tubes in the oven.

[mechanical equipment failure, air system failure]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

During the recommissioning of a hydrocracker, a tube failure occurred in the hydrogen recycle heater. The resulting explosion damaged other tubes and part of the heater refractory lining. The fire service, who were already on the unit to deal with a small fire on a leaking joint, contained the fire within the furnace and minimised damage to the casing.

Apart from minor burns, no injuries were sustained.

[fire - consequence, cracking]

---

**Lessons**

[None Reported]

---

123011984

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

An incident occurred during maintenance on a heat exchanger. Two fitters were sprayed with oil whilst removing three tubes from a vertical fixed tube sheet reboiler for inspection. Fortunately, neither of the fitters was injured.

An investigation discovered that the shell side of the exchanger had been left under nitrogen pressure.

[near miss, safety procedures inadequate]

---

**Lessons**

The following recommendations were stated in the report:

The condition of equipment must be checked before a clearance certificate is issued.

A check on the exchanger would have revealed that it was still under pressure.

Fitters carrying out the work must follow all safety precautions specified on a safety certificate.

This is particularly important in plants handling highly toxic material such as phenol.

---

2851 31 December 1983

Source : INSTITUTE OF INSURERS

Location : Haifa, ISRAEL

Injured : 0      Dead : 0

---

**Abstract**

Fire inside heater due to leak in 1 of its tubes and fire in gate valve due to gasket failure.

[fire - consequence]

---

**Lessons**

[None Reported]

---

Source : PLANT / OPERATIONS PROGRESS (VOL. 6, NO 1) JAN 1987

Location : Houston, USA

Injured : 0      Dead : 0

---

**Abstract**

Several firemen and an employee barely escaped from an anhydrous ammonia explosion in an ice-cream factory. The building engineer was checking the refrigeration system when he saw a developing vapour cloud, shut down the liquid line and notified the fire department. While the engineer and the firemen were making preparations to enter, there was an explosion which blew the building apart. Ammonia vapour issuing from the basement was controlled by heavy water coverage. The basement itself was filling with water from fractured sprinkler pipework. The Hazardous Materials Response Team decided to flood the basement, which eventually terminated the incident. It was impossible to determine the exact cause of the devastation. One theory, that hot light fittings had been shattered on contact with cold ammonia vapours, was later challenged by the possibility of hot compressor oil being initially ignited and, in turn, igniting the ammonia vapour. [refrigeration unit, vapour cloud explosion, gas / vapour release, normal operations, leak]

---

**Lessons**

The following lessons were learnt:

1. Misconceptions regarding ammonia incidents were seriously shattered.
  2. The incident proved that ammonia can burn violently.
  3. A new attitude to handling large ammonia leaks was brought about.
  4. Remote isolation and proper ventilation is a pre-requisite for fire teams' intervention.
-

4996 14 October 1983

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A severe internal explosion occurred inside the radiant section of the CDU main crude heater whilst it was in the process of being recommissioned, following a major overhaul. The explosion caused considerable damage. Consequential production losses valued at £1 million (1983) are also reported. No personal injuries, however, occurred.

[damage to equipment, commissioning]

---

**Lessons**

[None Reported]

---

2750 October 1983

**Source :** SEDGWICK LOSS CONTROL NEWSLETTER

**Location :** Rotterdam, NETHERLANDS

**Injured :** 0      **Dead :** 0

---

**Abstract**

Explosion in furnace, crude heater, of distillation column on a refinery. Cause was pipeline failure. Material involved:- fuel gas oil.  
[refining]

---

**Lessons**

[None Reported]

---

2727 14 September 1983

**Source** : INSTITUTE OF INSURERS

**Location** : Shuaiba, KUWAIT

**Injured** : 0      **Dead** : 0

---

**Abstract**

Fire in h-oil unit due to failure of tube in hydrogen gas heater.

[fire - consequence, tube failure]

---

**Lessons**

[None Reported]

---



2704 30 August 1983

**Source** : HAZARDOUS MATERIALS INTELLIGENCE REPORT, 1983, 16 SEP.

**Location** : Virginia, USA

**Injured** : 0      **Dead** : 0

---

**Abstract**

30000 lbs of phenol and 20000 lbs of cyclohexane spilled into a river due to faulty slurry cooler.

[mechanical equipment failure, pollution]

---

**Lessons**

[None Reported]

---

**2701 21 August 1983**

**Source :** INSTITUTE OF INSURERS

**Location :** Arklow, IRELAND

**Injured :** 0      **Dead :** 0

---

**Abstract**

Fire in steam superheater due to ignition of unburnt gases coming from auxiliary boiler.

[fire - consequence]

---

**Lessons**

[None Reported]

---

2649 02 July 1983

**Source** : LLOYDS LIST, 1983, 16 JUL.; TORONTO GLOBE AND MAIL, 1984, 12 SEP.

**Location** : Fort McMurry, CANADA

**Injured** : 0      **Dead** : 0

---

**Abstract**

Fire damaged heat exchanger of gas oil hydrotreating unit. Cause attributed to the rupture of a carbon steel pipe that should not have been installed in the first place. Material of construction incorrect.

[fire - consequence, incorrect equipment installed, damage to equipment]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

Atmospheric residue escaped from a leaking joint on the feed/overheads heat exchangers on a VDU. The escaping residue, which was partially vaporised, sprayed the nearby exchangers, piping, and pumps and ignited shortly afterwards. Fifteen minutes after raising the alarm the fire was extinguished using water monitors and portable dry powder extinguishers. No injuries are reported but repairs to insulation, cabling etc. cost about £125,000 (1983). The unit was offstream for about nine days.

[fire - consequence, damage to equipment, heating, gas / vapour release]

---

**Lessons**

[None Reported]

---

2632 15 June 1983

**Source** : INSTITUTE OF INSURERS

**Location** : Riyadh, SAUDIA ARABIA

**Injured** : 0      **Dead** : 0

---

**Abstract**

Explosion in naphtha hydrotreater charge heater.

---

**Lessons**

[None Reported]

---

2609 25 May 1983

Source : INSTITUTE OF INSURERS

Location : , KUWAIT

Injured : 0      Dead : 0

---

**Abstract**

Fire in soaking heaters of crude oil unit.

[fire - consequence]

---

**Lessons**

[None Reported]

---

2593 08 May 1983

Source : INSTITUTE OF INSURERS

Location : California, USA

Injured : 0      Dead : 0

---

**Abstract**

Explosion in crude vacuum heat exchanger.

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**Lessons**

[None Reported]

---

2569 14 April 1983

**Source** : LLOYDS LIST, 1983, 16 APR.

**Location** : Kalimantan, INDONESIA

**Injured** : 40    **Dead** : 3

---

**Abstract**

Explosion at LPG plant. Due to excessive pressure a cryogenic heat exchanger ruptured during start-up operations after tie in operations valve on main blow down header was not opened. Fatality.  
[cryogenic equipment]

---

**Lessons**

[None Reported]

---



Source : 100 LARGEST LOSSES 9TH EDITION, MARSH & MCLENNAN PROTECTION CONSULTANTS, 1986

Location : Bontang; East Kalamtan, INDONESIA

Injured : 0      Dead : 0

---

**Abstract**

The main cryogenic heat exchanger of an liquefied natural gas (LNG) plant ruptured violently due to a valve on a 24 inch blowdown line which collected the discharge from various relief valves was closed. Valve omitted from start-up checklist. It effectively prevented relief valves from performing their function as well as preventing the pressure controller at the top of the shell of the heat exchanger from operating since it also discharged into the same header. The plant was being started up following a shutdown. Substance involved: methane.

[cryogenic equipment]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

Five tonnes of butyraldehyde released during maintenance operation on tube bundle of heat exchanger. The process involved separation of N- and I-butuyraldehyde in a column with a water cooled top condenser and a distillate drum. The maintenance work involved cleaning of the condenser tube bundle and production was stopped. Hydrocarbons were left in the column and distillate drum to minimise the start-up time. Written procedure, on the correct way to carry out the work, was authorised by the Area Manager and Operators supervised the maintenance people carrying out the blinding operation. I-butuyraldehyde was released and a partial gas cloud formed. Most of the spill went to the sewer. The probable cause was

1. Hydrocarbons were left in the drum, which was not allowed.
2. The written procedure did not clearly spell out how important it was to put in the blinds in a specific order.
3. Bad communication between operating and maintenance personnel.

[drums, spill]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , USA

Injured : 0      Dead : 1

---

**Abstract**

Following a massive over - injection of a chemical additive severe foaming occurred in a cooling tower. The dense foam covered a large area, obscuring the pit and surrounding area. An employee entered the foam to cut off the chemical tank valve and fell through an open aluminium grating which had been moved by the foam. Rescue attempts were severely hampered by the dense foam.

[organic phosphonate, polycarboxylic, acid salt, caustic soda, mixing, cooling tower, fall, chemicals added incorrectly, fatality]

---

**Lessons**

Fasten down all gratings, including recessed gratings, that are located in potentially hazardous areas.

---

**Source** : 100 LARGEST LOSSES 9TH EDITION, MARSH & MCLENNAN PROTECTION CONSULTANTS, 1986.; HAZARDOUS CARGO BULLETIN FEBRUARY 1983.; FIRE SERVICE TODAY JUNE 1983.

**Location** : Tacao, VENEZUELA

**Injured** : 500 **Dead** : 145

### Abstract

A fuel oil tank at a power station exploded, killing at least 145 people including 43 firemen. In addition, 500 were injured and 1000 made homeless in a blaze which destroyed three of the nine fuel tanks at the plant and caused \$45m (1982) worth of damage. At the time of the blast an oil tanker was discharging fuel oil to the tanks. Suddenly a one-half filled storage tank containing 20,000 tonnes of product exploded and caught fire. During fire-fighting a second blast a few hours later tore off the roof of the tank, showering emergency workers with burning fuel oil and blew up a small hydrogen storage tank nearby. Two further tanks exploded some hours later. The second blast was the result of the contents of the tank erupting in an extremely violent boilover following several hours of intense burning.

[boilover, storage tanks, fatality, unloading, fire - consequence, injury]

### Lessons

Recommendations for the storage of heavy fuel oils:

1. The accumulation of water within the tank must be avoided. The accidental injection of waste or light hydrocarbons may create a violent evolution of steam or vapour where storage temperatures exceed the boiling point of water or the light hydrocarbons. The resulting pressure may cause failure of the roof-to-shell seam of the tank.
2. The roof must be watertight and free-draining.
3. Gauging hatches and roof manheads must be kept closed.
4. An open rain-proof vent to be considered. Flame arresters or pressure-vacuum vents are not generally used on heavy hot oil tanks since the flame arrester elements may become plugged or the pressure/vacuum valve pallets may stick.
5. There must be no interconnections to pipelines serving hot tanks through which water or light hydrocarbon liquids could inadvertently enter the tank. If such connections are necessary, they must have double-block valves, sealed in the closed position, with a bleeder between the valves or a roll-out spool piece.
6. Steam coils for hot-oil tanks to be tested for leakage when the tank is out of service. Preferably, coils to be of the all-welded type to minimise the possibility of leakage. Coolers or exchangers in a line to a hot oil tank to be arranged so that water pressures are lower than oil pressures to prevent water from leaking into the tank.
7. Tanks equipped with steam coils or heaters to be observed for steaming or burping. When coils are inactive, an atmospheric bleed to be opened and frequently observed for signs of oil leakage.
8. Tank storage temperatures must be carefully controlled. Flammable vapours can be generated if the oil temperature approaches the oil flashpoint.
9. Wherever possible, tanks must be operated and maintained either well below the boiling point of water so that water bottoms will not flash to steam, or they must be kept sufficiently hot at all times so that water bottoms cannot accumulate. Tanks must not be operated in a range where temperatures fluctuate above and below the boiling point of water.
10. In standing tanks, then main body of the oil may be substantially hotter than the oil near the shell or at the bottom. Hence, the temperature at these points may not be representative.
11. Direct-fired heater tubes, if exposed to the vapour space, will develop hot spots which may exceed the oil autoignition temperatures. It is important that the oil level in the tank be kept above the heater tubes or heating coils.
12. Temperature readings to be recorded routinely to control tank temperature. The temperature measuring device must be reliable and extend into the tank deep enough to obtain representative oil temperatures. Readings must not be taken near the shell or bottom of the tank nor near heating coils or heater tubes.
13. Blending of light fractions with No. 6 fuel oil is a very common practice which can change the physical characteristics of the oil substantially. It is important that samples of shipments of oil received from the supplier be laboratory tested upon receipt to assure that the oil meets specifications.

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

Two detonations occurred while relighting a three-celled CDU heater after a power failure. Each cell has two burners on both the south and north sides. On restoration of power the heater box was purged for 15 minutes using the forced draft fan. One pilot was lit on the south side of each cell followed by the corresponding main burner, firing fuel gas. While establishing pilots on the north side of the heater a detonation occurred. Although the detonation noise was very loud no damage could be seen and the furnace was again purged for 40 minutes using the forced draft fan. In neither case was a gas test taken after purging. On attempting to light the first pilot there was another detonation with refractory falling from the plenum roof.

Investigation showed that the forced draft fan louvre was stuck in the closed position and the audible function associated with the low pressure alarm had been disconnected.

[explosion, power supply failure]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A 3,500 cubic metre refrigerated LPG carrier was part way through its loading programme when the emergency release systems, installed at the jetty loading arm, parted without any initiating action having taken place and with the double ball valves open. A release of refrigerated butane occurred which was only stopped by the manual activation of the jetty shutdown system and closure of the ship's manifold isolation valves. The jetty head firewater monitors were switched on and the vapour cloud which had formed dispersed without incident in about 10 minutes. No injuries were reported.

An investigation into the incident concluded that the hydraulic sequence valve had been passing thus admitting hydraulic oil pressure to the emergency release system (ERS) coupling actuator when the ball valves were opened. However, in order to allow sufficient pressure to build up to cause the (ERS) coupling to release it was necessary for a bleed off facility, designed to prevent such an occurrence, to become inoperable. Subsequent examination revealed that a non-return valve had been fitted into the bleed off system in error and in such a way that no flow back into the bleed off system in error and in such a way that no flow back to drain was possible in the bleed off line.

[refrigeration unit, gas / vapour release, installation inadequate, marine tanker]

---

**Lessons**

[None Reported]

---

**Abstract**

Failure of a high-pressure steam line in an ammonia plant.

The ammonia plant with a rated capacity of 1,500 tonnes per day of ammonia, and commissioned in 1978. Problems occurred in the high-pressure system of the primary reformer soon after start up. The reformer was a standard terrace wall design with 172 tubes in the radiant section and contained auxiliary burners. Steam is fed to the reformer at 1,500 psi from waste heat boilers. The design exit temperature was 488 degrees C.

It was found difficult to control the superheated steam temperature during start-up, with excursions up to 593 degrees C. This occurred despite the fact that use of the auxiliary burners were not found necessary. These excursions occurred during the time between feed gas and air introduction and resulted in pipe distortions, e.g. outlet header. Before extra support could be installed to control the distortions, leaks developed at welds between the outlet coils and manifolds in September 1979. Following repair, it was noted in early 1980 that the metal temperature at the south side piping was running at up to 80 degrees C higher than the north side. To solve this problem, it was proposed to inject ambient air into the convection section during the critical period.

Before this approach could be implemented, however, the 30 cm diameter south side header failed violently in August 1982. The furnace was enveloped in steam with insulation and gravel scattered over some hundred metres in all directions. The line split over a length of 76 cm, and showed the appearance of a typical thin-lipped rupture caused by overheating and stress.

Following repair, a new air damper was put into service but had no effect on the steam temperatures. Inspection by an operator showed that the steam coils in the convection section on the north side were glowing red, indicating no cooling flow and hence a blockage. An inspection showed the pipe to be full of water.

The injection nozzle had been installed in the bottom of the vertical loop to provide as much residence time as possible. The steam velocity, however, was insufficient to carry all the water to the top of the loop, and when the pipe filled up the pressure drop was sufficient to force all the flow to the south side. The piping was therefore modified and the injection point moved to just beyond the top of the loop and a drain installed at the low point. This modification proved successful and allowed the temperature on both sides to be controlled automatically within a few degrees of design.

[mechanical equipment failure, processing, heat exchanger, rupture, design or procedure error, steam]

**Lessons**

1. Greater attention should be given to the design details of new installations and also repairs.
2. The P&I drawings for new installations must be reviewed periodically between initial approval and final installation in order to detect potential problems.

Source : ICHEME

Location : ,

Injured : 2      Dead : 0

---

**Abstract**

Ammonia leaked from a refrigeration unit in a wholesale food warehouse. The fumes spread through several blocks before fire fighters succeeded in stopping the leak, nearly three hours after it began. Two fire fighters were hospitalised for treatment after being overcome by fumes.

[warehousing, gas / vapour release, poisoning]

---

**Lessons**

[None Reported]

---



Source : ICHEME

Location : , UK

Injured : 1      Dead : 0

---

**Abstract**

Two fitters had been detailed to clean two heat exchanger covers on a butadiene plant. One of the covers fell onto one of the fitters foot during the cleaning operation, resulting in bone fractures.

---

**Lessons**

When working on heat exchanger covers it must be ensured that they are adequately supported by a suitable, safe, load bearing structure.

---

Source : ICHEME

Location : , BRAZIL

Injured : 0      Dead : 0

---

**Abstract**

An explosion in an effluent gas treatment plant caused considerable plant damage, including destruction of the effluent gas blower but fortunately, no injuries to personnel. Air and vent gas (flammable ex acrylonitrile plant) were mixed and ignited by heat from an incinerator. As a result of electrical power failure, the incinerator was shut down and, while operators were removing catalyst from the associated reactor, three explosions occurred. Flammable gas, remaining in the plant absorber was purged to the vent stack and leaked into the incinerator which was still at about 500 degrees C.

[damage to equipment, accidental mixing, processing,

---

**Lessons**

The following measures were installed:

1. Ensure complete purging of flammable reaction gas.
  2. Prevention of air inflow into the system.
  3. Isolate the incinerator from the vent gas system by mean of a remote operated valve.
-

Source : ICHEME

Location : Geneva, SWITZERLAND

Injured : 1      Dead : 0

---

**Abstract**

Laboratory work. A laboratory assistant was setting up an experiment in fume cupboard, which involved refluxing with petroleum ether in a 1 litre flask. A stirrer was incorporated into the top of the flask. After adding all constituents including petroleum ether to the flask, everything was ready to start the experiment. The assistant switched on the cold water for refluxing, switched on the oil bath heater (2 thermostats in oil bath), and then found that the plug for the stirrer motor was not in socket. The assistant reached over to put the plug in the socket and immediately received an electric shock.

The assistant was thrown involuntarily backwards and all of the glass ware was knocked onto the floor. The flask shattered spraying the assistant and surrounding area with petroleum ether.

About 2 and a half metres away, another experiment was taking place involving an electric heater. Approximately 20 seconds after the first incident, a small fire started near the second equipment due to the heat source there igniting the petroleum ether. The assistant's coat did not catch alight. Another assistant came in and put out the fire.

[petroleum ether, flask, heater, stirrer, electric shock, fire - consequence, spill, electrical equipment failure, injury]

---

**Lessons**

It has been concluded that a small electrical fault in the plug, probably due to wear and tear, started the chain reaction of events. The result could easily have led to a fatal injury.

It is recommended that:

1. Plugs are checked for safety regularly
  2. Switches are 'off' when plug is removed
  3. Locate electric sockets either outside of fume cupboards, or in a more accessible position in the fume cupboard
  4. Be aware of other experiments being carried out nearby
  5. Do not be complacent about carrying out routine work, the unexpected can happen
-

2327 04 February 1982

Source : ICHEME

Location : , ISRAEL

Injured : 0      Dead : 0

---

**Abstract**

Fire at a petrochemical utilities plant involving a cooling tower. Source of ignition was welding spark.

[fire - consequence]

---

**Lessons**

[None Reported]

---

Source : HAZARDOUS MATERIALS INTELLIGENCE REPORT, 22 JANUARY, 1982.

Location : Michigan, USA

Injured : 0      Dead : 2

---

**Abstract**

Two employees died from hydrogen sulphide poisoning at an incineration facility. They worked in the 'screenhouse', a series of filters to remove particles and lumps from waste streams before incineration, and inhaled fumes generated during unloading of a road tanker containing 3000 gallons of a spent sodium hydroxide solution contaminated with sulphides. The solution reacted with material in the building. 40 other workers were treated at hospital.

After the accident, tests with mice established that the ambient air was no longer toxic.

[filtration, fatality, unwanted chemical reaction, sodium hydroxide, hydrogen sulphide, incinerator, toxic fumes]

---

**Lessons**

The following recommendations were made:

1. Samples of the spent caustic in the tanker and of the material in the storage pit at the bottom of the screenhouse should be analysed, and studies made of records of wastes accepted immediately prior to the incident, to determine the nature of the reaction that generated the toxic fumes.
  2. More careful analysis of incoming wastes, or more frequent cleaning of the screenhouse, may have prevented the accident.
  3. In the absence of regulations establishing procedures for assuring compatibility of different wastes that pass through filtration or treatment units, industries are expected to use 'good management practices' to ensure that such incidents do not occur.
-

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

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**Abstract**

While shutting down a catalytic polymerisation unit temperature changes include induced thermal shock in a reactor feed/product exchanger. The tube sheet joint leaked propane. This was ignited from an undetermined source.

The unit had been through many shutdowns previously without incident.

[propane, shutdown, shell and tube heat exchanger, blowout, fire - consequence, thermal expansion, maintenance inadequate]

---

**Lessons**

Shutdown procedures had been normal and so maintenance procedures for making up exchanger flanges evenly were tightened up. This exchanger had been opened up for cleaning at the previous shutdown.

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

An explosion occurred in a churn system, which resulted in minor damage being sustained by the churn associated equipment and instrumentation. A churn vent fan and ventilation ducting were more severely damaged. The vent fan room door was blown off.

The explosion occurred shortly after the start of a venting cycle. Operating staff intervened to prevent the continuation of the automatic churn cycle, stopping the churn paddle and vent fan. These had continued to operate.

Heavy smoke and fumes were reported in the churn room, with some smoke and fume observed in an adjacent corridor. The vent fan room was filled with smoke.

The churn was blanketed with nitrogen and all personnel were cleared from the area, prior to pumping out the viscose batch. When two thirds of the batch had been discharged, the batch tank's attritor jammed. When opened up, this was found to be stripped of many teeth. A small piece of metal was recovered from it. When the churn rough cutter was examined, it too showed evidence of metal objects passing through.

When an examination of a conveyor (common to more than one churn) was made no loose bolts or other objects were identified. A length of the conveyor was however not protected by covers, allowing for potential foreign body ingress.

It was concluded, after examination, that the vent fan was not the source of ignition for the explosion. It was suggested that metal, trapped in the churn paddle was in fact the source, igniting a flammable atmosphere that would normally be present only during the first few minutes of the venting cycle.

[conveyor, vent, explosion, flammable atmosphere, air cooler]

---

**Lessons**

A number of recommendations were made following the investigation. These included:

1. The provision of additional covers on conveyors feeding churns.
  2. A trial to look at stopping the churn paddle during the critical stage of the venting cycle.
  3. A design review of the venting systems to improve personnel safety.
  4. Maintenance checks should include for inspection of items that could fall into conveyors, if loose.
-

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A fire occurred as a result of a small spillage of butadiene near an AN plant incinerator. The spillage occurred during preparation to purge a four inch butadiene line with a temporary nitrogen hose connection taken from the vicinity of the AN plant incinerator. The source of ignition was probably the hot surface of the incinerator which was in commission at the time of the incident. The fire was rapidly extinguished by the plant personnel using the fire extinguisher. There was no injury and damage to equipment was superficial.

It is concluded that the incident occurred as a result of failure to check that the temporary hose was connected at the nitrogen supply point. The wrong operating sequence when the connection at the hydrocarbon end was opened before applying nitrogen pressure to the hose.

[fire - consequence, leak, design or procedure error, purging]

---

**Lessons**

The following recommendation were made:

Purging of hydrocarbon lines and equipment with temporary nitrogen hose connections is all too often considered to be simple operation. The need to check that adequate connections are made at both ends of a rubber hose and the correct sequence of operation of applying nitrogen pressure first to the rubber hose to be highlighted.

---



**Source** : LOSS PREVENTION BULLETIN, 054, 31.

**Location** : Trail, BRITISH COLUMBIA

**Injured** : 0      **Dead** : 0

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**Abstract**

Approximately 60 tonnes of 93% sulphuric acid spilled at a lead zinc smelter facility after a cooling jacket in the acid plant ruptured. About half of the sulphuric acid which was spilt through a 6 inch hole in the jacket was neutralised with lime.

[smelting furnace]

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**Lessons**

[None Reported]

---

**Source :** HAZARDOUS CARGO BULLETIN, SEPT, 1981,; LLOYDS LIST, AUGUST, 1981.

**Location :** , PORTUGAL

**Injured :** 2      **Dead :** 1

---

**Abstract**

A quick release connection failed on refrigerated, semi-pressurised propylene cargo ship discharge arm resulting in one fatality and several injuries. The liquified gas was sprayed out in all directions at -48 degrees C. Shore staff who were injured were found not to be wearing appropriate protective equipment and where exposed to frostbite and asphyxiation. It is not clear whether the cause of the incident was due to equipment failure or operator error.

[mechanical equipment failure, refrigeration unit, fatality, safety procedures inadequate, people, gas / vapour release, unloading, marine transport, injury]

---

**Lessons**

The Marine Safety Committee had accepted in 1980 guidelines from the International Chamber of Shipping (ICS) outlining model forms to be followed as checklists prior to commencing offloading operations. It is not clear whether these were followed in this case.

---

**Source :** ICHEME

**Location :** , KOREA SOUTH

**Injured :** 0      **Dead :** 0

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**Abstract**

Fire at a refinery lube oil plant involving the air cooler. Source of ignition was static, caused by tube failure.

[fire - consequence, refining]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Failure of a joint occurred on a feed line from the pre-heater to the "B" riser to the reactor. An attempt was made to pull up the leaking joint but as part of the gasket had been blown out this was not possible. The two heater pass inlet valves were closed but the air operated outlet valves failed to function and could not be reached to close manually because of the intensity of the fire in the vicinity.

The third incident occurred an hour later whilst attempting to depressure the feed line to "A" riser through a hose connected to the drain at the base of the riser.

A sudden release of vapour from the draining hose ignited. The resulting fire was declared a 'Major Fire' and the appropriate procedures initiated including alerting the external fire brigade and calling in senior refinery management.

Subsequent to their arrival, the block valve on "A" riser was opened to relieve the pressure in the feed line into the reactor. The intensity of the pre-heater fire had declined and the two pass outlet valves were closed manually when they again failed to operate on air. Both pass blowdown valves were opened and blowdown steam was commissioned and the line slowly warmed. Snuffing steam had been commissioned to the heater boxes and the fires on the preheater were finally extinguished.

The unit was re-commissioned the following day with the preheater furnace bypassed.

[joint failure, reactors and reaction equipment, valve failure, fire - consequence, refining, commissioning]

---

**Lessons**

1. A suitable system modification to eliminate carryover of light hydrocarbon liquid with foul water from the LP separator to the deodoriser is required. In the meantime, it is recommended that the foul water be directed to closed drain.
  2. The equipment associated with the blowdown system should be over hauled to produce a reliable system in which the operators may place confidence.
  3. An in-depth study should be carried out into the selection procedure for air operated valves.
  4. Aspects to be considered should include the means of driving the valves, the means of protecting their operating mechanisms, routine maintenance procedures, on-stream checks, testing and accessibility.
  5. The development of operations personnel with intimate unit knowledge and long experience should be a recognised and implemented objective.
  6. The snuffing steam system should be clearly identified and all operations personnel instructed in its purpose and use.
-

2155 11 February 1981

Source : ICHEME

Location : , SOUTH AFRICA

Injured : 0      Dead : 0

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**Abstract**

An explosion in a coal gasification plant involving a heat exchanger and methane, caused by instrumentation failure.

---

**Lessons**

[None Reported]

---

10481 January 1981

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

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### Abstract

A chemical process employed a vertical shell and tube reactor, with molten salt in the shell and reactants in the tubes. The reactor was being modified, when it was noticed that the shell was bulging. Further investigation showed that two tubes in the reactor had burst. These were tubes which had been found to be leaking in a previous overhaul and had been plugged top and bottom.

The calculated burst pressure of the tubes was 3800 psig (roughly 260 bar gauge). It was surmised that the bursting of the tubes produced a shock wave which was transmitted through the salt and caused the shell to bulge.

When the tubes were plugged, a hole had been drilled through the tube wall near the top plug in order to relieve any build-up of pressure. However, it was found that there were substantial plugs of catalyst and carbonate in the tubes between the burst and the relief hole.

It was concluded that water had been trapped in the tubes behind the catalyst/carbonate plugs, rendering the pressure relief hole ineffective. On re-commissioning the reactor, the water vaporised, and at the high temperatures within the reactor sufficient pressure was generated to rupture the tubes.

[maintenance, repair, modification, heat exchanger, shell and tube heat exchanger, reactor tube, near miss, explosion, overpressure, overpressurisation, solids deposition, cleaning inadequate, reactors and reaction equipment]

---

### Lessons

When leaking tubes in heat exchangers or reactors are plugged at either one or both ends, it is essential to thoroughly clean the tubes by water jetting or drilling before plugs are inserted and vent holes drilled.

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

Corrosion caused leaks in crude unit overhead fin fan cooler tubes at similar locations on two occasions. The leaks did not ignite. Investigation indicated that the leaks were at the point where water started to condense and where the liquid corrosion inhibitor might not reach due to the inlet header layout. [naphtha, fin fan cooler, blowout, design inadequate, corrosion, safety procedures inadequate]

---

**Lessons**

The corrosion inhibitor was liquid at the air cooler inlet temperature. As the inlet headers to the multiple bundles were not symmetrical the inhibitor was maldistributed. Where the water first condensed it was very sour and where there was a lack of corrosion inhibitor corrosion was rapid.

The inlet headers were modified to be symmetrical, a spray nozzle was fitted to the corrosion inhibitor injection point and tubes at the water condensation point were inspected for corrosion at shutdowns.

No further failures have occurred. However, the modifications should have been made after the first failure.

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 1

---

**Abstract**

A sample point was causing trouble due to a blockage in the cooler and an alternative arrangement was provided and mentioned in the log book. An operator who was starting a new shift rota tried to use the old sample point and used another valve. He was overcome by benzene vapours. Fatality.  
[incorrect flow rate]

---

**Lessons**

[None Reported]

---



**2105 16 December 1980**

**Source** : FIRE PREVENTION, 1984, NO. 145, 20; HAZARDOUS MATERIALS INTELLIGENCE REPORT, 1980, 19 DEC.; CHRISTIANSEN V, , ET AL., ENVIRONMENTAL IMPACT OF A WAREHOUSE FIRE CONTAINING AMMONIUM NITRATE, JOURNAL OF LOSS PREVENTION IN THE PROCESS INDUSTRY, 1993, VOL 6, (4), 233-239.

**Location** : Leeds; West Yorkshire, UK

**Injured** : 21    **Dead** : 0

---

**Abstract**

A warehouse fire. A steel drum was overheated by an electric drum heater, burst and ignited other drums. Over 200 different chemicals were present. Most of the chemicals stored were flammable, toxic or corrosive and were stored in containers of steel, plastic or compressed fibre. 300 people were evacuated.

Estimated cost £600000 (1980).

[fire - consequence, warehousing, overheating, evacuation, unknown chemicals, injury]

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**Lessons**

[None Reported]

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2031 15 July 1980

**Source** : HAZARDOUS MATERIALS INTELLIGENCE REPORT, 1980, 25 JUL. & 1 AUG.; CHEMICAL AGE, 1980, 25 JUL.

**Location** : Leverkusen, GERMANY

**Injured** : 8      **Dead** : 1

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**Abstract**

Explosion in waste incineration plant. 1 of 2 rotary kilns at the facility exploded. Fatality.

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**Lessons**

[None Reported]

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2016 17 May 1980

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

### Abstract

A fire occurred at a fired reboiler at the hydrodesulphurisation unit in a refinery. The fire resulted from a ruptured tube caused by low flow. On the day of the incident, operating personnel noticed a decrease in total flow to the fired reboiler. After checking individual coil flow meter readings, which had not deviated, the accuracy of the total flow meter was questioned. Smoke was then spotted on the fired reboiler stack which was found to be from a fire in the heater. It was quickly determined that a tube had ruptured. The unit was shut down. After the fuel gas had been removed and the charge pump blocked in, the fire appeared to be extinguished. However shortly after the fired reboiler reignited and the heater was quickly engulfed in flames.

A review of plant data indicated the following as the cause of the incident.

1. Flow to one of the coils diminished without any change in the flow indicator.
2. One of the coil outlet temperatures increased from 700 degrees F to 1200 degrees F over a six hour period. Outlet coil temperatures are located on manual indicators, but these were not checked. The net result was a coked coil (found during dismantling) and a subsequent tube rupture.

After the initial fire was extinguished, hydrocarbons were pressured backwards from the main fractionator to the fired reboiler, reigniting the heater. This was due to the lack of a check valve in this line or other means to segregate the heater from the fractionating tower.

[fire - consequence, flow rate too low, refining]

### Lessons

The following recommendations were made:

1. Individual coil outlet temperatures are now recorded with a high temperature alarm.
2. Low flow alarms were installed in the heater outlet line returning to the tower. This allows the heater to be easily isolated from the rest of the process.
3. Both a check valve and a block valve were installed in the heater outlet line returning to the tower. This allows the heater to be easily isolated from the rest of the process.
4. A combination oxygen combustion analyser has been ordered.
5. High priority will be given any heater instrumentation not in proper working order.

These points will allow operating personnel to closely monitor operating conditions and may prevent reoccurrence of this nature in the future.

2013 07 May 1980

Source : 100 LARGEST LOSSES, 9TH EDITION, MARSH & MCLENNAN, 1986.

Location : Deer Park; Texas, USA

Injured : 0      Dead : 0

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**Abstract**

Vibration from a pump bearing failure in a cumene section of a phenol acetone unit caused the pump seal to fail. The released flammable liquids and vapours ignited. Process pipes opened adding fuel to the fire. Fin fan coolers elevated above the pipe rack collapsed, as did one process column.  
[fire - consequence, excessive vibration]

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**Lessons**

[None Reported]

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1998 26 March 1980

**Source** : LENOIR E.M & DAVENPORT J.A, A SURVEY OF VAPOUR CLOUD EXPLOSIONS SECOND UPDATE, PROCESS SAFETY PROGRESS, 1993, 12, (1), 12-33.

**Location** : Enschede, NETHERLANDS

**Injured** : 0      **Dead** : 0

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**Abstract**

Valve sheared from 3 cum (cubic metre) propane tank while transporting tank which caused an explosion. Ignition by nearby heater.  
[transportation]

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**Lessons**

[None Reported]

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A distillation column on a polyethylene plant was inerted with nitrogen, using a portable nitrogen heater and suitable flexible hoses. However, following inerting operations, the isolation valve on the column was left open, whilst the heater was not disconnected.

As a result, when the column was being purged with ethylene prior to start-up, a small quantity (approx. 10 kgms) of ethylene leaked to atmosphere from a hose connection.

[processing, gas / vapour release, human causes]

---

**Lessons**

This incident highlights the importance of implementing effective pre-start-up procedures.

---

Source : ICHEME

Location : ,

Injured : 1      Dead : 0

---

**Abstract**

A heavily fouled heat exchanger tube bundle was being cleaned by a specialist contractor using a water/sand mixture at a jet pressure of 400 atmospheres. The spray gun was held under the right arm and guided with the left hand. The discharge valve lever was operated by the right hand. The contractor got his protective glove caught between the valve lever and the top of the gun when he released it. At that moment with the jet not shut off, the contractor was forced by the counter pressure to turn through an angle of 180 degrees and stumbled; the jet hit him on the upper part of the right thigh. The contractor was seriously injured and remained off work for many months.

The area was surrounded with sheet steel screens which prevented the jet from hitting other personnel.

[cleaning, operator error, near miss, injury]

---

**Lessons**

High pressure jetting is potentially very dangerous. Facilities should be safe by design and operators should not do this type of work alone.

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Source : ICHEME

Location : ,

Injured : 1      Dead : 0

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**Abstract**

Two operators were using torches to light the pilot on the crude and heaters which were being purged with steam.

Kerosene was drawn from a sample point into a pot and two torches were soaked and lighted.

After the pilots were lit, the torches were extinguished with a steam hose and dumped into the pot which immediately ignited.

While attempting to remove the torches, the pot fell over and the operator's trouser leg caught fire.

Other operators extinguished the clothing fire with the aid of a fire blanket. Fortunately the operator was not badly burned.

[fire - consequence, competency lacking, burns]

---

**Lessons**

Do not use torches for lighting pilots and burners. Use a portable electrical ignitor. Where pilot burners are not fitted, the same ignitor can be used to directly light main gas burners. Heavy fuel oil normally requires more ignition energy than is provided by this type of ignitor and so a portable propane flame torch can be used.

Dry powder extinguishers provide the most effective means of dealing with a person whose clothing is on fire.

---



Source : ICHEME

Location : ,

Injured : 0      Dead : 0

### Abstract

The hook of a mobile crane failed when the crane attempted to lift a small box heater weighing approximately 15 tonnes. Fortunately, the heater had not been raised from its supports when the failure occurred and no one was injured. There was no damage to property.

The failure was due to corrosion of the threads on both the hook and nut of the assembly, resulting in the hook being pulled from the block when sufficient weight was applied.

After the investigation it was found that: The threads on the hook and on the nut were badly corroded and the only piece that had been holding the two parts together was a 3/8 inch diameter pin, inserted through the nut and hook to prevent the nut from turning. The corrosion was probably caused by exposure to moisture over an extended period of time.

The contractor stated that the problem with the hook had been noticed by one of his crane operators some time previously, and that he had taken it into his workshop and instructed the mechanic to repair it. However, he admitted that he had not followed up on it, and that someone had taken it out of the shop and placed it on the crane, unaware of the defect.

[human causes, near miss, operational activities]

### Lessons

The following points should be checked before lifting plant is permitted on site:

1. Check that valid crane test and insurance inspection certificates are available.
2. Check that test and inspection certificates are available for all "loose" items, including hook blocks, ropes, slings, shackles, etc.
3. Examine condition of such items on site and check that rope terminations are in accordance with good practice.
4. Inspect the machine's general condition; if it looks shabby then items that cannot be readily seen may be in a poor condition.
5. Check with the Contractor that the safe load indicator and all other safety devices are functioning correctly.
6. Check the condition of tyres if wheel mounted.
7. Check that ropes are spooling correctly on the drums - refuse acceptance if rope is piled-up towards one drum flange.
8. Check that the crane hook is fitted with safety latch.
9. Check for loose items such as bolts, washers, etc. in the driver's compartment - these items have often become wedged under brake pedals and prevented effective operation.

Although the list appears lengthy, it should only take a competent person about 15 minutes to complete.

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A fire occurred in a light ends fractionation unit when a feed line to the unit ruptured, causing a major hydrocarbon release which was subsequently ignited by static electricity. It resulted in no personnel injuries, but caused significant damage to instrumentation and kept the unit out of service for four weeks.

The unit is designed to fractionate unstable light naphtha from a number of different sources throughout the refinery. The unit consists of two fractionator towers with a combined total capacity of 41,000 B/D. The dual tower configuration processes two streams, one of which is essentially butane and lighter and the other butane and heavier. The operating pressure of the prefractionator was 160 psig (11 atmos.) and the temperature of the stream to the prefractionator at the point of failure was 170 degrees F (77 degrees C). The feed line to the prefractionator was eight inches in diameter, schedule 20, carbon steel. It was insulated and weatherproofed.

The rupture occurred at the base of a vertical segment of the line feeding the prefractionator.

Subsequent investigation showed severe thinning of the line in the section where the failure occurred, general corrosion throughout the straight run of line above it, and severe corrosion adjacent to the pipe guide. The corrosion resulted from extended exposure to moisture. Moisture apparently entered the insulation through a break in the weatherproofing in the form of rainfall and from extended exposure to mist from a nearby cooling tower. The refinery concluded that the most likely entry point was where the pipe guide passed through the weatherproofing.

Water ran down the vertical section and accumulated at the horizontal section where the failure occurred. The elbow which failed is 16 feet above ground and inaccessible for routine inspection.

The inspections conducted in earlier years at this location revealed no problems. Since the refinery did not anticipate a problem with external corrosion, more recent inspections were only made to detect internal corrosion at more accessible locations selected on the basis of process stream velocity and turbulence.

The overhead instrumentation cables and wiring to motor operated valves and other electrical equipment in the fire zone suffered severe damage. The fireproofing of drums and supports was severely damaged, but it did prevent the supports from sagging and the drums from failure.

[fire - consequence, damage to equipment, separation, refining]

---

**Lessons**

Stringent measures should be taken to prevent external corrosion by effective sealing to exclude moisture. However, this is difficult to achieve and corrosion monitoring in vulnerable areas must be carried out.

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Liquid hydrocarbons were carried over through the H<sub>2</sub>S (hydrogen sulphide) recovery unit into the fuel gas system following a process upset on a coker unit almost causing a total shutdown of the refinery. The incident was initially caused by a heater failure which resulted in the accumulation of 'uncracked' liquid in a coke drum. This liquid presumably evaporated rapidly causing a large carry-over from the main fractionator overheads system.

The fuel gas mix drum was equipped with four level alarms including an automatic trip system to shut down boiler and heaters in the event of a high level.

However it appears that the instrumentation system may not have been functioning properly and/or the operators had not responded to the alarms.

There was also a loss of steam pressure and subsequent loss of instrument air pressure (steam turbine driven air compressors) when a boiler tripped off-line while changing from gas to oil firing.

The refinery are modifying their operating practices on the coker unit to prevent the possibility of a recurrence. They had already recognised the problem of liquid carry-over and the possibility that some condensation of gas could occur in cold weather. The diameter of the drain line at the base of the fuel gas mix drum had been increased to 4 inches and additional instrumentation had been installed to alert operators of a high liquid level.

[instrumentation failure, refining, plant shutdown]

---

**Lessons**

Sometimes liquid knock-out pots are installed in fuel gas lines within plants and the lines between the knock-out pot and the burners are steam traced. The reason for these precautions is to prevent flammable liquid going forward with the gas into the combustion chamber and creating a fuel rich condition. Unburnt fuel could then accumulate either in the firebox or further downstream in the flare ducting or stack and the eventual restoration of excess air could cause an explosive mixture to form which would almost certainly ignite.

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Operator error caused fire in a cooling tower at a fertiliser utilities plant. Source of ignition was welding.

[fire - consequence]

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**Lessons**

[None Reported]

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Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

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**Abstract**

Main steam coils fractured on superheater. The failure is attributed to the thermal shock to which the superheater coils were subjected. The thermal shock occurred when steam at approximately 300 degrees F was admitted to the coils of the superheater. The coils had been heated for twenty minutes up to a temperature of above 1540 degrees F after the nitrogen flow through them had been stopped.

[high temperature, heating]

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**Lessons**

[None Reported]

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1908 18 September 1979

**Source** : LENOIR E.M & DAVENPORT J.A, A SURVEY OF VAPOUR CLOUD EXPLOSIONS SECOND UPDATE, PROCESS SAFETY PROGRESS, 1993, 12, (1), 12-33.

**Location** : Torrance; California, USA

**Injured** : 0      **Dead** : 0

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**Abstract**

A 300 mm line from the stripper tower to an absorber tower developed a propane/butane leak. Gas spread 50 m before being ignited by a heater. [explosion]

**Lessons**

[None Reported]

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

Chlorine leak from a heat exchanger caused by corrosion. Source of water ingress not known, but believed to be from humid air. The incident caused the shutdown and evacuation of the plant.

Two workers carrying out maintenance on top of a storage unit noticed a slight escape of chlorine and immediately left the area.

A few second later, a muffled sound was heard and a large plume of gaseous chlorine developed at the top of the structure. The person in charge was immediately informed and the loops were stopped.

Two people put on self-contained breathing apparatus with cylinders and entered the storage area, crossing the water curtain and after locating the escape, closed the gauge valve.

Shortly before the closing of this valve, a second escape of chlorine occurred near the pump on the methanolated water loop.

The escape which was much smaller than the previous one, was immediately beaten down with water from two branch pipes.

[gas / vapour release, plant shutdown]

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**Lessons**

[None Reported]

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1844 28 March 1979

Source : ICHEME

Location : , CANADA

Injured : 0      Dead : 0

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**Abstract**

The gas pipeline between the cold heat exchanger and gas cooler in an ethanol plant ruptured and a fire started. Cause due to erosion or corrosion by phosphoric acid droplets in pipe. Vapour cloud explosion.

[fire - consequence]

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**Lessons**

[None Reported]

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1809 January 1979

**Source** : SAFETY, 1979, NOV., 3.

**Location** : Preston; Lancashire, UK

**Injured** : 7      **Dead** : 2

---

**Abstract**

A serious explosion occurred in a drying oven during the evaporation of solvent, methanol. Operation of various dampers proved difficult to operate and inadequate explosion venting added to the problem. Fatality.

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**Lessons**

[None Reported]

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Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

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**Abstract**

An explosion completely wrecked the single storey prefabricated building and affected six adjoining buildings with varying degrees.

The explosion was caused by leaking propane gas from laboratory fitted bench gas taps being ignited by an electric radiant wall heater.

The gas supply from two 100 lb propane gas cylinders had run out the previous Thursday. The gas supply was used for heating and for Bunsen burners. The only form of heating in the building at that time was from a thermostatically controlled electric wall heater which was permanently switched on.

On Friday new Bunsen burner taps were fitted and the school closed for a one week holiday. On Wednesday, the day of the incident, two full cylinders were fitted by the Gas Suppliers. They were in a compound outside the building and, following standard procedure, the gas was turned on.

No-one entered the building where the gas fired heaters were fitted with a fail-safe arrangement and a press button ignition. The explosion occurred some 9 hours after the new cylinders were installed.

In the rubble following the incident, the three bench gas taps were found partly open.

[laboratory work, damage to equipment]

---

**Lessons**

[None Reported]

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1697 26 July 1978

**Source** : CHEMICAL WEEK, 1978, 2 AUG.

**Location** : Orange; Texas, USA

**Injured** : 2      **Dead** : 2

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**Abstract**

Valve on an 8 inch ethylene line broke as it was being closed to repair a small leak in the heat exchanger. Ethylene was released and ignited resulting in a flash fire. Maintenance, valve failure. Fatality.  
[fire - consequence, leak]

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**Lessons**

[None Reported]

---

1678 04 July 1978

Source : LLOYDS LIST, 1978, 18 JUL.

Location : Kolding, DENMARK

Injured : 0      Dead : 0

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**Abstract**

Fire when container of wood impregnating liquid was spilled on an oven in chemical plant. Because of lack of water fire burned for 12 hours.

[fire - consequence]

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**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Due to an unanticipated demand, the normal day operation of a Residues/Waste Oils incinerator was to be put on a shift basis. The shift operators had been trained to maintain normal operating conditions, but had not been instructed on how to deal with unusual fuel conditions. Residues in the fuel had caused blockages in the burners and the incinerator had been shutdown. Several attempts were made to start-up the incinerator, and after lighting one of two burners excessive overheating occurred, causing damage to the induced draft fan.

[damage to equipment, flow restriction, training inadequate, heating]

---

**Lessons**

The management and training needed to be improved to ensure that personnel were only asked to perform duties in which they had been adequately instructed.

---

1486 30 October 1977

Source : FINANCIAL TIMES, 1977, 31 OCT.; DAILY TELEGRAPH, 1977, 31 OCT.

Location : Abadan, IRAN

Injured : 20    Dead : 5

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**Abstract**

Explosion and fire on heat exchanger in refinery.

[fire - consequence, refining, fatality]

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**Lessons**

[None Reported]

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A tube failure in this asphalt mix furnace caused damage between £50,000 and £100,000 (1977). Subsequent examination of the furnace tubes revealed a 3 inch diameter hole in one of the tubes.

At about 05.00 hrs on the 18th September 1977, the smoke density alarm at the common stack sounded in the control room and a fire was discovered at the asphalt mix fired heater. The acting senior operator found that two burner assemblies were ablaze. The fuel line isolation valves, located 50 feet from the heater, were quickly shut off, one set of burner isolating valves was also reached and closed, and the blanket steam to the heater commissioned. The heater had been firing solely on gas at the time of the incident.

Attempts were made by operating staff to inspect the heater, but they were frustrated by asphalt coming out through the inspection door and flowing out of burner ports, as well the smoke filled fire box. A major tube failure was indicated however and the emergency shutdown procedure implemented (which avoided gas oil flush). Efforts were made to tackle the fires outside the heater with dry powder extinguishers, initially with some success. However asphalt continued to flow out of the south side burner ports and ignited.

The Refinery Fire Brigade arrived and laid down a foam blanket around the heater. A request for assistance from the outside fire authority was made and the Refinery Emergency Procedures implemented.

The P.D.A. Unit treating column valves were shut, and then the asphalt flash tower inlet valve. This latter large valve required the efforts of four operators, working in pairs, before it could be shut. During this time the blow-through steam was routed to drain to dry it, and when the asphalt flash tower inlet valve was finally shut, steam was commissioned to the heater at a low flow.

This blow-through steam caused some minor "bangs" in the heater, and propane ignited at the top of the stack. The stack emitted incandescent coke which fell over the unit, but fortunately no further fires were started. The stack gases continued to burn for approximately one hour, and then self extinguished, presumably when all the propane in the asphalt mix had gone; the residual asphalt in the fire box continued to burn for 24 hours. Throughout this period, the blow through steam remained in commission, and water was sprayed over the east end of the heater when the metal plates were overheating.

The outside fire authority brigade stood by until 06.45 hr, but their actual involvement was minimal since the fire was confined inside the heater.

[ heating, furnace, furnace tube, heater, tube failure, fire - consequence, asphalt, propane]

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**Lessons**

[None Reported]

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Source : LOSS PREVENTION BULLETIN, 071, 23.

Location : , UK

Injured : 0      Dead : 0

### Abstract

A ship was loading propane from a shore tank. The temperature of the propane resulted in vapour pressure above the relief valve setting of the ship's tank. Consequently the refrigeration system on board the ship was used to reduce the temperature and hence the vapour pressure in the ship's tank by careful control of the loading rate. The refrigeration system failed but the transfer operation was not stopped immediately. The safety relief valve on the ship's tank lifted and would not re-seat. The crew tried to restart the refrigeration unit but failed. The shore transfer pump was eventually stopped but the relief valve could not be re-seated. At least 100 tonnes of propane was spilled into the dock area causing a shut down of all systems in the area while the gas cloud dispersed. There was no ignition and it was eight hours before the dock area was again fully operational. The relief valve was found to have a fatigue failure of a weld in the bellows. The manufacturers had advised a modification to the relief valve and this was to be carried out at the next annual refit.

[mechanical equipment failure, weld failure, spill, gas / vapour release]

### Lessons

The report stated the following conclusions:

1. The relief valves on the propane marine tanks lifted because of the slowness with which the refrigeration system was commissioned.
2. No member of the crew was in attendance on deck when the relief valve blew.
3. A period of 22 minutes elapsed before the situation on board the marine tanker was considered to be serious and it was left to the jetty operator to take the initiative, and indeed to advise the master.
4. A jetty checklist was established for future tankers to ensure that loading of pressurised propane into semi-refrigerated tankers could be carried out without problems. This checklist would include relief valve settings and crew training.

### Emergency Response

Three fixed water monitors were established to assist in gas dispersion. Refinery fire service received a call 22 minutes after the relief valve lifted and called for assistance from another site and the national fire brigades. Four mobile monitors were then established. The police were informed and established control of traffic to the jetty. All ship engines and operations were shutdown. Explosimeter tests around the jetty varied from 10% to 70% of LEL.

After 2 hours no gas was detected at the jetty. After a further one hour no gas could be detected in the ship's accommodation and control room area. The master was informed that the ship's engines could be restarted.



Source : LLOYDS LIST, 1977, 20 JUN,; ICHEME.

Location : Llandarcy; Swansea, UK

Injured : 0      Dead : 0

### Abstract

A fire occurred in a building which contained double pipe scraped heat exchangers separated by a wall from the ammonia compressor house. A waxy solvent mixture passes through the exchangers, the solvent being methyl ethyl ketone/toluene.

At about 0500 hr, an operator noticed a fire as "a glow reflected against the pumphouse wall". The fire quickly spread to the other scraped chillers/exchangers, including some which were out of commission but full of lube oil for corrosion protection. The flames ignited the cork lagging surrounding the exchangers/chillers and pipework and spread throughout the chiller house. The covered structure above the exchangers caused the heat to be retained within the building.

After investigation it was established that the material feeding the initial fire must have come from the chillers/exchangers. It was known that the exchanger G1-4 glands were leaking, several days before the fire. Under normal circumstances, any material leaking out of these glands would drain into the exchanger sump and hence to the plant drainage system. However, because of the high wax content of the material, the drain could block if the leakage rate were high, and allow solvent-rich mixture to overflow the sump. In addition to natural draining, it is speculated that a particularly bad leak on G1-4 could have resulted in a jet of solvent being directed to the source of the fire. A single damaged brass sprocket found on G1-4 suggests that solvent could have leaked at sufficient pressure to traverse the gap between the gland and the drive assembly. In this respect, the lower diagonally opposite gland in the bank showed a very bad leak during steaming and therefore could well have been the source of the main leakage. It is also significant that the drive sprocket on this particular shaft was scored and might therefore have been a source of ignition.

Despite the lack of a firm explanation of the flame propagation, a mechanical source of ignition associated with the chiller/exchanger drive mechanism was considered the most likely source of ignition.

Before dismantling for repair, it was evident that the clearances between the sprocket hub and the bearing cover varied greatly on G14 and G2-3 exchangers.

In some cases it appeared that there was contact between these two items with definite indications of scoring on the sprocket hub. Since both these items are constructed of steel, spark formation and/or overheating were virtually certain.

Two reasons for such metal to metal contact were established, both involving the sprocket hub. The shackle pins connecting the sprocket hub and drive hub are only threaded into the drive hub; they simply slot into holes in the sprocket hub itself. Thus since the sprocket hub/shaft bearings are only a push fit, the hub is free to move on the shaft, being limited on one side by the fixed drive hub and on the other by the bearing housing cover bolts. Provided the drive chain tension is sufficient, all sprocket hubs are kept in alignment by the chain itself. However, slackness in the chain and/or poor initial alignment between the drive and idler wheels, can result in the sprocket hub moving along the shaft. Following the fire, various shift crews recalled that the drive chains were "slapping", i.e. were loose, although this fact was not recorded in the unit log. Slackness would allow the sprocket hub to move up its shaft and give metal-to-metal contact with the bearing cover bolts. If such contact occurred it would almost certainly result in spark formation.

[heat transfer, heat exchanger, overheating, mechanical spark, fire - consequence, refining]

### Lessons

The need for cleanliness and a high standard of maintenance on dewaxing equipment is clearly demonstrated by this incident. Wax/oil build up on and around these types of exchangers has always been a problem. The incident has also shown the speed at which solvent/heavy oil will burn when the "wick effect" of contaminated lagging is introduced; it was increased in this case by the heat build up under the roof of the building. The re-built exchangers system will be in the open air.

**Source :** ICHEME

**Location :** ,

**Injured :** 0      **Dead :** 0

---

**Abstract**

Fire at a refinery reformer plant. Source of ignition was autoignition. Equipment involved: heat exchanger.

[fire - consequence, refining]

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**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A fire occurred on an ethyl benzene final heater when material was released from a crack near the base of the heat exchanger releasing ethyl benzene and steam. Metallurgical examination indicated that the shell metal failed because of local overheating to 1000 degrees C. This temperature was generated during the burn off of carbon on the shell side. The carbon deposit caused carburisation of the metal which may have contributed to the metal failure.  
[fire - consequence, processing]

---

**Lessons**

The following recommendations were made:

1. The ethylbenzene feed system should be examined for any possible reduction to the severe operating conditions.
  2. The burn-off of carbon deposits in exchanger shells should be discontinued until a suitably controlled procedure is produced.
  3. The condition of the shells of the other ethylbenzene final heaters should be examined.
-

1321 21 January 1977

Source : ICHEME

Location :

Injured : 0      Dead : 0

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**Abstract**

Petrochemical utilities plant. Damage to cooling tower.  
[damage to equipment, processing]

---

**Lessons**

[None Reported]

---

117011977

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

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### Abstract

Twenty four hours after a recycle gas compressor trip, a fire occurred on the reactor effluent exchangers of this catalytic reformer. Hydrocarbons and hydrogen leaking from the exchangers spontaneously ignited, and flames engulfed the exchangers and were carried upwards towards the adjacent fin-fan coolers. Steam snuffing to the exchanger flanges via the installed steam rings, removal of unit feed and purging with nitrogen successfully controlled and extinguished the fire. A foam blanket was laid under the exchangers and a water curtain established to protect adjacent equipment.

Damage was limited to replacement of certain exchanger and nozzle flange joints, and tightening up of other joints, at a cost of some £12,000 (1977), but there was some 16 days lost production.

Whilst the above type of incidents, caused in the main by thermal shocks, have not been uncommon in a number of refineries over the years one feature of the above incident attracted particular attention. This was that the exchanger flanges had been covered with lagging boxes during the 1976 overhaul as an energy conservation procedure.

On reflection it is now appreciated that for these light hydrocarbon/hydrogen duties this meant that any leakage was difficult to detect, accumulating beneath the lagging boxes, eventually igniting, and due to the insulating properties of the boxes causing expansion of the exchanger bolts with subsequent increased leakage rate.

Before the installation of the lagging boxes, although there had been several small flange fires these had been successfully extinguished using steam without needing to shutdown the plant.

[refining, catalytic reformer, heat exchanger, spontaneous combustion, leak, design inadequate, fire - consequence]

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### Lessons

Refineries are advised against such insulation of tube sheet and channel flanges on heat exchangers on hydrogen service, and advised only to provide partial protection for bolts against rainfall whilst still allowing sufficient gap for leakage to dissipate.

Bolt tensioning techniques should also be reviewed.

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

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**Abstract**

A plant for the manufacture of iso propyl alcohol was being recommissioned after a shut down for inspection and maintenance. Shortly after introducing liquid propylene feed to the depropaniser distillation column, the operator noticed a substantial gas / vapour release from flange joints at the tops of two reboiler heat exchangers. The leaks became worse, so a Factory Emergency was initiated and the Works Fire Brigade stood by. In the event, there was no fire. After about 40 minutes the leakage rate was reduced to an acceptable level.

It was established that a leakage test had been carried out when the reboilers were reassembled. However, lighting conditions during the tests were poor, and the job was not supervised by a foreman. Also, the tests were carried out at about 100 psig, whereas the operating pressure was about 250 psig.

On subsequent inspection, it was found that the bolts on the top joints of both heat exchangers (which had been tightened by hand) were inadequately tight.

The bolts on the bottom joints, which had been tightened using an impact wrench, were secure. In addition, it was found that the soft metal joint on one of the flanges had been misplaced.

[start-up, commissioning, maintenance, near miss, bolts incorrectly tightened, gasket failure]

---

**Lessons**

The following points were noted:

1. better procedures required for the fitting and tightening of flange joints.
  2. better procedures required for leak testing.
  3. tests should be carried out at as close to operating conditions as possible.
-

1267 20 October 1976

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Fire at petrochemical reformer plant. Equipment involved, heat exchanger. Substance involved: naphtha. Cause: flange leak.  
[fire - consequence, processing]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 1      Dead : 0

---

**Abstract**

An employee was cleaning out a tubular cooler. He was wearing, as prescribed in his instructions, a rubber apron but not the rubber boots also prescribed. Consequently, the legs of his trousers became soiled with aqueous sludge containing nitrobenzene. Eighteen hours after the cleaning operation, he developed symptoms of nitrobenzene poisoning, due to the resorption of nitrobenzene through the skin of his legs.

[operator error]

---

**Lessons**

[None Reported]

---



Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

An operator filling bags on a spray unit heard a loud bang followed by flames coming out of the flange on top of a collection box. The operator triggered the fire alarms and went for assistance.

An investigation into the incident found the following:

1. Vaporisation of the residual formaldehyde.

2. Ignition of the vapour had followed with the possible cause of ignition being an electrical fitting.

[formaldehyde, spray drier/unit, explosion, fire - consequence, gas / vapour release, vapour cloud explosion, loading, spark]

---

**Lessons**

The following recommendations were made:

1. The doping system on the unit to be modified so that it is isolated by switching off the pump at the same time as the formaldehyde feed is isolated.

2. Paraformaldehyde to be removed from the unit whenever it is shutdown.

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

At 5:00 an operator was fillings bags on a spray unit. He heard a loud bang and saw flames coming out of the flange on top of the collection box. He then triggered the fire alarms and went for assistance.

The conclusions reached were that:

1. There had been vaporisation of the residual formaldehyde; and
2. Ignition of the vapour had followed with the possible cause of ignition being the electrical fitting.

[fire - consequence, explosion]

---

**Lessons**

Recommendations included:

The doping system on the unit should be modified so that it is isolated by switching off the pump at the same time as the formaldehyde feed is isolated.

Paraformaldehyde should be removed from the unit whenever it is shutdown.

[formaldehyde, spray drier/unit, explosion, fire - consequence]

---

Source : ICHEME

Location : , GERMANY

Injured : 0      Dead : 0

**Abstract**

On the 7th September 1976, at 06.00 hrs an explosion occurred in the incinerator system of the No.1 Sulphur Recovery Plant due to a carryover of LPG from the 3 / 4 - H<sub>2</sub>S Absorber Column on the Catcracker Unit via the Amine regeneration Column. There were no injuries to personnel but damage amounted to some £30,000 (1976), confined mainly to the unit stack and the incinerator air blower. The internal packing of the 3 / 4 absorber column required cleaning, and the column was therefore being taken out of service for water flushing. The flow of LPG to the H<sub>2</sub>S absorber column 1 was stopped, and diverted into the fuel gas system, and the column depressured to approximately 5 bars. The bottom level gauge on the absorber was unreliable due to blockage with deposits, and therefore an indirect system of measuring the drainage rate from the absorber was used.

Draining from the absorber column 1 commenced via the bypass valve of its bottom level control valve into the amine regeneration column 2 of the sulphur recovery plant. At the same time amine was drained from column 2 into the amine tank at such a rate as to keep the level in column 2 constant. By gauging the increase in level in the amine tank the operators were able to indirectly measure the loss in level of the absorber column 1, although the diameter of the latter was much less than that of the former. Approximately 1 hour after draining started, a high level alarm indicated in the amine regeneration column, and draining of amine from the absorber was therefore reduced to a minimum. About 1 minute later, the high flow alarm of the H<sub>2</sub>S flow from the regeneration column sounded. Draining of amine was ceased immediately, but it was too late to stop a large LPG carry over to the sulphur recovery section of the plant, which was still in commission. Liquid seals on the sulphur recovery section were blown gaseous and LPG was released into the sulphur pit. From here it was drawn into one of the air blowers via a line which had recently been installed to remove foul odour gases from the sulphur pit for disposal in the incinerator. The air blower 6, as well as removing foul gases from the sulphur pit provided combustion air for the incinerator and cooling air for the incinerator flue duct. LPG vapours were therefore carried forward from the sulphur pit into the incinerator and also into the flue duct. At the same time, LPG vapours travels through the reaction system into the incinerator, but these remained mainly in an unburnt state due to insufficient oxygen being available in the reaction system. Two eye-witnesses described two distinct explosions. The first explosion was in the blower 6, whilst the second some 3 seconds later occurred in the stack within the flue gas inlet area, causing a collapse of stack internal brickwork.

The investigating team considered that the first explosion was probably initiated by a flash back from the incinerator burner travelling back through the air line to the air blower. The second explosion was considered to have occurred due to a delayed autoignition of the induced LPG in the stack.

[heating, draining, incinerator, absorption, instrument/controller, autoignition, process causes]

**Lessons**

Recommendation made by the refinery include the proposal that the vent line from the sulphur pit should be fitted with a flame arrestor, and various improvements are also being considered to improve the drainage control from absorbers.

**1241 30 August 1976**

**Source :** 100 LARGEST LOSSES 9TH EDITION, MARSH & MCLENNAN PROTECTION CONSULTANTS, 1986; EUROPEAN CHEMICAL NEWS, 1976, 17 SEP.

**Location :** Plaquemine; Louisiana, USA

**Injured :** 0      **Dead :** 0

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**Abstract**

A leak between the shell and tubes of a reactor heat exchanger in an ethylene oxide plant allowed air to enter the heat transfer system. The top blew off the heat transfer oil surge tank. The ensuing fire lasted 4 hours causing extensive damage to six reactors and associated equipment.

[damage to equipment, fire - consequence, processing]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

Circulation was lost in a reboiler heater, automatic shutdown devices failed to activate the burner trips, the condition went unnoticed for at least five minutes during which time the controls called for more heat to the tower while none was being removed from the heater. The result was badly deformed heater tubes that required a unit shutdown for tube repairs or replacement. It was thought at this time that damage was limited to the reboiler and all maintenance emphasis was on these repairs.

Investigation into the cause of the incident revealed the following:

1. When circulation was lost through the heater, the automatic heater shutdown failed.
  2. The contents of the heater vaporised and the heater tubes overheated to such an extent that they badly deformed.
  3. As vapour traffic up the tower causing high liquid levels.
  4. The level control on the bottom of the first tower increased the reflux to the second tower and the rising level increased the reflux to the third further aggravating the level problem in No.3. There is some conjecture that the level may have covered the heater outlet to No.3 and was prevented from backing into the heater by the rate of vaporisation out of the heater.
  5. The operator restarted the reboiler pump without first shutting off all burners to allow the heater tubes to cool.
  6. Vaporisation at an extremely high rate occurred due to the heat level in the heater and the extremely narrow boiling range of the tower bottoms.
  7. A pressure surge was recorded at the bottom of all three towers with the most severe being in No.3 and diminishing as it travelled up the three towers. Severe liquid entrainment similar to a water knock in a stream line was undoubtedly incurred in at least the bottom of No.3.
  8. This pressure surge accompanied by high liquid entrainment similar to water knock in a stream line caused the tray damage in No.3.
  9. The destructive forces were dissipated by the tray damage in No.3 and the direction changes in the vapour line to No.2. Additionally more normal liquid levels in No.1 and No.2 did not result in high liquid entrainment in those towers.
  10. None of the charts or operators statements support the possibility that the wreck occurred during start-up following the initial repairs
- [safety equipment failure, overheating, damage to equipment, heating]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A contract electrician received an electric shock from live 250V anti-condensation heaters fitted to a motor, whilst removing a 3.3 kv electric motor for refurbishment.

The electrician fortunately received no injuries.

Investigation into the incident found that the motor was considered to be totally isolated with the correct Electrical Valid Isolation Certificate and Permit to Work for the removal of the motor.

[electrical, preparation for maintenance]

---

**Lessons**

The following recommendations were made:

1. A schedule of isolation control sheet should be prepared, for all refurbishment projects requiring electrical isolation, by the local instrument/electrical engineer and project engineer.
  2. This should detail the level of isolation of each electrical item for reference by the process personnel issuing Permits to Work for the project.
  3. For electrical contractors, induction courses should include the requirement to prove dead with an approved test instrument.
  4. A programme of refresher training should be carried out across the site to ensure complete awareness of the use of the Permit to Work on the electrical apparatus.
-

1179 16 May 1976

**Source :** ICHEME

**Location :** ,

**Injured :** 0      **Dead :** 0

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**Abstract**

Fire at a refinery desulphuriser plant. Source of ignition was autoignition. Equipment involved, heat exchanger. Substance involved: kerosene. Cause: flange leak.

[fire - consequence, refining]

---

**Lessons**

[None Reported]

---

1021502 March 1976

Source : ICHEME

Location : New Jersey, USA

Injured : 0      Dead : 0

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**Abstract**

A cooling tower had been out of service for about one week during which time the basin was emptied and cleaned. A contractor performed minor repair on the tower. After work had been completed the contractor disconnected his tools but left the 110 volt power cord on top of the cooling tower. It is projected that the energised cord became caught in the windblown blade of the fan cowling, thereby severing and arcing the 110 volt cord. The resulting sparks ignited the wood resulting in a fire in the cooling tower.

[repair, fire - consequence, maintenance procedure error, arcing]

---

**Lessons**

Procedures have been modified to require that all temporary power sources to be disconnected at ground level on a daily basis when working on cooling tower modifications.

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1132 25 February 1976

**Source** : CHEMICAL WEEK, 1976, MAR.

**Location** : Deer Park; Texas, USA

**Injured** : 0      **Dead** : 0

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**Abstract**

Fire - possibly caused by furnace tube rupture in ethylene dichloride process heater of vinyl chloride monomer (VCM) unit.

[fire - consequence, processing]

---

**Lessons**

[None Reported]

---

1115 21 January 1976

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

An explosion occurred involving an incinerator at a petrochemical styrene plant. Source of ignition was electric motor. Substance involved: ethylbenzene.  
[processing, heating]

---

**Lessons**

[None Reported]

---

1113 17 January 1976

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Refinery utilities area. Fire at cooling tower.

[fire - consequence]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

An alert operator noted a loose tube sheet flange stud on a high temperature, high pressure heat exchanger in an hydrodealkylation unit.

The stud was found to be cracked through an on testing it proved to be standard steel rather than the alloy type specified. Some of the other studs had started to crack.

The studs had been replaced on the previous shutdown when the heat exchanger was opened up to clean the tube bundle.

[heating, shell and tube heat exchanger, near miss, incorrect material of construction, crack, maintenance inadequate, hydrogen]

---

**Lessons**

Quality control of replacement parts used in maintenance is as important as for new equipment.

---

1083 16 December 1975

**Source** : CHEMICAL MARKETING REPORTER, 1975, 22 DEC.

**Location** : Penuelas, PUERTO RICO

**Injured** : 3      **Dead** : 2

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**Abstract**

Leaking propylene gas was ignited in a refrigeration unit causing flash fire during maintenance shutdown. Fatality.

[fire - consequence]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , GERMANY

Injured : 0      Dead : 0

---

**Abstract**

During the night shift of the 27th October 1975, a mild explosion occurred in the fume disposal heater of the bitumen plant at this refinery. No-one was injured and there was only a slight damage to the heater brickwork.

The fume disposal heater is normally used to dispose of vapours from the blowing towers of the bitumen plant and the bitumen tanks. At the time of the incident the heater was already in operation, whilst the continuous blowing tower was being prepared for recommissioning. It was noticed that the level control valve on the knock-out drum in the vapour line to the heater was moving even though at that time there was no bitumen in the plant. It was therefore decided to purge through the system with plant air. This was done, and simultaneously the burners on the fume disposal heater went out. When the operator was about to re-ignite the burners, a mild explosion occurred in the heater which blew open the explosion door damaging in its 22 mm thick cast iron handle.

The refinery considered that there were two possible reasons for the explosion:

1. The burners were blown out by the plant air, and vapours and droplets of hydrocarbon, transported by the plant air via the preheated vapour train to the heater, formed an explosive hydrocarbon /air mixture in the heater which then ignited

or

2. The burners went out because of too heavy a fuel gas, or an unstable fuel gas supply. Fuel gas could have accumulated in the heater box and ignited explosively when the burners were re-ignited by the operator. This would mean that the fire box was not sufficiently purged prior to the recommissioning of the burners

The refinery has re-informed the operators of the existing standing instructions applicable to the commissioning of the heater, including the necessity to adequately purge before lighting any burner.

[refining, commissioning, heater, unwanted chemical reaction, explosion, bitumen]

---

**Lessons**

In the absence of pilot burners, it would have been advisable to shut off other burners in the heater whilst blowing the system through, since there is always risk of flame-out.

---

1040 13 August 1975

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Ethylene oxide and air gas cloud explosion in cooling tower bay. Shutdown procedure wrongly carried out. This allowed ethylene oxide back into the already decontaminated ethylene oxide stripper. When lean absorbent pumps started ethylene oxide and water were sent to the cooling tower. Ethylene oxide was desorbed and the gas cloud exploded, ignited by nearby furnace.

[human causes]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 1

---

**Abstract**

To perform its function a coking unit furnace must operate close to the temperature at which coke is laid down on the tube walls. An abnormal localised laydown of coke can result in raising the metal temperature to the point where the tube fails. Traditionally the operators inspected the heater tubes to detect these hot spots visually. After two serious failures this was replaced by the use of multiple skin thermocouples. An infrared camera was used to detect the points on the tubes where hot spots were almost likely to occur. These points were where the skin couples were installed on each tube pass.  
[hydrocarbons, heating, continuous reaction, furnace tube, rupture, fire - consequence, fatality, tube failure, creep, design inadequate]

---

**Lessons**

Where internal coking or scaling of furnace tubes may rise the wall temperature locally during a run, a reliable method of measuring the maximum temperature is required.

An infrared camera survey to detect the normal points of maximum temperature and skin thermocouples are one way of meeting this requirement. Skin couples have a tendency to detach from the tube so three were fitted to each tube pass.

---



Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A high pressure, high temperature hydrodesulphuriser reactor charge heat exchanger suffered from repetitive leaks from the tubesheet to shell joint. These were not cured by replacing the gasket and adhering strictly to the bolt tightening schedule.

A check on the design showed that the flanges did not meet the standard to which they had been supplied. Re-machining the flange faces to a new configuration corrected the problem.

As the oil was above autoignition temperature fire resulted.

[maintenance, shell and tube heat exchanger, fire - consequence, flange leak, design inadequate, hydrocarbon]

---

**Lessons**

1. Independent checking of equipment vendors design calculations is desirable.
  2. If the same problem occurs more than once on a piece of equipment do not repair it, look for a design fault.
-

Source : ICHEME

Location : ,

Injured : 11    Dead : 2

---

**Abstract**

An explosion occurred recently in a control room of an olefine unit which took the lives of two operators. Eleven other people were injured. The damage, was confined to the control room and its electronic equipment, the unit itself remained undamaged.

The explosion occurred in a cellar underneath the control room in which the central heating facilities were installed. This included a steam supplied hot water heater. The steam trap from this heater relieved into an atmospheric receiver in the cellar. Before the explosion a tube leakage occurred in a steam supplied preheater on the unit. The exchanger had exhaust steam on the tube side and hydrogen rich gas on the shell side. This leak allowed hydrogen rich gas to penetrate into the exhaust steam system and to escape via the steam trap into the cellar underneath the control room. When the smell of the gas was noticed, an operator descended into the cellar and switched off a non-explosion proof motor on a condensate pump. It is not known for certain if this switching operation ignited the gas accumulated in the cellar, but the subsequent explosion blast destroyed the ceiling of the cellar and caused the control room to partly collapse.

An operator, who happened to be smoking in the rest room on top of the cellar, was killed immediately. Eleven other people were hurt when the control room collapsed. The operator, who had descended into the cellar, was not hurt by the explosion blast, although at the centre of the explosion, but he was unfortunately so severely burnt that he died later in hospital.

The reason for the internal leakage of the steam preheater was that during a previous commissioning operation, condensate had been frozen within the tubes and split some of the tubes open.

[processing, heat exchanger, heater, leak, tube failure, fatality, injury]

---

**Lessons**

Where the steam pressure in an exchanger is exceeded by the process stream pressure then a non-return valve should be fitted in the steam supply to the exchanger. Consideration is also necessary of the exhaust steam/condensate routes and types of steam traps. This may well involve a detailed study to determine possibilities of inter linking contamination of steam and condensate, specific to a particular refinery.

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1141028 October 1974

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

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### Abstract

During the evening of the 28th October, 1974, a low intensity explosion occurred in the splitter vertical reboiler heater on a catalytic reformer, followed immediately by a fire underneath the heater. No injuries to personnel were reported but the furnace floor collapsed and fuel oil and fuel gas pipework was buckled and severed in places.

The reboiler was in the final stages of being shut down with three main gas and pilot burners in commission. Operation of the heater at this time was troublesome because of the instability of the refinery fuel gas supply main and also the strong gusts of wind which reached gale force at times. While closing the furnace damper (a minimum stop is fitted), the burners went out and before any emergency action could be taken there was a muffled explosion followed by the collapse of the four segments of the heater floor and the emergence of a fire beneath the furnace. The source of the fire was partly from small quantities of residual oil in the burner registers, but mainly from the severed fuel gas lines which were still open to the refinery main. The fuel oil lines had been previously isolated and steamed out. The gas supply was isolated and the fire extinguished in about 5 minutes using steam lances and two water monitors. The 300-400 gallons of water from the monitors created a problem in the area because of the inability of the drainage system to cope with it and eductors had to be used to remove it.

[fire - consequence]

---

### Lessons

[None Reported]

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A fire occurred on a superheater return bend of two furnaces. The fire spread to an open pit and used to drain off the fuel oil knock-out drum. Significant electrical and instrumentation cable damage occurred.  
[fire - consequence, damage to equipment, heating]

---

**Lessons**

[None Reported]

---

**Source :** ICHEME

**Location :** Kurashiki City, JAPAN

**Injured :** 0      **Dead :** 0

---

**Abstract**

During repairs of a heat exchanger in a benzene plant, a mixed gas (methane and hydrogen) contained in the cold box attached to the exchanger leaked and caught fire from a welding spark. The exchanger was severely damaged by the fire.

The cause of the incident: The valve was not provided with a blind plate, the cold box was in a incompleted closed position.

[fire - consequence, damage to equipment, operation inadequate]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : California, USA

Injured : 0      Dead : 0

### Abstract

A fire and explosion occurred in the convection section coil of a reforming unit heater. All units were operating normally prior to the fire.

The fire was discovered at 0520 hours by an operator checking the firebox. The fire was permitted to burn while the unit was being shut down.

At approximately 0555 hours, 150 psig steam was introduced into the circulation line upstream of the heater, per unit operating instructions, in order to push oil through the convection coils into the fractionation tower. At 0610 hours an explosion occurred enveloping the heater and adjacent area in a large amount of fire. All heater coils were then blocked in and the steam shut off. The fire burned for about 30 minutes until all fuel was consumed. The heater itself was severely damaged, and many items of adjacent equipment were destroyed. The unit was shut down for 11 days.

The heater was of dual purpose design, the radiant section acting as a reheater for a reactor charge stream and the convection section supplying heat to a fractionation column reboil system. The reboil fluid contained 0.05-0.3% sulphur compounds. Normal operating pressure was 120 psig, normal operating temperature was 570 degrees F. The heater was installed in 1955 accounting for the convection and radiant tubes, service life of approximately 170,000 hours. The convection tubes were 6-5/8 inch OD, Schedule 40, low carbon A-161 steel.

Inspection following the fire revealed two bottom row convection tubes with one quarter inch to half an inch holes directly at the point where the tubes were in contact with a tube support. Presumably these holes were the source of the initial controlled fire. One of these tubes had an 18 inch long rupture in the same general location as the holes. Examination of the tubes indicated that the cause of tube failure was internal corrosion from high temperature sulphur attack. The initial failure occurred at a point at which corrosion was locally aggravated by hot spots caused by contact of the tube with the tube hanger. The subsequent tube rupture occurred in an area where there was general thinning of the tube wall. The thinning was caused by localised heating in an area where hotter flue gases reached the convection tubes through a gap in the lower row of radiant tubes.

In the inspection report, it was postulated that the massive tube rupture was caused by a combination of excessive wall thinning due to internal corrosion, elevated temperature due to flame impingement from the original tube failure fire, and internal pressure.

[fire - consequence, damage to equipment]

### Lessons

1. Several tube wall thickness measurements had been made of 'accessible' tubes in prior years. Projections of indicated wall loss showed that retirement wall thickness would have been reached in 1977 at the earliest.

2. Primary action to prevent a recurrence will be to initiate more frequent and more detailed inspection of the convection tubes. It will be necessary to periodically remove selected tubes for proper inspection.

3. Steaming of the coil to the tower has been eliminated as a standard procedure, since it appears the positive aspects of this action are outweighed by the negative factors. In this case, it is felt that a combination of excess air and distillate pressured into the firebox by the injection of steam created an explosive mixture.

4. No equipment changes were recommended as it was felt that the revised inspection programme will provide adequate protection.

5. Although no injuries occurred, just prior to the explosion several employees had been near the heater. Refinery fire training now stresses that close approach to danger areas during an emergency should be minimised.

6. Operator training should emphasise the value of frequent routine firebox inspections. Early detection of a small leak will reduce the chances of that leak developing into a massive rupture by minimising the duration and severity of flame impingement from the leak onto adjacent coil surfaces.

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A fire occurred in the heat banks and ducting of a friction dust plant oven floor. Fortunately the fire did not spread to the trolleys in the ovens due to the metal mesh filters in the heater banks acted as flame arresters. The activation of the steam snuffers in the ovens during the incident effectively prevented later ignition.

Chemical involved: furfural

[fire - consequence, near miss]

---

**Lessons**

The following recommendations were made:

The ovens and ducting to be fitted with effective detectors to give early warning of fires and to automatically shut off the circulating and scrubber fans in the event of their being activated.

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866 09 February 1974

Source : CHEMICAL MARKETING REPORTER 25-2-74; EUROPEAN CHEMICAL NEWS, 1974, 15 FEB.

Location : Sarroch, SARDINIA

Injured : 0      Dead : 0

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**Abstract**

A fire broke out on a heat exchanger in a hydrocarbons plant. The cause of the fire was leakage of hydrogen.

[fire - consequence]

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**Lessons**

[None Reported]

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Source : BOND J, CASE STUDIES OF UNSTABLE SUBSTANCES, HAZARDS FROM PRESSURE, ICHEME SYMPOSIUM SERIES NO.102, 37-44.

Location : ,

Injured : 7      Dead : 0

#### Abstract

This incident led to an explosion caused by copper acetylide. The shell of a heat exchanger ruptured on a methanol product condenser. Copper acetylide formed in a heat exchanger from a process stream containing 300 ppm of acetylene and decomposition occurred when the exchanger was shut-down for maintenance work. The conditions for the formation of copper acetylide are given and the means of deactivating it are also given.

[heat transfer]

#### Lessons

Examination of the literature has shown that the following conditions favour acetylide formation in copper equipment.

1. The construction material has to contain more than 50% copper. The higher the copper content the easier the acetylide forms.
2. Formation is assisted by corrosion of the copper surface. Mineral acids, caustic solutions and ammoniacal solutions all encourage the formation of acetylide.
3. Moderate temperatures (10-50 degrees C) are probably necessary for the formation of active material; decomposition can occur at any temperature depending on activity.
4. The higher the concentration of acetylene present the greater the probability of active deposits of acetylide forming, but concentrations of a few ppm of acetylene can be sufficient.

These conditions were present in the exchanger. The source of acetylene was identified as a minor process stream containing 300 ppm of acetylene which was used intermittently.

A procedure for deactivating copper acetylide deposits has been developed so that all copper equipment suspected of containing acetylide can be made safe.

Vessels are treated with 5% hydrogen peroxide in water at 50-60 degrees C followed by a 5% solution of sodium diethyl dithio-carbamate also at 50-60 degrees C. Cleaning is then completed by flushing with methanol/water.

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

An ethylene cracker was being brought on steam for the first time. Some hours after the furnaces had first received feed and were producing cracked gas, one of a series of low pressure heat exchangers in the gas separation plant became over-pressurised and fractured. In turn this split open a high pressure heat exchanger and large amounts of flammable vapour escaped. Ignition occurred after 34 seconds and the serious fire that occurred burned for 12 hours. The aluminium heat exchangers, 30m above ground on an open steel structure, were destroyed and ancillary equipment was seriously damaged.

[overpressurisation, gas / vapour release, damage to equipment, fire - consequence]

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**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

An explosion followed by a ground fire occurred in a cat cracker pre-heater as a result of spirit carryover from a phenolic soda washery. A pilot gas line located 20ft. above the fire ruptured after exposure to flame.

No personnel were injured but the pre-heater and nearby pipework suffered damage.

Operational difficulties had been experienced in the washery during the two days prior to the fire and it had recently been recommissioned. The trouble was subsequently found to be due to blockages in the pipework caused by the precipitation of solids while operating with a phenolic soda strength in the region of 14%. The carryover was attributed to a build-up of spirit in the soda regenerator due to these blockages. Shortly before the incident the washery had once again been taken out of service and the soda and wash systems shut down. However the foul gas line to the pre-heater was left in service and the air to the regenerating column kept in commission.

[cracking, catalytic cracker, heater, isolation inadequate, fire - consequence, explosion, damage to equipment]

---

**Lessons**

This incident could have been avoided if:

1. The personnel on duty had been fully aware of the potential dangers associated with the carryover problems experienced by previous shifts, thus emphasising the necessity for good handovers in changes of shift
  2. The soda regenerator off-gas line had been isolated from the pre-heater when the soda system was shut down.
-

111951974

Source : ICHEME

Location : ,

Injured : 2      Dead : 0

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**Abstract**

A new fin fan cooler was undergoing a hydraulic test when a plug blew out. The jet of water injured a fitter and his assistant.

Investigations revealed that the pressure gauge had been fitted to the air supply driving the pump instead of on the water discharge. It is estimated that the actual pressure developed in the cooler was between 1000 to 1500 psig.

[testing, fin fan cooler, operator error, overpressurisation, injury]

---

**Lessons**

Detailed procedure on 'Hydrostatic Testing' should be available and training held in the correct setting up and use of hydrostatic test pumps. All connections to the test pumps should be colour coded and signwritten to denote their services.

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A tube in a hydrofiner heater ruptured resulting in an extensive fire inside and outside the furnace. The main fire in the furnace was extinguished within 15 minutes and the escaping gas / vapour release from the ruptured tubes allowed to burn under controlled conditions. There were no injuries to personnel but the furnace suffered damage estimated at £10,000 (1973), which included four distorted tubes and certain refractory damage. Some cabling, electrical and instrument fittings on the outside of the heater were also badly burnt.

The investigations revealed that during changes in operating conditions a cold circulation start-up valve was opened by mistake resulting in liquid feed/hydrogen starvation of the heater tubes for a period of 35 minutes and eventual rupture of the tube with massive release of hydrogen and hydrocarbon vapours.

[damage to equipment, fire - consequence, operator error]

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**Lessons**

1. Keep the 4" cold circulation start up valve locked in the 'shut' position when the unit is on-stream and attach a 'Danger, Valve Not to be Opened' tag to the valve wheel.
  2. Fit tube skin thermocouples with maximum temperature alarms to the furnace to give warning of overheating.
-

**Source** : MITCALF J, FAILURE IN START-UP HEATER TUBE, AMMONIA PLANT SAFETY VOL.17, 1975, 123-125.

**Location** : Ince, UK

**Injured** : 0      **Dead** : 0

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**Abstract**

During the start-up of an ammonia plant there was a violent explosion due to a tube rupture in the start-up heater. The investigation showed from nitriding that the failed tube had been subjected to 500 degrees C at its internal wall for most or all of its life. At this temperature and stress from the pressure, creep failure could be expected.

[incorrect temperature, tube failure]

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**Lessons**

[None Reported]

---

Source : JOURNAL, 1973, 21 NOV.; NORTHERN ECHO, 1973, 21 NOV.

Location : Jarrow, UK

Injured : 5      Dead : 0

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**Abstract**

Explosion followed by fire in steam heated drying oven.

[fire - consequence]

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**Lessons**

[None Reported]

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1256526 October 1973

**Source :** ICHEME

**Location :** Yokohama City, JAPAN

**Injured :** 0      **Dead :** 0

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**Abstract**

A fire occurred in the chimney of the heater on a gas desulphurisation plant. The fire was extinguished soon after the stoppage of gas oil feeding. The cause of the fire was due to deformation of the heater tubes on the furnace due to being locally super-heated. No one was injured in the incident.  
[fire - consequence, high temperature]

---

**Lessons**

[None Reported]

---



Source : EUROPEAN CHEMICAL NEWS, 1973, 5 OCT.

Location : Ardeer, UK

Injured : 0      Dead : 0

---

**Abstract**

350 ft cooling tower collapsed at nylon salt plant during adverse weather conditions, gales.

[weather effects]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , UK

Injured : 1      Dead : 0

### Abstract

A contractor's employee was fitting a lagging box to the shell-side flange between two fluxed asphalt coolers, when a test plug sited immediately above the flange blew out. Fluxed asphalt sprayed over the lagger and the surrounding area. He sustained third degree burns to his face and arms, and second degree burns to other parts of the body. Plant personnel immediately reduced the pressure in the asphalt exchanger line and the hole was plugged with a solid plug, normal operating conditions were re-established within 30 minutes.

The victim's job involved the fitting of lagging boxes on exchanger flanges after the joints had been proved tight under operating conditions. The work was correctly covered by work permit. The failed plug was found to be a three quarter inch barrel nipple fitted with a three quarter inch screwed cap, which does not meet the heat exchanger specifications, these require the use of bar stock plugs to blank off unused heat exchanger sockets. Capped screwed fittings are not normally permitted because the parallel threaded caps tend to leak in service. Such a fitting however, cannot be held responsible for this accident because the socket connection and not the cap had failed.

Although it could not be definitely established, it seems likely that this fitting was first introduced to the exchanger during the precommissioning, after the exchanger floating head had been found to be leaking. It was not therefore subject to the manufacturer's hydraulic test and the process tightness testing was almost certainly limited to a 100 psig standing nitrogen test under which conditions no leakage was reported.

The exchanger containing the faulty plug had in the past, operated for a considerable period at the pressures up to 120 psig, since the installation of a back pressure controller in the asphalt product line, the exchanger had operated consistently at 30 psig maximum. No leakage was reported under either condition. At the time of the incident the unit was operating steadily and there is nothing to suggest that the exchanger operating pressure was other than the 30 psig. It is believed that he must have knocked against the plug and disturbed it sufficiently to cause it to blow out: the screwed thread of the barrel of the nipple had probably not been inserted to a sufficient depth to hold safely.

[operational activities, cooler, heat exchanger, flange, mechanical equipment failure, injury]

### Lessons

The following recommendations were made:

1. For operational Lub. Oil Units

- (a) All exchanger and other plugs should be check visually for the use of non-standard fittings and possible inadequate tightening
- (b) Suspect fittings should not be touched whilst the unit is in operation. Senior staff should decide whether the unit should be shut down to replace or repair any plug

2. For Lub. Oil Plant currently non-operational

- (a) All plugs should be checked by responsible engineer

**Source :** URSENBACH W.O, HAZARD ASSESSMENT FROM INDUSTRIAL EXPLOSION INVESTIGATION, ICHEME SYMPOSIUM SERIES NO. 80 , 1983, N4-N13; URSENBACH W.O, UNUSUAL EXPLOSION AND FIRE INVESTIGATIONS, LOSS PREVENTION AND SAFETY PROMOTION IN THE PROCESS INDUSTRY, 3RD INTERNATIONAL SYMPOSIUM, BASLE, SWITZERLAND, 15-19 SEP., 1980, 1/138-1/147.

**Location :** ,

**Injured :** 0      **Dead :** 0

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**Abstract**

An explosion and fire destroyed an ink manufacturing plant. Investigation showed the initial explosion occurred near a ceiling natural gas heater and this triggered an explosion in a solvent tank and release of naphtha which led to a serious fire in other buildings. Extensive discussion on the path and sequence of events.

[fire - consequence, processing]

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**Lessons**

[None Reported]

---

Source : ICHEME

Location : , NORTHERN IRELAND

Injured : 0      Dead : 0

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**Abstract**

A tube in the hydrofiner heater d resulting in an extensive fire inside and outside the furnace. The main fire in the furnace was extinguished within 15 minutes and the escaping gas/vapour from the ruptured tubes allowed to burn under controlled conditions until 17.50 hours. There were no injuries to personnel but the furnace suffered damage estimated at 10,000 lb, which included on ruptured and four distorted tubes, and certain refractory damage. Some cabling, electrical and instrument fittings on the outside of the heater were also badly burnt.

During changes in operating conditions a cold circulation start-up valve was opened by mistake resulting in liquid feed/hydrogen starvation of the heater tubes for a period of 35 minutes and eventual rupture of the tube with massive release of hydrogen and hydrocarbon vapours.

[processing, heater, furnace, overheating, tube failure, additional incorrect operation, gas / vapour release, fire - consequence]

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**Lessons**

The following recommendations were made by the refinery to avoid a possible repetition:

1. The 4 inch cold circulation start up valve should be locked in the 'shut' position when the unit is on-stream and a "Danger, Valve Not to be Opened" tag attached to the valve wheel.
  2. Fit tube skin thermocouples with maximum temperature alarms to the furnace to give warning of overheating.
-

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A serious fire occurred on an ethylene plant when a heat exchanger forming part of the 'Cold Box' of the gas separation system failed due to overpressure. This caused a massive release to atmosphere of flammable vapours and thermal insulation powder. The vapours ignited shortly after release and the resulting fire burned for several hours under controlled conditions. The 'Cold Box' was extensively damaged, but there were no serious injuries to personnel.  
[overpressurisation, gas / vapour release, fire - consequence, damage to equipment, ethylene]

---

**Lessons**

It is likely that failure occurred on large bore high-pressure aluminium pipework (probably 12 inch) or headers in the lower heat exchanger area. Equipment manufactured from aluminium which has low fire resistance, contributed to the size of the fire.

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Source : ICHEME

Location : ,

Injured : 0      Dead : 1

### Abstract

The liquid receiver of a 0.25 tonne per hour capacity refrigeration unit ruptured. The receiver, apart from the dished base end, was propelled upwards and passed through the corrugated asbestos roof to land in the roadway outside the building.

The vessel rupture was caused by overpressurisation of the system due to the increase of air through a leaking valve. The particular valve was of the spring loaded pressure control type with a bellows seal which, in its failed condition, was capable of being closed against the flow of refrigeration and leaking inwards under vacuum conditions at the same time (via failure of the bellows). The valve was fitted after the liquid receiver and on the inlet side of the evaporator. In this position, it was capable of shutting off the flow from the compressor whilst at the same time allowing air to be drawn into the system by the compressor valve. He (or indeed anyone else) would not have been able to anticipate the results of such action, unless he had knowledge of the particular failed condition of the valve. It is extremely unlikely that he had such knowledge.

The unit was not protected with a high pressure out-out switch or pressure relief device. The protective switch originally fitted to the unit was located near the unit, however, it was disconnected at the time of the incident. It is believed that the switch was disconnected by the Maintenance Service contractors when the compressor of the unit was replaced in 1968, in accordance with their stated practice for this size of unit.

[valve failure, refrigeration unit, fatality]

### Lessons

The following recommendations were made:

1. All industrial refrigeration units irrespectively of size should comply to B.S. Code of Practice CP406 (1952) with particular reference to Part II Safety and also to B.S.4434 (1969) Refrigeration Safety.
2. All units should be clearly marked with the following information.
  - (a) Refrigerant type and capacity
  - (b) Normal working temperatures and pressures.
3. All liquid receivers of identically sized units to that mentioned should be convex dish ended vessels.
4. The liquid receivers of small refrigeration units should not be secured by bolts welded to the dish end. The securing device should be so designed as not to impose any stress on the receiver.
5. Small refrigeration systems should be tested on a scheduled basis and adequate records of such tests and servicing should be maintained.
6. Servicing contracts and maintenance requirements of refrigeration units should be reviewed. In addition, regular monitoring of such contract work should be introduced.
7. All maintenance supervisors should be given refresher training on the basic principles of refrigeration practice and attendant trouble-shooting.

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A near miss incident occurred when an operator recommissioned a fin-fan cooler upon which a fitter was working. Fortunately the fitter was still removing the safety guards and was not injured.

The electrician, when requested to electrically isolate a fin-fan cooler required by maintenance, signed the Work Permit to certify that he had done so before isolating the equipment, even though this procedure is strictly forbidden. In the event, he became involved in another task and the Permit was issued and work commenced without electrical isolation of the motor. A second unit operator, seeing the fin-fan had stopped, restarted the fan.

[operator error, competency lacking]

---

**Lessons**

Following this incident the company carried out a review of the Work Permit system with particular reference to their issue.

As an additional safeguard against possible malpractice, hoods are now placed over push-button pedestals in addition to certified electrical isolation.

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A major fire which occurred at the base of a vacuum distillation column resulted in serious damage to two adjacent banks of fin-fan heat exchangers, cable runs and extensive areas of column cladding.

Two bottoms residue pumps, associated with the vacuum column were in use at approximately 80% of their capacity. During the night shift of 4th July, 1973, the seals on one of the pumps started to leak and fire occurred which was extinguished with steam and dry powder. The pump was therefore taken out of service. Almost immediately after the operators had blocked in the residue pump, the relief valve on the column lifted followed by a large leak and fire around the remaining running residue pump.

The major fire alarm was raised, and the fire fought with water monitors by the refinery personnel, later assisted by mutual aid participants and the local authority brigade. The fire was under control and extinguished within one hour.

Investigation after the fire showed that the section line had been torn open over a length of about 60 cm wide by 10cm. Also other parts of the lines had holes in them. The material of the bend in the section line seemed to be 10mm thick at the top side, where ultra sonic testing had always been carried out.

A test carried out at the bottom side showed that this part the thickness was only 4mm. Other parts of the suction line showed variations in thickness. The vacuum column bottoms line was constructed of carbon steel and was about 10 years old. Ultrasonic testing of it had been practised at selected points, by cutting pockets in the metal cladding covering the line. Lines in other parts of the unit had already been replaced in chrome steels.

An explanation given for the incident is that the capacity of the one running residue pump was insufficient to hold down the level in the vacuum column to the normal operating position. As the level rose, vacuum was lost, the relief valve lifted and eventually the static head of oil in the column was such that it caused the failure of the badly corroded pump suction line.

One feature of this fire was again the unwelcome part played by the updraft through the fin-fan cooler banks, and the difficulty in fighting fire in the confined areas adjacent to column bases.

[distillation, vacuum distillation column, line, pump, fin fan cooler, corrosion, leak, fire - consequence]

---

**Lessons**

The installation of fixed water monitors on the unit was recommended.

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112121973

Source : ICHEME

Location : ,

Injured : 2      Dead : 0

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#### Abstract

Two maintenance men were adjusting the drive belt of a fin fan cooler on a new 200,000 BPSD crude distillation unit when the fan was recommissioned. Both men received head injuries which would have been more serious if they had not been wearing helmets. The fitters had completed work on one air cooler and, after informing the unit operator that it was ready for commissioning, asked for another one to be isolated. On returning to the bank of fin fan coolers, the fitters started work on the fan that was shut down which, unfortunately, was the one they had just handed back to the operations department who recommissioned it shortly afterwards.

[design or procedure error, people, injury]

---

#### Lessons

The refinery reviewed the procedures involving fin-fan exchangers, and recommended that warning signs be placed on the electrical equipment operating the fans. In addition, the refinery is considering the installation of a safety lock which restricts access to the fin-fan cooler and when opened, automatically shuts off the power supply to the fan motor.

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112111973

Source : ICHEME

Location : , NORTHERN IRELAND

Injured : 0      Dead : 0

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**Abstract**

A near miss incident occurred at a refinery when an operator recommissioned a fin fan cooler upon which a fitter was working. Fortunately the fitter was still removing the safety guards and was not injured.

The electrician, when requested to electrically isolate a fin-fan cooler required by maintenance, signed the Work Permit to certify that he had done so before isolating the equipment, even though this procedure is strictly forbidden. In the event, he became involved in another task and the Permit was issued and work commenced without electrical isolation of the motor. A second unit operator, seeing the fin-fan had stopped, re-started the fan.

[operational activities, fin fan cooler, operator error, isolation inadequate, management system inadequate, near miss]

---

**Lessons**

As an additional safeguard against possible malpractice, hoods should be placed over push-button pedestals in addition to certified electrical isolation.

---

**Source :** ICHEME

**Location :** ,

**Injured :** 0     **Dead :** 0

---

**Abstract**

Aluminium smelter.

[fire - consequence, smelting furnace]

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**Lessons**

[None Reported]

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Source : ICHEME

Location : ,

Injured : 1      Dead : 0

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**Abstract**

An explosion occurred during an attempt to light a burner in a heater. The explosion caused total destruction of the heater and injury to an operator. In the sequence of events leading to the explosion, the unit was shutdown midday on the day of the incident due to compressor problems. In the shutdown process, the heater was shutdown by closing the main fuel gas cock valve at the fuel gas header. The burner valves may have been left wide open.  
[operation inadequate, injury]

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**Lessons**

[None Reported]

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**Source :** ICHEME

**Location :** Yokkaichi City, JAPAN

**Injured :** 0      **Dead :** 0

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**Abstract**

A fire occurred when a break occurred in the ethylene supply pipe connected to the upper part of a reactor in an ethylene alcohol plant; ethylene gas remaining in the pipe caught fire.

The fire was quickly extinguished.

The cause of the incident was due to power supply failure, which shut the plant down.

A heater was left incompletely suspended, and the temperature of ethylene gas present at the inlet of the reactor rose abnormally high, resulting in a collapse of the ethylene supply pipe.

No injuries occurred.

[fire - consequence, plant shutdown, high pressure]

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**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Following an operational upset on the catalytic cracker on 29th July, 1972, flow through the south pass tubes of the unit's feed preheater furnace was interrupted for about 10 minutes while the heater was still being fired. The heater tubes were subjected to 'creep shock' which resulted in leakage at the expanded ends of 11 of the tubes. The leaking vapours ignited and a minor fire occurred in the east end header box of the south radiant wall tubes. The fire was readily extinguished by a fire steam hose and the vapours blanketed by the fixed snuffing steam.

There were no injuries to personnel and damage to the heater was minimal.

Prompt emergency action was taken by the operating staff in opening steam to the header boxes and shutting down the furnaces. The refinery fire service was on site within 2 mins. of receiving the alarm and the fire in the header box was extinguished without difficulty using a fire steam lance and controlled thereafter by the snuffing steam to the header boxes.

The initiating cause of the incident was the loss of the gas compressor but the tube overheating and subsequent escape of oil with a fire was due to the faulty furnace temperature controller.

[fire - consequence, refining, instrumentation failure, cracking, temperature meter/control]

---

**Lessons**

The heater outlet thermocouples were located ca 30 ft. downstream of the heater and sufficiently remote so as not to be influenced by conducted heat from the furnace. This 'dead-leg' location was responsible for no temperature increase being recorded during the no-flow condition.

---

4754 22 July 1972

Source : ICHEME

Location : ,

Injured : 2      Dead : 0

---

#### Abstract

On 22nd July at 22.35 hours a fire lasting about 20 minutes broke out under the furnace of the vacuum distillation unit due to the accidental entry of water into the blowing tower which frothed and carried foaming oil over into the heater. One man suffered foot and a second injured his finger on a steel structure during the ensuing emergency actions. The plant was out of commission for about a fortnight.

The bitumen blowing tower and plant was in the process of starting up, and a gas oil wash had been carried out following which the tower was filled with feedstock from the vacuum unit.

The oil/water in the blowing tower was produced at the moment when the circulating pump was started. It was later discovered that a cooler in this system was leaking and that water had passed from this into the circulating line and then into the tower.

[fire - consequence, injury]

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#### Lessons

A number of recommendations followed the investigation of the fire:

1. The ejector circuit was modified to allow the vapours to go to atmosphere during the start-up period instead of to the furnace; only after the unit is operating steadily would the gases go to the furnace.
  2. The start-up procedure was being mended and to avoid sending water into the tower when it was full of feed, the circulating pump will be started as soon as the level in the column permits it.
  3. The cooler on the circulating line will be pressure tested before start up.
-

6681 15 July 1972

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

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**Abstract**

At 1750 hours on 15th July, 1972, and again at 0605 hours on 26th July small fires occurred at the inlet nozzle flange of the catalytic reformer effluent heat exchanger. Both fires were extinguished with dry chemical and the flange bolts tightened.

[fire - consequence, processing]

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**Lessons**

The occurrence of flange fires in plants on hydrogen service was investigated and a questionnaire was circulated within the company to establish whether this hazard continued to be a problem or whether it has decreased to acceptable levels.

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9344 13 May 1972

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A crane lurched whilst attempting to lift a channel cover from heat exchanger. Warning lights failed to operate on 50% overload.  
[maintenance]

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**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

### Abstract

A severe and prolonged fire broke out on a crude oil heater of a crude distillation unit at 3.57 hours on 9th May. At this time the unit was in the preparatory stages for handing over to maintenance. Crude feed had been taken out two days earlier, the unit circulated down, desalters pumped out and a gas oil wash introduced.

The gas oil circulation was commenced at 07.00 hours on 8th May and the heater outlet temperatures raised to 250 degrees C and held for 5 hours. Circulation continued whilst the heater outlet was cooled back to 38 degrees C -50 degrees C (100 degrees F -125 degrees F) and at 20.00 hours a programme of clearing oil from the exchangers, vessels and lines was started, the oil to be displaced via the heater into the column using nitrogen. This was only partially successful and oil had to be drained to the ground from exchangers and vessels whilst it was decided that steam should be used to blow through the residual oil in the furnace.

At 03.00 hours on 9th May dry steam was admitted into the four main heater inlet passes serving the two cells of the furnace; six pilot burners were maintained in commission in each cell. Some steam hammer was noted at this time and the steam flow was reduced but at 03.30 hours there was no sign of anything untoward and the passes were being blown in turn. At 3.55 hours heavy black smoke was noticed coming from the stack and it was then seen that there was a fire underneath and around the furnace, internal and external fire assistance was requested. Eye-witnesses from neighbouring plants reported that the fire reached maximum intensity in a very short space of time, burning oil was draining from the west section of one of the cells and the flames reached up and over the south face of the heater licking the side of the concrete stack.

It was decided not to blow through the remaining passes in case this spread the fire. After about half an hour the fire was contained within the fire-box and burned fiercely here, the fire fighting effort being directed at cooling down structures and preventing heat damage from fire and flames.

There was some risk of fire spread to other areas within the plant and to an adjoining major pipe track because of insufficient drainage but this risk rapidly disappeared as the fire became centred inside the firebox.

By 05.30 hours the fire was relatively small but continued to burn as isolated minor fires until about 10.00 hours at which time it was considered extinguished.

No-one was injured in this incident but the furnace was extensively damaged and complete re-tubing of one cell and much of the other cell was necessary. It was expected that the plant would be off-stream for about four months.

The fire was caused, it is believed, by steam hammer on one of the tubes which was thin due to overheating at an earlier stage in the run-life of that plant.

The history of this unit had revealed some design faults and there were difficulties in operating the heater both in pass balance and heat input control. Uneven firing was occurring and overheating of tubes was known to have occurred, in fact some tubes had been replaced at an earlier, unscheduled shutdown.

The ignition source was assumed to be the pilot burners which had remained alight in the furnace during the steam blow-through stage in anticipation of later spalling of the tubes. Steam hammer which is thought to have caused the actual break in the tube was probably a result of the low temperature oil in the furnace being contacted by the much hotter steam.

For part of its operation, the furnace was being dual fired with gas and oil burners in the same port.

On some occasions, due to wrongly sized burner tips, high L.P. gas flows from the fractionation column overheads, and blocked burners, the heat release at certain ports was greater than the design figure, and together with uneven pass flows contributed in a large degree to the local overheating and tube thinning.

[fire - consequence, damage to equipment]

### Lessons

[None Reported]

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

On 14th April, a leak was observed on one of the vacuum unit heater outlet passes under the thermowell. This was during cold circulation prior to start-up and following a four week shut down period.

When the lagging was removed from the transfer line close to the thermowell it appeared at first that the weld below the coupling was leaking. However, while the fitter was working on the thermowell, the coupling broke away from the transfer line; immediate action was taken to shut down the unit. The broken section was examined and it was found that the 1 inch API coupling which contained the thermowell was not directly welded to the transfer line (as per P Standard sketch) but that a short length of one inch pipe was welded between the coupling and transfer line. This pipe was found to be of carbon steel while the 24 inch transfer line and one inch coupling were alloy steel. The failure of the connection was due to severe internal corrosion of the carbon steel pipe.

Further inspection showed other thermowells suffering from similar bad workmanship and these were replaced with the correct materials.

[coupling failure, weld failure, human causes]

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**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 2      Dead : 0

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**Abstract**

An operator on a sulphur recovery unit noticed a drop off in the air flow to the main H<sub>2</sub>S (hydrogen sulphide) furnace and shortly afterwards yellow smoke was observed coming from the incinerator stack.

He took certain corrective action but there was no improvement and toxic gases blew out of the seals of the sulphur pit in reverse flow through the suction filters of the air blower. The plant was crash shutdown using the emergency button in the control room but in this period some of the escaping gas penetrated an area of the unit including the control room. Two men were seriously affected by the gas and lost consciousness. There were other people in the area at the time and the affected men were quickly removed to the Medical Centre and later transferred to hospital where they made a full recovery. One of the men had put on a H<sub>2</sub>S cartridge mask as soon as he noticed the strong smell of gas on the plant, but he was either too late in taking this action or the cartridge mask was ineffective.

[gas / vapour release, plant shutdown]

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**Lessons**

1. It is extremely important that unit operators and maintenance workers are aware of the hazards of H<sub>2</sub>S and that they know what and where the protective facilities are on plants containing this gas at toxic levels.
  2. Because of the high toxic risk, if there is a break-out of H<sub>2</sub>S on one of these plants it has been recommended that an alarm should be installed to warn other units in the vicinity that a serious gas leak has occurred.
-

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

During a hot tapping operation on the crude distillation unit heat exchanger piping, a leak from the hot tap machine occurred. Crude oil sprayed out onto an adjacent heat exchanger flange and ignited momentarily before being extinguished by dry chemical powder. No damage or casualties were suffered.

The hot tapping operation was being carried out to provide a new bypass line around some heat exchangers which were partially fouled up and restricting plant throughput.

In order to install the bypass, two 6 inch flanged branch connections were prepared, welded into position, fitted with isolating valves and then hydrostatically tested. The provision of the capping machine and the actual execution of the hot tap was carried out by the suppliers.

While the first hot tap was being carried out, a leakage of crude oil occurred from the flanged joint between the hot tapping machine and the isolating valve fitted to the flanged branch connection for the bypass. The leakage was contained by closing this isolating valve, after which the tapping machine was removed for examination. This inspection showed up a defective flange in the machine, in the reducing fitting. Crude leaked along the fixing studs which had been fitted to tapped holes drilled right through the flange instead of terminating part way into its thickness. Examination of other such reducing fittings on site showed that in all cases the stud holes were not drilled right through the thickness of the flange.

[hot work]

---

**Lessons**

Since the incident, the company decreed that all hot tapping machines should be hydrostatically tested with all reducing fittings connected, before use.

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**Source :** ICHEME

**Location :** , CANADA

**Injured :** 1      **Dead :** 0

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**Abstract**

An employee at a service station cleaned the floor with motor spirit adjacent to an open heater. Inevitably a fire broke out which resulted in the employee being seriously injured and extensive damage to the station.

The lesson from this incident is self-evident but once again the folly of using flammable solvents for cleaning is stressed.

Proprietary non-flammable cleaning materials are available and should be used.

[fire - consequence, injury]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 3      Dead : 1

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**Abstract**

During the overhaul of a crude distillation unit a worker was killed and three others received severe injuries.

The workers were working in or around the top heat exchanger in a bank of two about nine feet above the ground. The shell cover was the usual dish shape with rim flange about 40 inches in diameter and weighing 885 lbs, clearance between the shell cover and the floating tube sheet was sufficient under normal circumstances to permit movement of the tube sheet within the enclosing shell cover as required by the expansion and contraction of the exchanger tubes. All the bolts holding this cover had been removed before the accident and various means were being used in an attempt to remove the shell cover on the day of the accident as well as the two previous shifts. The chamber block was attached above the cover to support its weight as it came free from the exchanger shell and wedges had been driven between the shell cover flanges to help prise the cover loose. Coffing hoists, hydraulic jacks and other means had been used but none of these had been successful.

Sometime during the evening shift of the previous day, a steam hose was connected to a 3/4 inch tapped vent opening in the shell cover and 125 psig steam was admitted behind the cover for the purpose of heating and loosening the coke which it was thought was helping to hold the cover in place. Prior to this, an outlet for the steam was provided by removing the valve and pipe nipple from a 3/4 inch tapped opening in the bottom shell nozzle and, when steam was introduced into the shell cover there was evidence of some flow from this opening.

On the day of the accident the workmen had returned from lunch and were on the scaffold at the end of the exchanger. One of them was preparing to strike one of the wedges when without warning the cover blew off with great force striking the men. It was evident afterwards that steam under pressure had been trapped inside the shell cover resulting in the violence in which the cover separated. Fatality.

[overpressurisation, maintenance, injury]

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**Lessons**

Recommendations made after the enquiry were mainly mechanical in nature:

1. Scalloping of the tube sheet for better circulation and the possibility of less coking.
  2. Leaving sufficient retaining bolts in the cover to withstand the maximum possible steam pressure so that when the cover is freed, it will be impossible for it to fly off.
  3. Low pressure steam should be used in preference to high pressure steam since it is the heat effect which is the main benefit in removing coke and gummy deposits.
-

**Source** : OIL PAINT AND DRUG REPORTER, 1971, 15 NOV.; OIL PAINT AND DRUG REPORTER, 1971, 6 DEC.

**Location** : Joliet; Morris; Illinois, USA

**Injured** : 0      **Dead** : 0

---

**Abstract**

Explosion in ethylene oxide reactor feed line/feed product exchanger following oxygen feed control malfunction. Extensive damage. The oxygen analyser on the reactor inlet was out of service being recalibrated at the time of the incident.  
[processing, instrumentation failure, damage to equipment, heat exchanger]

---

**Lessons**

[None Reported]

---



Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

An operator placed 12 sample tins each containing about 500 g of various grades of bitumen on an electric heating plate and switched it on.

The heater was in a fume cupboard with the 'on' switch coupled to the extraction fan; the switch was supposed to be at half load setting.

Around 07.30 hours a fire was detected in the corridor and the alarm raised. Heavy black smoke made the fire fighting very difficult and breathing apparatus was worn before an entry could be made.

The fire was probably caused by one of the bitumen sample cans leaking, or by boiling over so that the heavy oil got on to the hot plate and ignited. The other tins would have caught fire generating quantities of smoke with which the extraction fan could not cope. The whole room was blackened by the smoke and the fume cupboard damaged by the heat of the fire.

When the room was inspected after the fire, the hot plate switch was on a high setting contrary to the laid down instructions.

[fire - consequence, human causes, laboratory work, breathing apparatus]

---

**Lessons**

As a result of the fire, overload protection is to be provided for the heater to shut it off automatically after reaching a pre-set temperature.

---

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

#### Abstract

An explosion occurred in a heater furnace of an extraction unit A. A and B units have four fired heaters sharing a common stack, the raffinate heater in question being fitted with a single main burner and gas pilot.

Extraction unit B was shut down for exchanger cleaning and the opportunity was taken to repair a jammed flue gas damper on the (extract) furnace. When the damper was freed and being moved, unit A raffinate heater burner was extinguished: the fuel oil was automatically shut off by the flame eye.

Operators switched the flame sensor out of the control circuit, which is normal practice during start up, and attempted to start the burner again by hand without purging the furnace. Several light-offs were achieved but extinguished by unsteady draught conditions.

At the last attempt, a minor explosion occurred which extinguished not only the burner in the raffinate heater but also that in the extract heater. A normal shut-down of the unit was completed to inspect the furnace.

No personnel were injured in the incident; the heater suffered split and bulging brickwork which necessitated repairs lasting approximately one week during which time the unit was off stream.

It is fairly clear that in the various stages of trying to get the single burner alight, fuel oil was sprayed onto hot brickwork in the furnace and vaporised. Also at one point the pilot gas had been blown out and so a pocket of flammable gas could have been present somewhere within the heater which ultimately ignited with explosive force.

[damage to equipment]

---

#### Lessons

Where single burner furnaces are employed, purging of the furnace and gas testing must precede any light-off.

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

Three drums of chemicals from the polybutenes plant were delivered to the factory incinerator. One drum was loaded into the solids chamber in the incinerator, the door closed and the incinerator prepared for normal burning. After 45 minutes the door was opened and the empty drum removed.

A second drum was loaded and ten minutes later liquid suddenly poured out from under the door onto the concrete area around the incinerator. The burning liquid flowed westwards underneath the fans, burner, electric cables and auxiliary equipment.

The fire was extinguished using a powder extinguisher, and the fuel gas supply to the burners was isolated. At this time the liquid re-ignited, and was once more extinguished. With liquid chemical still coming out of the furnace door, it re-ignited once more, and this time a steam lance was used to fight the flames.

[incinerator, fire - consequence, drums, unwanted chemical reaction, unknown chemicals]

---

**Lessons**

The investigation found that it was the first time that the chemicals within the second had been burnt in the incinerator, and lab tests conducted showed that when heated to ignition point the chemical foams. This would have allowed the full drum to overflow and allow liquid to escape.

Recommendations made included:

1. This particular chemical should not be incinerated, or when there is no other alternative, it should be supervised and the drum be no more than half full.
  2. A metal deflector should be installed on the corner of the incinerator to reduce the likelihood of flame damage to auxiliary equipment.
-

**Source** : OIL PAINT AND DRUG REPORTER, 1971, 26 APR, 7.

**Location** : Chicago; Illinois, USA

**Injured** : 0      **Dead** : 0

---

**Abstract**

Fire on isomax unit damaged the heater and cooling system sections.  
[processing, fire - consequence, damage to equipment, cooling equipment]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

On the 30th March 1971, oil sprayed from a leak at the connecting flange between the top and bottom reactor feed effluent heat exchangers of a catalytic reformer unit. The oil spray fell on to an adjacent heat exchanger and caught fire causing the shut-down of the plant for 43 days. There was no evidence to suggest that any unusual plant operational conditions initiated the leakage, and the primary cause was attributed to the use of a solid, flat, stainless steel gasket.

[operation inadequate, fire - consequence, damage to equipment, plant shutdown, processing, incorrect material of construction]

---

**Lessons**

Use spiral wound gaskets not solid, flat, stainless steel gasket.

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

On the 12th March, 1971 following the loss of the catalytic reformer unit recycle gas compressor, the reactor feed effluent heat exchangers were subjected to extensive thermal shock.

Liquid hydrocarbon leaked from the heat exchanger channel head joints and, after a short period, ignited spontaneously, resulting in a serious fire. Damage was limited to cladding and insulation of the heat exchangers, but the plant was offstream for several days.

[fire - consequence, spontaneous combustion, thermal degradation, damage to equipment]

---

**Lessons**

Resulting from this incident, the following recommendations were put forward by the local investigating committee:

1. The reactor feed and reactor furnace fuel systems to be linked into the recycle gas trip-out instrumentation to ensure immediate shut-down of the systems on a compressor failure (the existing shut-down device, located in the control room, is not desirable in such instances as it is designed to shut down other sections as well as the reformer).
  2. Installation of a manually controlled vent valve to flare from the suction side of the recycle gas compressor, so that the unit could be depressured in 30 minutes.
  3. Fitting of snuffing steam rings as a permanent fixture around all exchanger shell/channel head joints.
-

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

At 19.15 hours on the 22nd February, 1971 a severe flange fire occurred on the outlet of the reactor charge/effluent heat exchanger. Leaking oil ignited spontaneously causing a serious fire in which a great deal of material damage was caused. The unit was out of commission for 11 days.

The unit was operating normally prior to the fire, and no mechanical failures or defects in equipment were found after the fire to cause the leak.

[fire - consequence, damage to equipment, spontaneous combustion, heat transfer]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A no-damage, no-injury incident occurred during the recommissioning of the bitumen plant hot oil belt furnace. The heater had been in operation for about 10 minutes with the gas oil outlet temperature at 162 degrees C (325 degrees F) when an explosion occurred.

It was noticed that the gas oil surge drum was venting and at the same time the gas oil circulating pump began cavitating. The heater shut itself down, apparently on low oil flow rate, but before the pump could be stopped it picked up suction again. The heater air blower then resumed operation and the explosion resulted.

In spite of simulation tests carried out after the incident it was not possible to restart the blower once the heater had shut itself down, nor was there any satisfactory explanation obtained for the presence of gas in the heater after the automatic shut off of main and pilot gas burner solenoid valves, pre-start up of the heater had included drainage of liquid from the fuel gas knock out pot.

During the investigation, one possible hazard in the automatic control circuitry was found and eliminated. This was associated with the Reset button. If, following a normal automatic start up of the heater, the Reset button was pressed in error, the control system would revert to the ignition phase. The pilot and main fuel gas supply solenoid valves would close and then re-open when the button was released.

---

**Lessons**

1. Modify the system so that when the Reset button is pressed with the heater in operation the full shut down automatically takes place it is then necessary to start from the initial air purge sequence.
  2. Also ensure that the main fuel gas solenoid valve cannot be activated until the 'Pilot burner alight' indicator is energised.
-



Source : LOSS PREVENTION BULLETIN, 006, 7-8; ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

The fire started as a result of an explosion in the process section of a refinery. An open structure of steelwork protected with reinforced concrete housed the usual furnaces, reactors, heat exchangers, storage vessels, overhead pipe racking, pumps and ancillary equipment associated with the refining of crude oils. Also included in the area were three 46m (150 ft.) high stripping and drying columns built on a concrete base approximately 91m x 21m (300 ft. x 70 ft). A pipe in a gasoline hydrogen treating plant ruptured; a mixture of superheated naphtha and hydrogen under pressure leaked from the fracture and either exploded on contact with a hot process line or was ignited by static electricity. The fire reached its maximum severity within a few minutes.

Plant controllers operated an immediate shutdown but the contents of the many pipes and vessels, which had been superheated and were under high pressure, continued to flow from fractured pipes and distorted flanges cascading burning liquid through the plant.

At the point in the process where the fracture occurred, water was injected into the system to improve the flow of materials. The corrosion tolerance was accepted at 1mm (0.05 in.) per year but due partly to the presence of corrosive contaminants and an unfavourable flow pattern inside the pipe, corrosion and erosion were much higher than expected, contributing to excessive thinning of pipework, leading to its ultimate failure.

The explosion and fire destroyed the stripping and drying columns associated with two hydrogen treating plants; other parts of the processing equipment were severely damaged. The remainder of the process area, offices and ancillary buildings, though seriously threatened remained unaffected by the fire. Part of the concrete cladding protecting the main load-bearing steel columns, and the underside of the platform at first-storey level was affected by spalling but the steel structure itself was undamaged and will not need to be replaced. There were no serious casualties.

[overpressurisation, fire - consequence, refining, damage to equipment]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A vertical cylindrical hydrodesulphurise reactor change furnace was being started up with hydrogen flow only rather than hydrogen plus oil as in normal operation. As a result of the low heat load only a couple of the burners were being fired. The uneven firing resulted in one pass of the furnace being overfired and a tube ruptured. This problem was solved by installing a single centre burner for start-up. In addition multiple skin thermocouples were installed on each tube pass at the hottest points.

[start-up, furnace tube, rupture, fire - consequence, damage to equipment, creep, faulty instructions, design inadequate]

---

**Lessons**

Operating instructions should have warned of the danger of uneven firing particularly during start-up. The operations should have been told to monitor the heater pass outlet temperatures closely.

Tube skin thermocouples are the most direct measure of the risk of creep failure in furnace tubes. A multiple installation is required on each pass because skin couples have a tendency to detach from the tubes.

If start-up required only two burners then the design did not permit even firing of the four passes.

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A vertical cylindrical fired heater was used on the charge to a hydrodesulphuriser reactor. The flow was two phase at the heater inlet (hydrogen and hydrocarbon). The distribution of flow to the multiple tube passes depends on symmetrical pipework and the pressure drop through the passes. There were no individual pass flow meters.

During start-up when the flow was low a radiant tube ruptured in one pass. This was thought to be due to static head in the U tubes of that pass with liquid in the up legs and vapour in the down. Thus there was no flow in that pass and it overheated.

[heating, reactors and reaction equipment, rupture, fire - consequence, damage to equipment, tube failure, no flow, design inadequate]

---

**Lessons**

1. It should not be assumed that two phase flows will distribute properly between multiple passes in all circumstances. This is particularly true of the furnaces with vertical tubes.

2. One cure is to fit separate flow meters on the gas and liquid streams to each individual pass.

3. Where this is complex or impractical multiple tube skin thermocouples can be fitted to each pass. A voting system to defect failed skin couples is required.

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A power supply failure in the 440 volt supply stopped the electrically driven feed and product pumps of a Propane Deasphalting Unit at 04.00 hours. When the steam driven charge pump failed to cut-in, the asphalt mix from the base of the extraction column to the fired heater was reduced to 50% of normal flow with the outlet temperature on automatic control at 232 degrees C - 260 degrees C (450 - 500 degrees F).

Power was restored about 15 minutes later but the electrically driven charge pumps could not be successfully recommissioned and it was decided to inject a flow of liquid propane through the furnace tubes until the heater could be put on circulation.

The heater outlet temperature controller had been placed on manual following a temperature increase to 276 degrees C (530 degrees F). After dropping to about 171 degrees C (340 degrees F), the temperature increased rapidly to 316 degrees C (600 degrees F) when the furnace was put on circulation, burner firing was cut back until the temperature dropped again and appeared steady.

The flow reading to the tube side of the furnace fell to zero as circulation was commenced but the meter was disregarded by the operator because of the known poor performance of its magnetic flow element and also because the reciprocating pump was obviously operating. Unfortunately it is likely that this pump was labouring against a high back pressure and not in fact pumping material through to the furnace.

At 06.50 hours smoke was seen coming from the furnace and the condition of the firebox indicated a tube failure. The unit was taken offstream and the furnace inspected after it had cooled down.

One tube had holed at a U-bend adjacent to a weld due to external wastage.

Further investigation revealed a number of tubes with excessive wear on the outside resulting from dew point corrosion. It is believed that cold air entering the furnace around the inlet pipe produced temperatures below the dew point.

Internal examination of the tubes showed coke in some to a depth of inch and the tube hardness had increased confirming that overheating had occurred for a prolonged period. It is fairly certain that the furnace was fired without any tubeside flow and that the thermocouple on the outlet pipe showed a decrease in temperature because of this lack of flow.

[pump failure, power supply failure, tube failure]

---

**Lessons**

Block in the sources of air in-leakage around the tubes and improve the temperature indicating facilities within the heater.

---

Source : AMMONIA PLANT SAFETY, A.I CHEME, VOL13, 1971

Location : Oulu, FINLAND

Injured : 0      Dead : 0

---

### Abstract

A forged steel chamber, in one of the effluent coolers of an ammonia plant failed explosively.

The escaping gas caught fire. Extensive damage was caused to the plant and surrounding buildings. The purpose of the heat exchangers was to condense ammonia and cool air that was supplied to an air cooler. Prior to installation and operation, the condenser forgings had been heat treated, hydrostatically pressure tested and the welds tested with dye penetration. They had operated normally for about two and a half months prior to the incident. The failure originated at an overlay weld on the chamber wall.

[fire - consequence, gas / vapour release, damage to equipment, mechanical equipment failure, weld failure]

---

### Lessons

Investigations indicated that the explosion was caused by "brittle failure" of the forging. The reasons for this were:

1. Selection of the material used in preparation of the forging.
2. Light forging
3. Defective heat treatment

The following recommendations were made:

1. Carbon content of the steel less than 0.15% to improve welding properties.
  2. Vanadium 0.17% for acceptable hardness.
  3. Heat treatment sufficient to ensure adequate toughness, e.g. temperature over 600 degrees C for many steels.
  4. Avoid hydrogen cracking during welding, e.g. by maintaining preheating temperatures for a few hours, to allow hydrogen to be released.
  5. Overlay welds should not extend as far as the wall of the forged chamber.
-

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

A vertical cylindrical hydrodesulphuriser reactor charge heater lost hydrogen flow briefly while the unit was being changed over from recycle to once through hydrogen flow. This was due to a passing relief valve on the recycle compressor. As the hydrogen flow was such a large percentage by volume of the flow to the exchangers and furnace, the main part of the mass flow at the furnace outlet was lost while the exchangers and heater tubes filled with oil. During this period the outlet tube in one pass overheated and ruptured. The operating procedures did not warn that the furnace fires should be cut when making such a changeover. Skin thermocouples were added to the heater outlet tubes at a later date.

[furnace tube, rupture, fire - consequence, damage to equipment, creep, flow rate too low, faulty instructions, design inadequate, reactors and reaction equipment]

---

**Lessons**

Operating instructions should cover abnormal operations which are predicable.

Tube skin thermocouples are the most direct measure of the risk of creep failure on furnace tubes. A multiple installation is required on each pass because skin couples have a tendency to come detached from the tubes.

---

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

---

**Abstract**

The casing of a hot oil pump cracked at the suction nozzle. This was found to be due to excessive stress from the suction piping. Since the original design a heavy suction strainer had been installed and two of the original spring hangers were ineffective. One had been disconnected and the other was carrying no load due to maladjustment. As the oil was above its autoignition temperature a fire resulted.

[Hydrocarbon, modification, strainer, rupture, fire - consequence, damage to equipment, design inadequate, inspection inadequate, oil - hot]

---

**Lessons**

1. The design and installation of any modification to a plant should be reviewed as carefully as the original design.
  2. The condition and adjustment of spring hangers requires auditing on a regular basis. Maladjustment is often not obvious on casual inspection.
-

10666July 1969

Source : COMPENDIUM OF SHIPPING INCIDENTS, 1967-1979, NO.4.

Location : ,

Injured : 2      Dead : 0

---

**Abstract**

A marine transportation incident. Two ships officers were lighting a leak detector lamp inside an office on board ship. They were going to use it to detect the source of a leak of refrigerant gas from the ships main refrigerator system. The lamp had been filled with kerosene, ignited and was functioning correctly. A container of methylated spirit, used to prime the lamp, had been left open on a desk near to the lamp. One of the officers picked up the container to close it, a small explosion and fire occurred. Both officers suffered severe hand burns.

The fire had to be extinguished by the ship's fire-fighting personnel. Damage to the office was not serious.

[refrigeration unit, fire - consequence, methylated spirits, damage to equipment]

---

**Lessons**

1. All pressure type kerosene gas detector lamps were replaced by electronic halogen gas detector types.
  2. Kerosene lamps of this type should never be lit in confined spaces where flammable vapours might collect.
  3. Flammable fuel containers must be kept closed and clear from lamps, during lighting operations.
-



**Source** : MARSHALL VC, MAJOR CHEMICAL HAZARDS, ELLIS HORWOOD, 1987. ENVIRONMENTAL PROTECTION BULLETIN, 035, 15.

**Location** : Bolsover; Derbyshire, UK

**Injured** : 79    **Dead** : 1

---

**Abstract**

The oil temperature control of a heater on a reactor containing 2,4,5-trichlorophenol failed causing a runaway reaction. The reactor exploded releasing dioxins.

[reactors and reaction equipment, temperature meter/control, explosion, fatality]

---

**Lessons**

[None Reported]

---

**Source :** LOSS PREVENTION, VOL. 3.

**Location :** ,

**Injured :** 0      **Dead :** 0

---

**Abstract**

In a process soda plant a corroded part in an ammonia distillation tower fell and broke heat exchanger lines. The tower flooded and cast iron parts failed , under hydraulic pressure.

[collapse, processing, mechanical equipment failure, damage to equipment]

---

**Lessons**

[None Reported]

---

9538 23 January 1968

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

---

**Abstract**

An ammonia pipe in a refrigeration plant of a meat factory fractured. (wrong material and vibration). Subsequent explosion and fire occurred. Ignition source was either electrical switchgear or water heater pilot light.  
[fire - consequence, hot surface]

---

**Lessons**

[None Reported]

---

9798 19 October 1966

Source : LOSS PREVENTION, VOL. 3.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Ether escaped from loosely stoppered bottles of collodion type corm remover awaiting subdivision and was ignited by the pilot light of a nearby hot water heater. Damage was mostly from smoke and water to paten medicine type materials.

[leak, damage to equipment, fire - consequence]

---

**Lessons**

[None Reported]

---

Source : LOSS PREVENTION, VOL. 3.

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

Cocoanut charcoal ignited in a gas fired kiln when flow was interrupted by the failure of a crusher in feed line. Heat damaged the kiln.  
[mechanical equipment failure, damage to equipment]

---

**Lessons**

[None Reported]

---

Source : LOSS PREVENTION, VOL. 3.

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

Failure of a carbate heat exchanger allowed chromate laden cooling tower water to leak into a line feeding concentrated brine to mercury cells for electrolysis. The chromate ion in the brine caused massive hydrogen evolution in the cell, the mixture of hydrogen and chlorine burned inside an electrostatic precipitator and ruined it and adjacent equipment.  
[unwanted chemical reaction, damage to equipment]

---

**Lessons**

[None Reported]

---

Source : VERVALIN C.H (ED.), FIRE PROTECTION MANUAL, 2ND ED., GULF, 1973, PG 92; ICHEME

Location : , USA

Injured : 0      Dead : 0

---

**Abstract**

Failure of pump packing or of a brass valve in a 1/2 inch steel pipeline carrying oil at 175 psi and 150 to 175 F released oil that ignited at exposed parts of a 600 pound steam regulator in an absorption gasoline plant. Employees discovered the fire almost immediately and used two dry chemical extinguishers to try to control it. They were making progress when they noticed that the heat had caused the head of an oil-to-oil heat exchanger to start leaking around the seals, adding additional fuel to the fire. The employees then tried to put a mechanical foam line in operation, but the rapidly intensifying heat forced them to leave. [fire - consequence, processing, valve failure, pump failure]

---

**Lessons**

[None Reported]

---

**Source :** ICHEME

**Location :** ,

**Injured :** 0      **Dead :** 0

---

**Abstract**

An explosion occurred in a gas interchanger of an ethylene oxide plant following loss of drive gas to main gas compressor allowing it to slow down and explosion limits exceeded. Exchanger badly damaged. Oxygen analyser loops responded too slowly.  
[processing, damage to equipment]

---

**Lessons**

[None Reported]

---



Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

---

**Abstract**

The accident occurred during maintenance work on an aluminium plate heat exchanger. To prepare for replacement of a section of pipe, a pressure recording valve was closed and the system downstream of this control valve was depressured. Leakage occurred through the valve, the exchanger ruptured due to overpressure, and an explosion and fire followed. The most likely source of ignition were sparks created when the metal insulation cover was blown against a metal scaffold.

[valve failure, mechanical spark, overpressurisation, fire - consequence]

---

**Lessons**

The following recommendations were made:

1. Install new safety valves.
  2. Pipe discharge from new safety valves into existing flare stack.
  3. Inform operating personnel of the events prior to the accident and the reasons for the modifications.
-

Source : LOSS PREVENTION, VOL. 3.

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

An insecticide was produced by reacting in a hexane medium. After product removal, the by-products and the hexane were incinerated. As an economy measure, a distillation system was set up to recover hexane for recycle before incineration of the residue. During this particular run, the residue became sufficiently concentrated so that it exploded.

[explosion, unwanted chemical reaction, incinerator]

---

**Lessons**

[None Reported]

---

**Source :** ICHEME

**Location :** , WEST INDIES

**Injured :** 0      **Dead :** 0

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**Abstract**

The pressure on a distillation column was controlled by a hot vapour bypass round the air cooler used as an overhead condenser. The hot vapour bypass joined a horizontal section of the air cooler outlet piping. This caused a hydraulic hammer which was so severe that light weight fireproofing was shaken off the supporting structure and the operating linkage on the vapour bypass butterfly valve broke.

[naphtha, air cooler, butterfly valve, near miss, design inadequate, water hammer]

---

**Lessons**

The vapour bypass return was relocated to the downpipe just above the overhead receiver. An alternative would be to connect it directly to the top of the overhead receiver.

---

Source : ICHEME

Location : ,

Injured : 9      Dead : 4

---

**Abstract**

A serious explosion occurred in the cumene hydroperoxide concentrator due to storage over a period of hours of a large bulk of partially concentrated cumene hydroperoxide/cumene mixture at 109 degrees C in a thermally insulated tank. This led to a rapidly accelerating decomposition. The explosion had its focus in the second stage of the concentration unit and resulted in a fire. Fatality.

[fire - consequence]

---

**Lessons**

1. At all points in the process after the oxidation system steps should be taken to minimise the quantity of cumene hydroperoxide in storage.
  2. Where some such storage is unavoidable, for example at the concentrator and cleavage feed points, storage should be 'cold' and the tanks should be fitted with positive means of cooling. By 'cold' is meant, for example, a temperature not exceeding 65 degrees C for 25% cumene hydroperoxide and not exceeding 30 degrees C for 80-85% cumene hydroperoxide concentrate.
  3. Immediately following the shutdown of all or part of the plant particular attention should be paid to any equipment which normally contains cumene hydroperoxide or which might possibly contain it, for example because of blockage of an outlet pipe, etc. Steps should be taken to ensure that such equipment is adequately cooled, and the equipment should be drained to a dump tank containing water or dilute aqueous alkali, and if possible flushed with cumene.
-

**Source :** BALL W.L, EXPLOSION IN AFTERCOOLER OF A COMPRESSOR USING SYNTHETIC LUBRICANT, AMMONIA PLANT SAFETY, 1964, VOL 6, 11-16.

**Location :** Allentown, USA

**Injured :** 0      **Dead :** 0

---

**Abstract**

An explosion occurred in the 4th stage aftercooler of the main air compressor of a tonnage air separation plant. The operator initially became aware of the blowing of the third stage discharge safety valve and an increase in pressure. He assumed from this that a fourth stage valve had failed. He then left the control room to activate the system to take product oxygen from the liquid storage tanks before shutting down the plant, and replacing the broken valves. The explosion occurred, however, before he reached the outside door.

---

**Lessons**

[None Reported]

---

106521963

Source : ICHEME

Location : , USA

Injured : 1      Dead : 0

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**Abstract**

Methylene chloride was being drained from a refrigeration unit. Two maintenance men were sent to install a 25mm valve on a drain point, which was approximately 6m above the ground. When they removed the cap, refrigerant escaped and soaked one mechanic's clothes, he became dizzy, but climbed down without incident, later losing consciousness. Neither man wore any safety equipment except goggles.

[draining, gas / vapour release, poisoning, procedures inadequate, permit to work system inadequate, protective equipment inadequate, design or procedure error, refrigeration unit]

---

**Lessons**

The following recommendations were made:

1. Install permanent drain valve.
  2. wear necessary safety equipment.
  3. when in doubt about a job - call your foreman.
-

**Source :** ICHEME

**Location :** , WEST INDIES

**Injured :** 0      **Dead :** 0

---

**Abstract**

When commissioning a new distillation unit, rapid plugging of the reboiler heater change pump suction strainers with construction debris and scale made it difficult to keep a continuous flow to the furnace. By the time the strainer on one pump was cleaned out the on the other was plugged.

The operator continued to fire the furnace as he expected to restore the flow imminently. On one occasion the flow stopped for four minutes which was enough to overheat and rupture the heater tubes.

[strainer, furnace tube, creep, rupture, fire - consequence, damage to equipment, design inadequate, operator error, naphtha]

---

**Lessons**

1. Operators were instructed and new procedures provided to ensure that furnace firing was cut as soon as flow was lost in the tubes.

2. In the long term all fired heaters were either:

- fitted with shut down system to shut off the heater fuel when low flow to the heater was detected.

- fitted with a heater outlet temperature control on the fuel to the burners. In this case the thermowell had to extend down the heater tube far enough to be in the firebox.

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**Source :** ICHEME**Location :** ,**Injured :** 0     **Dead :** 0

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**Abstract**

The explosion occurred in a continuous flash still used to concentrate oxidate to 75-80% cumene hydroperoxide. The focus of the explosion was a vertical exchanger heated by steam. The unit had been operating normally until the pressure increased. The vacuum could not be improved so supplies of steam and oxidate were stopped. After 3-4 mins. two explosions occurred. The first ruptured both heads of the heat exchanger and the second travelled horizontally as a ball of fire. The damage was confined to the flash still. The basic cause of the explosion was believed to be an increase in the exit pressure of the heat exchanger, probably caused by an unusually high liquid level in the base column. This slightly increased pressure may have increased the boiling point to a temperature of incipient decomposition, making it difficult to obtain a vacuum. When steam and the feed were cut, concentrated cumene hydroperoxide settled in the exchanger tubes where it could be further heated by the hot metal. This accelerated the decomposition to the point where the ends of the exchanger ruptured.

[processing, high pressure, continuous reaction]

**Lessons**

As a result of the explosion, the following corrective measures were taken.

1. A permanent lowering of the liquid level in the flash still.
  2. Installation of a thermocouple in one of the tubes of the heat exchanger to measure the temperature at the point where this was a maximum.
  3. An automatic steam dump valve was installed to release the pressure on the steam side of the exchanger whenever the steam supply was cut off.
  4. A cumene flush system was installed to flood the exchanger.
-



190 13 July 1959

**Source :** BOHLKEN S.F, HEAT EXCHANGER EXPLOSION AT A NITROGEN-WASH UNIT, AMMONIA PLANT SAFETY VOL 3, AICHE, 1961, 13-16.

**Location :** , NETHERLANDS

**Injured :** 0      **Dead :** 0

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**Abstract**

An unexpected explosion in the second heat exchanger of a nitrogen wash unit occurred causing severe damage. The unit was working under full load after being in normal service for 42 days.

[processing]

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**Lessons**

[None Reported]

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Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

---

**Abstract**

An explosion and fire occurred in a department store, when an ammonia tank ruptured releasing ammonia gas which was ignited by a water heater.  
[fire - consequence, material of construction failure]

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**Lessons**

[None Reported]

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Source : ENVIRONMENTAL PROTECTION BULLETIN, 001, 10-11, 1989.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A process for making soda in 1790's operated for about a century before it was found to be one of the most wasteful and environmentally hostile.

The process involved:

Common salt was reacted with sulphuric acid in iron pans at red heat (a highly dangerous operation) to produce sodium sulphate and hydrochloric acid which was evolved as a gas. The product was then mixed with chalk and coke and heated in a kiln. The resulting product was a mixture mainly consisting of sodium carbonate, calcium sulphate and unconsumed coke. The mixture was treated with water which dissolved the carbonate leaving the insoluble calcium sulphide behind.

There were two waste products of the process in its original form and both were highly obnoxious. The first was hydrogen chloride (ca 0.75 tonnes per tonne of soda). The second was impure calcium sulphide known as 'alkali waste' (ca 2 tonnes per tonne of soda).

The hydrogen chloride was discharged to the atmosphere where it reacted with moisture to form hydrochloric acid. In wet weather this came down as acid rain inflicting damage on people, textiles, building materials and vegetation. Even the erection of chimneys of a height which was unusual for the time, around 100 meters tall, did little to dispel the nuisance which was most serious in winter when temperature inversions are common.

The alkali waste was simply dumped in heaps near the factory. The heaps, which were phosphorescent, must have given off toxic hydrogen sulphide when acid rain fell on them. Some of these heaps, with the calcium sulphide oxidised by passage of time to sulphate, exist to this day. These waste products from the process, as it was originally worked, represented a very inefficient use of materials as all the chlorine and all the sulphur utilised in the process ended up as waste products.

[heating, pollution]

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**Lessons**

[None Reported]

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

### Abstract

A fire occurred on a crude unit feed line. The incident occurred during normal operation of the crude unit.

Prior to the fire, the process operators were routinely draining the desalter in order to break a rather stable cuff formed at the interface.

Apparently during this time water was allowed to carry over from the desalter to the crude surge drum, with out the knowledge of the operator. The crude furnace charge pump picked up a mixture of 260 degrees F crude and water and pumped it through the heat exchanger train on the way to the furnace.

The resulting vaporisation of the water caused a build-up of pressure and eventual popping of the safety valves on the inlet to the crude-slurry oil exchangers.

The popping of the safety valves caused severe vibration of the crude oil charge line and other related piping and equipment.

The controller for the crude oil control valve, which was mounted on one of the vibrating lines, caused the control valve to malfunction and caused severe gyrations of the crude flow, almost shutting off the crude flow at one momentary point.

Almost immediately, a drain nipple and valve on the low point of the crude line entering the exchanger became disengaged from the coupling and hot crude oil emitted from the coupling. Operators in the area took immediate steps to shut off the fuel gas to the crude furnace and also shut down the crude charge pump.

Before these operations were completed, the hot crude oil contacted the hot catalytic slurry oil line and flashed.

Ensuing flames reached a height of 40 feet. Dry chemical was applied to the fire whilst water was used to cool and protect all adjacent equipment and personnel. The source of crude oil to the fire was stopped and the fire was extinguished within ten minutes. No injuries were reported.

An investigation indicated that the nipple and valve had been installed but there was no assurance of how tight the nipple had been screwed into the coupling or whether the union and drain piping to the sewer had been connected. It is thought that both the union and drain piping had not been connected or that the vibration caused the union to become disconnected. It is also thought that either the drain valve had not been tightly shut and some plugged material had prevented leakage during normal operations prior to the extreme vibration or that the vibration had caused the valve to partially open. It is further theorised that due to the piping configuration, which had an elbow ahead of the valve, that oil escaped through the partially open drain valve, which resulted in a jet action, which caused the nipple to unscrew itself from the coupling. As a result of the nipple becoming disengaged from the coupling. A three quarter inch stream of crude under 340 psi pressure and at a temperature of approximately 369 degrees F gushed out of the open coupling and subsequently flashed when it contacted the hot slurry line.

[fire - consequence, normal operations, mechanical equipment failure, design or procedure error]

### Lessons

The report stated the following:

1. Due to the high naphthenic content of the crude being processed, there was not a sufficiently high potential across the electrode plates of the desalter to break the resulting tight emulsion formed, thereby allowing water to carry over into the crude surge drum. Plans have now been made to revamp the desalter design at an upcoming unit shutdown to increase the potential across the desalter electrodes.
2. Poor location of safety valves and inadequate support of the safety valves.
3. Insufficient support for the adjacent small piping such as the drain connection etc.
4. Mounting the control valve controller on piping that could be subjected to vibrations.
5. Allowing a condition to exist whereby water could reasonably be expected to carry over from the desalter into the crude surge drum and subsequently into the suction of the crude charge pump.
6. Not having drain connections properly plugged.

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

A nitrogen system was being used to purge the insulation-filled space between the walls of a new refrigerated storage tank for butane. At the same time, the nitrogen supply was being used by welders to provide an inert gas blanket. A welder found that the #inert# gas was actually combustible. All work was stopped and no accident occurred.

It was found that the nitrogen supply was contaminated by a combustible gas. Although at first this was believed to be butane, tests showed that it was mainly hydrogen.

The source of the hydrogen contamination was found to be a catalytic reforming unit. Nitrogen had been used to purge this unit during start-up, and procedures required that positive isolation should take place immediately after purging by the insertion of slip plates. In this case, initial isolation was only by valves, and positive isolation did not take place until 24 hours later. In the interval, hydrogen pressure exceeded nitrogen supply pressure and the contamination occurred.

[welding, near miss, operation omitted, blind/spade/slip plate, purging, storage tanks, refrigeration unit]

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**Lessons**

The incident reinforced the importance of complying with existing procedures - ie the immediate positive isolation of nitrogen supply lines after purging process units.

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Source : LOSS PREVENTION BULLETIN, 025, 10.

Location :

Injured : 0      Dead : 0

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**Abstract**

Inside a large spray drier handling herbicide a fire broke out. Possibly there was also a mild dust explosion. The thick layer of about 25 tonnes of product on the drier walls were consumed by the fire. All pressure relief doors opened. The escaping flames barred the escape ways of three operators on the roof of the drier. They had to clamber down the side of the steel structure.

The fire broke out during the test run of a recently installed atomizer unit. The upper one of four atomizer discs, rotating at 15,000 rpm, scraped at the housing of the gearbox and was heated locally up to the melting point of the material. It finally burst, the pieces being hurled with full force against the drier walls.

[fire - consequence, heating]

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**Lessons**

[None Reported]

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10216Date Unknown

Source : ICHEME

Location : Illinois, USA

Injured : 0      Dead : 0

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**Abstract**

Two cooling towers suffered damage to exterior Louvre walls caused by severe icing during periods of low temperature and high winds. The damage resulted from accumulations of ice which broke the panels loose from the structure. Ice formation resulted from the water distribution pan at the top compacting the cold transite Louvres on the exterior of the tower and being chilled to freezing point by cold winds.

[damage to equipment, normal operations, cold weather]

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**Lessons**

1. The distribution of water was revised by plugging some orifices in the inner section of the distribution pan while leaving all orifices open near outside walls of the tower.
  2. Water barriers were installed on the horizontal bracing supports of the Louvres.
  3. Motors and electrical switching equipment were revised to provide high speed, high horsepower operation providing better warm air flow across the Louvres inside.
-

**4365 Date Unknown**

**Source :** LOSS PREVENTION BULLETIN, 025, 11.

**Location :** ,

**Injured :** 0      **Dead :** 0

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**Abstract**

At a food manufacturer's premises, rusks were being dried in a natural-gas-fired conveyor belt oven. The conveyor stopped, the rusks overheated and ignited. The fire spread to involve the timber and hardwood casing enclosing glass fibre insulating material.  
[overheating, fire - consequence, heating]

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**Lessons**

The fire could probably have been prevented by an interlock between the conveyor and the burners, provided the fans were kept running.

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**4140 Date Unknown**

**Source :** ICHEME

**Location :** , UK

**Injured :** 0      **Dead :** 0

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**Abstract**

During start-up of a phthallic anhydride plant, air issued from the top of a lagged heater after a main air blower had been switched on.

Removal of lagging revealed a hole, approximately 1 foot diameter, in the top of the heater outer casing.

It was concluded that periodic corrosion, due to water ingress to the lagging, had caused the failure. Pressure of the lagging had hidden the progressive corrosion.

The cost of the incident (repair, loss of production) was estimated at £120,000 (1990).

[plant / property / equipment]

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**Lessons**

[None Reported]

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**3331 Date Unknown**

**Source :** LOSS PREVENTION BULLETIN, 113, 13-14,; QUARTERLY SAFETY SUMMARY, 1977, VOL.48, NO. 190.

**Location :** ,

**Injured :** 0      **Dead :** 1

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**Abstract**

A concentrator was to be used to render down animal fats. It consisted of a cylindrical vessel, 1.2m in diameter and 3m high, heated by a steam jacket. The materials to be processed were fed into the vessel by a hopper which could be sealed by a bolt-down cover. The accident happened while the concentrator was being tested under steam. When the pressure in the vessel began to rise, a leak was detected near the cover of the hopper. While a fitter was investigating the leak, an explosion occurred and the fitter was fatally injured. Fatality.

---

**Lessons**

[None Reported]

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**2877 Date Unknown**

**Source :** LOSS PREVENTION BULLETIN, 030, 160.

**Location :** ,

**Injured :** 0      **Dead :** 0

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**Abstract**

The dyestuff was dried at 100 degrees C to 150 degrees C in a circulating air drier. The air fan and the steam were shut off at 16.00 hours. The dyestuff remained in the drier overnight. The temperature chart showed a temperature rise starting at 20.00 hours. The decomposition of the dyestuff was first discovered on the following morning when the oven was opened.

Fortunately no-one was injured. However, the cause of the incident is unknown. According to tests made, the dyestuff belongs to hazardous class Tr O, maximum allowable wall temperature 140 degrees C.

[high temperature, dyestuffs]

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**Lessons**

[None Reported]

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9748 Date Unknown

Source : ICHEME

Location : , AUSTRALIA

Injured : 0      Dead : 0

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**Abstract**

A road transportation incident. A tank truck caught fire when a welded repair to a seam crack in the casing of the air eliminator split, spraying petrol onto a water heater six metres away.

[fire - consequence, weld failure, leak, hot surface, gasoline]

---

**Lessons**

Hydrostatic tests should be carried out on any oil containing equipment that has been subjected to weld repair.

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**1545 Date Unknown**

**Source :** LOSS PREVENTION BULLETIN, 030, 160.

**Location :** ,

**Injured :** 0      **Dead :** 0

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**Abstract**

300 g of the monoazo derivative of a nitro-amino-phenol and a pyrazolone was being dried under vacuum at 110 degrees C, when a violent detonation occurred. The drying oven was heavily damaged. No one was injured.

Small quantities had previously been dried at 110 degrees C, without evidence of decomposition. A possible explanation of the difference in behaviour is that the harmless batches were filtered at pH 7.5 and the explosive batch at pH 8.8 in addition, a check revealed that the surface temperature of the trays in the drying oven differed from the recorded temperature by 20 degrees C, to 30 degrees C. Such temperature differences can suffice for a spontaneous decomposition in the case of critical products.

[high temperature, explosion, damage to equipment, heating]

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**Lessons**

[None Reported]

---

Source : LOSS PREVENTION BULLETIN, 127, 11.

Location :

Injured : 0      Dead : 0

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**Abstract**

An incident occurred on a heat exchanger bellows which was supplied with an external support ring to give support to the convolutions against internal pressure while allowing the bellows to expand with rise in temperature. The support ring was removed and as a result the bellows became deformed. Fortunately, this was observed before serious fatigue failure occurred. Near miss.

---

**Lessons**

The following conclusion was made:

Manufactured equipment should not be modified without first taking expert advice.

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Source : LOSS PREVENTION BULLETIN, 130, 7.

Location : ,

Injured : 0      Dead : 0

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#### Abstract

An incinerator used to burn waste gases and non-recoverable solvent streams overheated and suffered structural damage due to accidental overloading of the combustion system.

The incinerator shut down automatically due to high stack temperature. The gases which were being fed to it were automatically transferred to another incinerator which was operating on standby mode burning diesel only. However, this too suffered an emergency shutdown due to high stack temperature after just 65 seconds.

Fire-fighters were called when it was noticed that the cladding of the cooling duct on the first incinerator was glowing. The incident was brought under control by cooling the incinerator and its ducting with water jets, and spraying water into the incinerator.

[overheating, material transfer, modification procedures inadequate, heating]

---

#### Lessons

The following conclusions were made:

The practice of transferring hot liquids to vessels that vent directly to the incinerator has been discontinued. Vents feeding incinerators should not be used as vessel overflows. Hazop studies, through application of the guide word more, should have identified the hazards of overloading incinerators via vents/overflows. A number of the overflow/venting arrangements were modifications and the possibility of overloading the incinerator should have been addressed if an effective modification procedure had been followed.

---

**7703 Date Unknown**

**Source :** SAFER PIPING, ICHEME, SAFETY TRAINING PACKAGE, 012, 4.61.

**Location :** ,

**Injured :** 0      **Dead :** 0

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**Abstract**

During routine maintenance of an ethylene plant, cleaning activities required the isolation of a seawater cooler. Complete isolation of the heat exchanger was achieved by providing the inlet and outlet valves with spectacle blinds. While one of the valves was being unbolted the pipe fitters heard a crack. The lower flange of the 350 mm (14 inch) valve had cracked over 300 degrees of its circumference. Fortunately the crack was on the non-pressurised side of the valve preventing any major leak of propylene. The upstream pressure was approximately 13 bar. Near miss.

[flange failure]

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**Lessons**

[None Reported]

---



Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A fire totally destroyed the internals of a forced draught cooling tower following a maintenance job involving cutting and burning.

A number of corroded metal downcomer pipes were to be removed and replaced. Cold-cutting of the branch pieces and their studded flanges connected into the concrete troughs proved difficult and time consuming and the decision was taken to use oxy-acetylene burning equipment.

The work was taking place in one cell of a four-cell reinforced concrete unit, each cell having four induced draught fans. The returned warm water was fed into concrete primary distribution troughs and overflowed down steel pipes into secondary wooden distribution boxes. Water flowed into tertiary channels to irrigate the packing which was in the form of thin egg-box panels constructed in impacted polystyrene.

Valid permit-to-work, entry and hot-work permits were in force and the men concerned were working from a scaffold and battened platform inside the cell. A water hose was in continuous operation to wet the surrounding area and to render safe any sparks or hot metal which fell upon the fire blankets which were laid below the working area.

During the work, smoke was suddenly observed emanating from an area below the working platform. The men immediately vacated the cell area via the ladders provided and attempted to extinguish the source of the smoke with the water hose. This was unsuccessful and the Fire Brigade were called.

The Brigade arrived within 2-3 minutes by which time flames and dark billowing smoke were being emitted from the tower. It took about an hour to put out the fire completely. The cell was completely burned out, but nobody was injured or suffered from inhalation of fumes.

Upon investigation it was concluded that the thin neoprene coated (0.65 mm thick) glass fibre blankets used were inadequate for the purpose, i.e. to contain sparks and hot molten metal. Furthermore, it was not possible to wet the packing adequately below the immediate working area with the hose provided.

In tests, subsequently, the type of fire blanket used was found to burn when subjected to hot burning metal and this may well have contributed to the development of the fire. It was not known whether the sparks or hot metal had:

1. Fallen on to and rolled off the blankets,
2. Burned through the blankets, or
3. By-passed the blankets altogether.

The preparation and fire-fighting precautions for the work were inadequate and the supervisors issuing the permits had failed to personally check the work area.

As a result of the incident it is recommended that burning/welding will only be permitted inside cooling towers if other methods are impractical and only after rigorous appraisal of the precautions taken.

[fire - consequence, hot work, entry into confined space, fire protection equipment]

---

**Lessons**

The type of blanket previously used is only to be used in future for spark retention curtains and, where hot metal is likely to be involved, a heavier (2-3 mm) fibreglass fabric resistant to molten metal up to 1200 degrees C to be used, preferably supported by metal sheeting and formed into a box shape for proper containment.

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

During repairs to a heater, a grinding wheel broke and struck the man using it on his protective visor. The wrong type of wheel was being used and the guard was not fitted.

A series of re-training courses have been organised for all workshop personnel involved in grinding operations.

However, the incident does highlight the need for all personnel not to use equipment which is in an unsafe conditions especially if safety guards have been removed.

[power tools, safety procedures inadequate]

---

**Lessons**

It is not uncommon for employees to get particles in their eyes from grinding and the type of incident is not uncommon, fortunately dealt with promptly.

The results of using the wrong type of wheel can be very serious, with cases of fatalities.

---

8030 Date Unknown

Source : ICHEME

Location : , UK

Injured : 0      Dead : 0

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**Abstract**

A large slug of inert gas entered a section of the fuel gas system and passed through into the nearest fired heater. The furnace burners were extinguished momentarily. The furnace outlet temperature controller sensing a drop in temperature opened the fuel gas control valve, and on returning to normal composition the fuel gas re-ignited with explosive force. The furnace was so badly damaged that a complete rebuild was needed.  
[explosion, damage to equipment]

---

**Lessons**

[None Reported]

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Source : LOSS PREVENTION BULLETIN, 024, 172-175.

Location : ,

Injured : 0      Dead : 0

#### Abstract

A rupture in a 6 inch, high pressure, flash-gas pipe caused damage and production loss. The rupture occurred downstream of an air fin-fan exchanger on the vacuum gas oil desulphuriser/hydrocracker of a medium sized oil refinery. The rupture of the 6 inch line was attributed to erosion, corrosion, by high velocity (50-70 f.p.s) sour water, containing ammonium hydrosulphide (NH<sub>4</sub>HS). Due to the high pH (8-9) of the NH<sub>4</sub>HS sour water, the normally protective iron sulphide film (scale) is relatively soft and thus, easily eroded by high velocity sour water streams.

The escaping gas, mainly hydrogen, exploded (ignition possibly by static electricity) disrupting 23 pipes of various diameters carrying hydrocarbons, steam and water. The hydrocarbons caught fire from the ignited hydrogen, enveloping all the piping in the area. Electrical power lines were cut in the explosion and destroyed in the immediate fire. As a result of the failure of steam and power lines to the hydrogen generators the process was thrown out of balance and came to a sudden stop. Imbalance in pressure caused hydrocarbons to overrun the catalyst in all the reactors.

The ruptured pipe which contained ammonium hydrosulphide in condensed water had a drop of nineteen feet in a total run of thirty feet and during this run there were no fewer than eight elbows in the pipe. It would appear that the erosion/corrosion was due to a combination of the following:

- i. The turbulence set up in the multi-elbowed pipe by the flow.
- ii. The high pH (8-9) of the NH<sub>4</sub>HS flow softening the sulphide scale deposited by the inhibitor.

[damage to equipment, product loss, leak , fire - consequence, reactors and reaction equipment, refining, heat exchanger]

#### Lessons

The following recommendations were made to overcome this type of problem:

1. Increase the size of the pipe to 12 inch nominal bore and hence reduce the velocity.
2. Remove the trim condenser which is not essential to the process and thereby simplify the pipe-work and minimising the number of bends or elbows.
3. Continue with inhibitor injection.
4. Closely monitor the pipe sections and exchangers for further corrosion/erosion.

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

An explosion occurred while a sulphur recovery unit was down for maintenance. Operators were shutting down two utility steam boilers that share a common stack with the unit when a rumble and explosion occurred in the tail gas plant.

The cause of the explosion was traced to an explosive mixture igniting from pyrophoric iron sulphide in the stack common to the sulphur plant and the two utility boilers. Fuel gas was leaking through closed block valves from the amine flash drum cross-tie into the thermal oxidiser. As the utility boilers were shut down a large flow of inert gas to the stack was not present. As a result, the small fuel - containing gas stream educted from the tail gas plant by the hot stack was no longer heavily diluted by boiler flue gases. Although the sulphur unit was under a nitrogen purge this was found to be inadequate and the nitrogen bottle trailer was found empty at the time of the explosion.

[separation equipment, incinerator, isolation inadequate]

---

**Lessons**

The following recommendations were made as a result of this incident:

1. Review and revise blinding requirements during the various possible shutdown conditions to ensure proper isolation of cross-connected systems.
  2. Re-evaluate the nitrogen purge system design and modify it as necessary to ensure that it is capable of providing an adequate supply of nitrogen.
  3. Develop procedures covering the establishment and monitoring of nitrogen blankets including regular testing for oxygen content.
  4. Process plant cross-connections of the type between the flash drum and the thermal oxidiser should be designed out of these facilities.
-

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Damage occurred during the start-up of the regenerator due to local overheating in the air heater and air distributor.

The plant was being recommissioned after a major overhaul but had to be shut down because of vibration of the regenerator and associated structure.

During the heating up phase prior to catalyst loading, the air heater outlet temperature was being raised at a nominal 50 degrees C per hour.

This temperature was logged on a temporary recorder with a range maximum of 600 degrees C. Above this temperature only spot readings could be taken from the multi-point indicator in the control room and much higher temperatures than this could have been reached towards the end of the warm-up period. The gas supply to the heater is taken from the refinery main at 3.4bar through a knock-out drum and pressure reducer, a bypass line around the reducer was installed at an earlier date to allow increased output from the burner. There is no flow indicator in this system and the fuel is controlled manually on the block valves of the main and bypass lines.

The warming up phase had to be interrupted between 22.00 hrs and 05.00 hrs. because of an upset on another refinery plant. At 06.30 hrs catalyst loading began and the air heater was opened up to compensate for the drop in temperature. By 08.20 hrs. sufficient catalyst was in the regenerator to allow torch oil to be introduced and the air heater was shut down. At 08.55 hrs., the first visible sign that something was wrong occurred when catalyst emerged from the air compressor vent and at 11.00 hrs, after fresh feed was cut-in to the reactor, unstable conditions and vibration of the regenerator and structure were noted.

The unit was shut down for investigation.

[damage to equipment, plant shutdown, reactors and reaction equipment]

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**Lessons**

[None Reported]

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**Source :** ICHEME**Location :** ,**Injured :** 0     **Dead :** 0**Abstract**

Following interruption of oil flow through a hot oil circulating plant and due to a failure of the flow measuring instrumentation, the low flow heat-off trip to the burner failed to operate and resulted in overheating and partial evaporation of the oil in the heater tubes. The hot oil plant including a storage vessel is sited inside a building with the fired heater located outside. The hydrocarbon vapours produced by the overheating were pushed through the system and escaped from the vent of the storage vessel into the building where they were ignited. The source of ignition could have been electrical equipment in the vicinity or autoignition may have occurred since the outlet temperature of the heater reached above 450 degrees C.

Two employees present at the time suffered minor burns. Electrical cables and a switchboard near the storage vessel were severely damaged.

The fire was extinguished by the work's and local authority's fire brigades using high and medium expansion foam generators.

Heat-off on the burner is automatically initiated by:

1. low flow through the orifice plate in the discharge line from the circulation pump
2. high temperature in the transfer line from the heater to the user vessels

3. high temperature in the fire box of the heater

On the day when the incident occurred, the plant had just been started up. It was frequently shut down and started up because of the varying demand for hot oil from the batchwise operated grease vessels. The operator's first action was to start the circulation pump and to open the bypass around the user vessels since the signals "pump is running" and "no low flow" were required to obtain the "all clear" signal necessary for burner ignition. When the operator checked the temperature instruments on the control panel, he noticed that No.1 oil transfer temperature was reading zero whereas No.2 was reading 200 degrees C and the heater box temperature showed 220 degrees C. The instrument mechanic was called to check No.1 temperature. 15 minutes later a repeated check of the instrument panel showed that the heater box temperature had risen to 350 degrees C, the level at which heat-off is initiated. Simultaneously rumbling noises were heard from the pipework system and fumes were seen emerging from the storage vessel's vent. Although the burner had been extinguished, the temperature in the transfer line continued to rise above 400 degrees C. The oil fumes from the storage tank vent then ignited.

The refinery investigation led to the finding that the incident was initiated by an interruption of oil flow through the circulating system possibly due to coke formation in the heater tube, but that the following aspects were largely responsible for it reaching serious proportions:

1. The low flow alarm/shutdown trips failed to operate because an orifice impulse line was blocked.
2. The No.1 temperature indicator/alarm/shutdown trip thermocouple was installed in a section of transfer line that was not used during the start-up phase.
3. The oil storage vessel vented to atmosphere inside the building instead of outside.

[flow meter/control, refining, instrumentation failure, flow rate too low, fire - consequence]

**Lessons**

The refinery plan to demolish the unit and take heating oil from a more modern unit on the site.

Alarm/trip arrangements should preferably be taken from separate measuring points to those used for indicating and controlling process flows through a fired heater unless the design and control instrumentation provides a reliable alternative to alert the operator of low flow.

2081 Date Unknown

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

An explosion occurred in the tail gas plant during warm up following a one week shutdown of a sulphur recovery unit for minor maintenance. Cause of the explosion was traced to flame failure in the thermal oxidiser, which allowed unburned fuel gas and combustion air to be carried through the downstream equipment mixing with air from the main blower. When this mixture reached the pilot fire in the stack gas heater, it flashed back through the unit.

The unit was designed with flame detectors to trigger automatic shut down of the thermal oxidiser in event of flame-out but the shutdown system was not in service, because the flame detectors had proved unreliable.

[start-up, separation equipment, incinerator, design inadequate]

---

**Lessons**

Plants are now being equipped with dual-redundant flame detectors. Two flame sensors view each flame. Both detectors must register a flame-out before the shutdown is triggered.

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

During an overhaul, on a refinery, a fitter was removing a plug from a furnace tube on a distillation unit. When loosened, the plug, weighing approximately 20 lbs., was ejected by pressure from within the tube. The plug was later found approx. 30 yards away from the furnace. A quantity of oil was also emitted from the tube. When loosening the plug the fitter fortunately positioned himself to the side of the tube rather than in front of it. It was later found that the work permit for the job was inadequate and incomplete.

[maintenance, refining, permit to work system inadequate]

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**Lessons**

[None Reported]

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**Source :** ICHEME**Location :** ,**Injured :** 0     **Dead :** 0

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**Abstract**

An explosion occurred in a sulphur recovery unit at a refinery during regeneration.

The plant had been regenerating for roughly 24 hours, when a boiler leak was discovered in the tail gas thermal oxidiser waste heat boiler. The thermal oxidiser was shut down, and the waste heat boiler depressured, vented, and drained.

The thermal oxidiser blower was used to cool the firebox and waste heat boiler as the regeneration continued. Burns in each catalyst bed were well established and after operating for a further 8 hours pressure drop across the unit began increasing.

Increased back pressure caused combustion air to leak out of the main reaction furnace, so the main air blower speed was increased to force more air into the plant. In adjusting the main air blower speed, too much excess oxygen caused a high exotherm in the first catalyst bed. Operators increased natural gas to the main reaction furnace to consume some of this excess oxygen. Plant pressure drop continued to increase, and air flow continued to fall. The main reaction furnace flame became dark and smoky, and the decision was taken to shutdown the unit. Before shutdown was completed an explosion occurred.

Cause of the explosion was unburned natural gas from the front end mixed with purge air from the thermal oxidiser air blower. This mixture ignited at the stack gas heater.

The pressure drop was caused by plugging in the thermal oxidiser or waste heat boiler from either of two possible causes. Since the thermal oxidiser firebox was cold, it probably condensed the water produced from combustion, and the water from the quench steam in the main reaction furnace. A water balance calculation has shown that water condensation could fill the firebox with water in 12 hours, restricting flow from the front of the plant. The other possible cause of plugging was -sulphur deposition on the cold waste heat boiler tubesheet.

[catalyst regenerator, separation equipment, flow restriction, solids deposition, refining, incinerator, incorrect pressure, plant shutdown]

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**Lessons**

Specific detailed procedures are required for any "Special Operation." The procedures must be completely thought-out to ensure that all potential hazards have been considered. Impromptu operations as seen from this incident can be extremely risky.

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

**Abstract**

During start-up of a catalytic reformer and desulphuriser units the outlet header on the desulphuriser heater ruptured. The resultant fire was extinguished in approximately 48 minutes and damage is estimated at £600,000 (1979). The rupture was caused by overheating due to the cessation of flow through the heater tubes. This loss of flow was caused by a sudden increase in pressure in the gas separator. The steam turbine driven feed pump had been manually throttled back so that it was unable to develop the "head" necessary to overcome the sudden increase in back-pressure. After a thorough investigation it was concluded that the most likely cause of this increase in pressure was unintentional feeding-in of hydrogen into the gas separator on the desulphuriser unit at the time the hydrogen supply was being recommissioned to pressurise the catalytic reformer. After the catalyst in the desulphuriser reactor had been presulphided with DMDS (dimethyl disulphide) using the standard procedure, the reactor was shut down and blocked-in, and the recycle gas compressor was shut down.

The desulphuriser unit was then flushed through with light naphtha to stop using the steam drives turbine pump throttled back to 2,000 RPM which gave a flow of 45m<sup>3</sup>/hr at a total head of 15 bar. The fuel gas supply to the heater was being manually controlled to give a nominal outlet temperature of 250° C for a 45m<sup>3</sup>/hr feed rate.

All pilot burners and six out of the twenty main burners (three each side to provide equal distribution of heat transfer) were in operation.

The pressure in the system was maintained at 7 bar by the intermittent manual operation of a valve in the hydrogen supply manifold. The manifold in turn was supplied from a battery of hydrogen cylinders mounted on a lorry trailer. The pressure in the cylinders as supplied was 200 bar. When the outgoing product was free of DMDS, it was directed to the reformer stabiliser in order to establish a level in the column for reheater furnace circulation. The reformer section had already been commissioned with hydrogen, and it is believed that the valve on the hydrogen manifold to the desulphuriser unit was open in error at the time when it was decided to increase the pressure in the reformer section.

The operating staff had just noticed that the pressure in the gas separator of the desulphuriser had risen to 29-30 bar and were taking action to release to the fuel gas system when the rupture occurred. Fortunately the operating staff were able to shut the hydrogen valves, shut off the fuel gas supply to the heaters, open the steam purge to the fire box and stop the feed by closing the steam valve to the turbine driven pump. None of these operations would have been possible a few minutes later due to rapid escalation of the fire.

There were a number of contributory factors;

1. The hydrogen cylinders were sited 80 metres from the compressor house where the manifold valves were operated; the hydrogen system was not equipped with a pressure reducing station.
2. The outlet temperature from the heater had to be controlled manually because the measuring element is isolated when the desulphuriser reactor is bypassed.
3. The steam supply to the turbine driven pump was throttled back manually to give a speed of 2,000 RPM equivalent to a flow of 45m<sup>3</sup>/hr at a 15 bar head. The pump is capable of 45m<sup>3</sup>/hr with a total available head of 57 bar at a speed of 3,600 RPM.
4. The feed controller was manually set to give 45m<sup>3</sup>/hr flow but there was no other control room instrument or alarm to warn the operators of low flow to the heater.
5. After the reactor was blocked in, it was only possible to monitor the furnace outlet temperatures by the multipoint instrument.

[flow rate too low, separation equipment, commissioning]

**Lessons**

The following recommendations were made;

1. Steam turbine driven pumps feeding a furnace should not be operated with the steam supply throttled back. The differential head generated by a centrifugal pump is proportional to the square of the rotation, and hence operation below the governed speed will significantly reduce the head available at the pump discharge.
2. The feed controller should be switched to 'automatic' as soon as the pump has been started up. Consideration should be given to regulating the steam supply to the turbine drive through the set point of the feed controller under 'auto' control, not through a pressure controller as at present.
3. The temperature from each outlet pass of the furnace should be recorded separately on the same instrument equipped with a high temperature alarm and trip function to shut down the fuel gas supply.
4. The temperature controller should be provided with two separate measuring elements with switch-over facility for start ups. One measuring element should remain as it is at present, but the additional element should be installed in the header after the furnace but before the bypass around the reactor.
5. The instrument should be equipped with a high temperature alarm.
6. The local flow indicators in each feed pass to the heater should be moved into the control room to facilitate easier monitoring of the flow through each pass. Each flow indicator should be equipped with an alarm which should also initiate shutdown of the fuel gas supply in the event of low flow.
7. A relief valve should be fitted on the outlet side of the heater tubes.
8. Hydrogen should not be taken directly into the plant from the cylinders. It should first pass through a pressure reducing station so that a set pressure can be guaranteed to ensure that equipment cannot be subjected to pressure exceeding safe working levels.

The incident occurred on night shift and was associated with a considerable amount of operational activity on the two plants in question. During initial commissioning and re-streaming of plant it is often necessary to disarm or bypass safety trips and to be alert to faulty instrument readings such as levels, pressures etc. Good communications and attention by personnel outside and inside the control room is therefore of particular importance at these times and the aim of plant designers and refinery plant management should be to achieve a balance such that men and instruments are adequate for start-ups and shutdowns as well as for all routine operations

Source : ICHEME

Location : ,

Injured : 1      Dead : 2

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**Abstract**

Desulphurizer heater tube failure. A tube in the convection section of the bulk desulphurizer heater ruptured during the start-up of the heater at a pressure lower than normal operation. The firebox became flooded with a mixture of hydrogen and hydrocarbon it ignited, resulting in an explosion and the generation of a fireball. The immediate causes were tube ruptured during start-up. The basic causes were an increase in the tube metal temperature associated with the presence of non-metallic deposits which had formed on the bottom and inside of the tube. Contributing factors were formation of non-metallic deposits which had come from elsewhere in the refinery piping system. In addition it was the standard for inspection had assumed one tube in convection section to be representative of all tubes in the section.

[refining]

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**Lessons**

Mandate removal of a convection tube at an agreed frequency.

Tube skin thermocouples should be provided.

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

An explosion occurred after smoke was discovered coming from the ruptured shell/roof seam of a bitumen cone roof storage tank.

The tank's direct fired heater was shut down, transfer operations were stopped and steam was introduced via a 1 inch gauge pipe into the roof of the tank to prevent the possibility of re-ignition.

At the time of the incident, the 10,000 bbl tank measuring 12.8 m diameter x 12.6 m contained 60/70 penetration bitumen. A temperature at a thermowell showed 170 degrees C, a thermocouple showed 270 degrees C and a thermocouple attached to the heater coil indicated 480 degrees C.

A physical dip of the tank after the explosion revealed that the actual level in the tank was much lower than that indicated by the gauge reading, allowing the heater coil to be exposed.

The explosion was probably caused by the exposure of the overheated coil above the liquid level which ignited (autoignition) a flammable hydrocarbon vapour mixture above the liquid surface.

The exposure of the heater coil and low level in the tank would have contributed to the breakdown of the bitumen and formation of a flammable mixture.

[instrumentation failure, overheating, storage tanks]

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**Lessons**

It was recommended that more frequent manual dips should be done to check the accuracy of the board gauge and re-affirmed the importance of shutting off the heater before the level was drawn below the coil.

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Source : LOSS PREVENTION BULLETIN, 137, 17-18.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

The incinerator had been burning plant residues throughout the night, steadily and satisfactorily, although there was some difficulty with the feed of residues on the following morning. At about 14:00 hours black smoke and flames were seen being emitted from the chimney. The fuel gas burners were then shut off. The fault was quickly diagnosed as the burn-off of liquid residues which had accumulated in the incinerator fire-box. The fire brigade were called but were only required to stand by, whilst the fire burned itself out in forty minutes.

Because of the possibility of a toxic emission the acrylonitrile plant was evacuated. Gas tests downwind of the incinerator, using indicator tubes, detected no hydrogen cyanide.

There were no injuries to personnel or damage to equipment, and the planned emergency procedures worked well.

[fire - consequence, evacuation, processing, heating, toxic residue]

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**Lessons**

The recommendations for remedial actions subsequently put in place included:

1. Discussion with the burner manufacturers about the design and output of both the residues and the fuel gas burners to ensure that these are sized for the range of firing conditions expected.
  2. Provision of means of control and measurement of flow of residues, to ensure that the rated capability of the burners is not exceeded.
  3. Provision of means for circulating the residues in the storage drums, to break any layering.
  4. Provision of means for monitoring the level of residues in the drums, both at the drums and in the control room.
  5. Installation of temperature monitoring of the incinerator hearth, to give warning of liquid build-up.
-

**Source :** ICHEME**Location :** ,**Injured :** 32    **Dead :** 3**Abstract**

An accident occurred when a plant was in the initial start-up phase following a shutdown for tie-ins for a new production train. The plant had been purged and defrosting (dry methane) gas was being introduced as part of the start-up procedure.

A block valve between the shell side of the main cryogenic heat exchanger and the blowdown system had not been opened by the plant operators after the tie-ins were complete and before start-up commenced. This isolated the shell side of the heat exchanger from the relief valves. Defrosting gas was therefore introduced into the shell side of the cryogenic exchanger with the exit to the blowdown system blocked. Pressure built up inside the exchanger until it disintegrated into several main sections and many small pieces, which acted as missiles.

Apart from the destruction of the main cryogenic heat exchanger, adjacent equipment was severely damaged by blast, falling equipment or the fire ball which occurred immediately following the rupture. Plant and piping over a wide area were damaged by missiles. The subsequent fire was quickly extinguished and added little to the damage. There were three fatalities and thirty two injured. Fatality.

[cryogenic equipment, damage to equipment, explosion, injury]

**Lessons**

[None Reported]

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

The ventilation pipes from underground storage tanks were left disconnected during vapour recovery work at a service station when a lunch break was taken. During the break a delivery vehicle commenced to discharge gasoline and vapours found their way into the building. The vapours ignited causing building damage but no injuries. The potential for fatalities and damage from this type of incident is very high. [material transfer, damage to equipment, unloading, vapour cloud explosion]

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**Lessons**

1. Work involving hazardous materials must be assessed for risk and then managed. This includes controlling access to work areas and making areas safe when unattended.
  2. Work permit systems are not enough, the total system of work including training and supervision must be effective.
  3. Prior to discharging any hazardous materials, the driver or person in charge must check as far as possible that it is safe to start the discharge, and continue it. This check should include ensuring that there is enough capacity in the receiving tank, that no vapour leaks exist and that there are no visible sources of ignition.
-



Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

On a catalytic reforming unit a charge/effluent heat exchanger tube sheet gasket failed. The failure was probably due to over tightening the joint. Inspection of replacement gaskets in store showed that the surface of the 5% chrome jackets was corroded. This rough gasket surface was the probable cause of the overtightening. These exchangers had a history of minor joint leaks.

[naphtha, hydrogen, heat transfer, shell and tube heat exchanger, gasket, blowout, fire - consequence, corrosion, gasket failure, inspection inadequate, incorrect material of construction]

---

**Lessons**

1. The quality of replacement parts should be checked before they are used.
  2. In the present case the 5% chrome jackets were replaced by 316 or 347 stainless steel to avoid deterioration in storage.
  3. Where repetitive problems of any kind occur a search should be made for the faulty part with one which is the same.
-

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

Catalyst in catalytic reformer units was reactivated by burning off coke deposits. The burn started with 2% oxygen and ended with 10% giving 2 bar partial pressure.

After the reactivation a leak was found in the cold end feed effluent heat exchanger. The cause was found to be combustion of an oily pyrophoric iron sulphide deposit in the tubes which had melted them. Due to problems elsewhere the unit charge had, had a higher than normal sulphur content for the preceding month.

[iron sulphide, hydrocarbon, oxygen, catalyst regeneration, shell and tube heat exchanger, damage to equipment, plant shutdown, spontaneous combustion, incorrect chemical present]

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**Lessons**

1. It is wise to analyse the potential consequences of any abnormal operation on a plant before proceeding with it. However it has to be said that in this particular case it would have been hard to predict what happened.

2. If there had been a temperature point in the exchanger train it could have picked up what was happening.

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Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

A naphtha hydrodesulphuriser unit was being operated by maximum charge rate. To achieve this bypass valves on the charge and fuel gas control valves had been opened. Furnace tube skin temperatures were just within acceptable limits, the highest being 570 degrees C. The heater outlet temperatures rose slightly because the fuel gas was virtually all flowing through the bypass valves. At this point a heater tube ruptured causing a damaging fire. 40% of the skin couples had come away from the tubes.

[naphtha, hydrogen, heating, modification, furnace tube, fire - consequence, damage to equipment, creep, overheating, design inadequate]

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**Lessons**

1. Bypass's should be set so that the control valve is near the middle of its range.
  2. Where at all possible control valves or their trim should be changed so that by pass valves remain closed.
  3. Because they are prone to failure skin thermocouples should be installed in pairs.
  4. The optimum location for skin thermocouples should be determined by an infrared camera survey to find points of maximum tube temperature.
  5. Skin thermocouples should be connected to a system which required both couples in a pair to show a high temperature before alarming.
-

11853Date Unknown

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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#### Abstract

On commissioning a catalytic reformer there was extreme vibration (0.6 miles) on this sell side of the feed/product heat exchangers. The feed there was a two phase mixture of naphtha and hydrogen. This resulted in fatigue failures in sample connections, pressure taps, and thermowells. Modification to the inlet flows and to strengthen damaged internals were ineffective. To try and "detune" the resonance each shell was then split in two by removing two rows of tubes and installing a long ditudinal baffle. This eliminated the vibration.

[naphtha, hydrogen, heating, shell and tube heat exchanger, rupture, damage to equipment, excessive vibration, metal fatigue, design inadequate]

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#### Lessons

1. Vibration caused by resonance's can be very difficult and expensive to correct by strengthening the equipment to withstand it.
  2. The correct approach is most often to "detune" and thus eliminate it.
-

11848Date Unknown

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

A hydroforming unit gasket failed on a reactor product heat exchanger flange. A fire started and flame impingement led to failure of a 450mm line greatly increasing the severity of the fire. The unit had been operating six weeks after shutdown. The failure was due to the use of a compressed asbestos gasket in place of the specified spiral wound gasket on the exchange inlet flange.

[hydrocarbons, hydrogen, heat transfer, shell and tube heat exchanger, gasket, blowout, fire - consequence, gasket failure, incorrect equipment installed, safety procedures inadequate]

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**Lessons**

1. The quality control on spare parts used for maintenance is just as important as that during initial construction.
  2. One company uses spiral wound gaskets only in process units rather than risk this type of error.
  3. The alternative is better training and procedures for all those involved in replacing gaskets.
  4. Finally occasional auditing of the reliability of the system will help to reduce errors.
-

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

A naphtha hydrosulphuriser started to have serious heat exchanger fouling when charging naphtha which had been in contact with air in storage. It is thought that because of a partial shutdown the deposits slowed off the heat exchanger and ended up preferentially in one of the two tube passes of the reactor charge furnace. The furnace then had to be fired harder and harder to maintain the combined outlet temperature. After 7 months operation a furnace tube ruptured. That tube pass was then found to be particularly plugged.

[naphtha, oxygen, heating, furnace tube, rupture, fire - consequence, oxygen enrichment, blockage by polymer, design inadequate]

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**Lessons**

1. Individual pass outlet temperature points or flow meters would have detected the problem before tube failure.
  2. In the present case multiple furnace tube skin thermocouples were installed on each pass. This is the most direct method of determining the cause of the failure - overheating of the tubes.
  3. An oxygen stripper was installed on the naphtha feed which greatly reduced the fouling.
-

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

Corrosion occurred on a catalytic reformer unit fired reboiler and two bottom row tubes in the connection section. Diesel leaking from the 10mm holes produced flame impingement on and rupture of another tube which resulted in an explosion. Although the unit was shutdown by that time, the convection bank was being steamed out which fed fuel to the fire. Although the furnace tube bank had been inspected routinely only accessible tubes had been measured and these were not where corrosion was most severe.

[hydrocarbons, sulphur compounds, heating, furnace tube, rupture, fire - consequence, explosion, corrosion, overheating, inspection inadequate]

---

**Lessons**

1. Inspection for corrosion must be targeted on areas where corrosion is likely to be greatest rather than those which are easy to get to.
  2. Sulphur corrosion is accelerated by high temperatures. An infrared camera survey is an effective way to find where tube temperatures are highest.
  3. Where a furnace tube leak is suspected steaming out the tube bank may not be the best option.
-

11859Date Unknown

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

On a catalytic reforming unit the 460mm pipe from a reactor to a reheat furnace ruptured due to high temperature hydrogen attack.

The carbon 1.5 % moly steel used was not adequate to resist this attack at the 450 degrees C and 25 bar hydrogen attack was found in a reactor charge effluent exchanger and the first reactor inlet line.

[hydrogen, continuous reaction, pipe, shell and tube heat exchanger, rupture, fire - consequence, damage to equipment, incorrect material of construction, inspection inadequate, hydrogen embrittlement]

---

**Lessons**

1. The affected heat exchanger shell and all the piping in high temperature hydrogen service were replaced in 1.5 % chrome .5% moly steel.
  2. Hydrogen attack frequently causes blistering well before failure. Thus adequate inspection might have prevented this incident.
  3. Inspection of units on their first planned shutdown should be particularly thorough.
-



11891Date Unknown

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

In a thermal reformer heater the replaceable seat of a return header box failed. On inspection it was found to be mild steel rather than the 9% chrome steel specified. As a result, it had corroded five times faster than the correct material and failed well before the next inspection was due. The resulting fire was well controlled and did not cause major damage.

[naphtha, normal operations, furnace tube, blowout, fire - consequence, incorrect material of construction, inspection inadequate]

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**Lessons**

Quality control of spare parts is as important as that on the original equipment.

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11892Date Unknown

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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#### Abstract

On a methane/steam reformer furnace for hydrogen production the 300 mm diameter cast ZS Cr/20Ni header cracked along the line of 25mm weld-o-let's where the pigtails from the catalyst tubes were connected. The failure appeared to have been initiated from cracks in the heat affected zone of the weld-o-let welds. There was also indication that stresses from restraint by the tube supports might have been involved.

[methane, hydrogen, steam, reaction, furnace tube, rupture, fire - consequence, thermal expansion, stress, embrittlement, maintenance procedure error]

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#### Lessons

1. Aged heat treated alloys of this type have poor cold and hot ductility.
  2. For the above reasons rewelding of heat affected zones is likely to fail.
  3. Full allowance to be made for thermal expansion to avoid added stress on the alloy components.
  4. Proven welding techniques to be used and subjected to strict quality control.
-

Source : ICHEME

Location : , USA

Injured : 1      Dead : 0

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**Abstract**

A solvent dewaxing unit was being started up after a major shutdown. Electric drills were still connected, though not in use for fixing cladding. A serious leak started on a packing gland on one of the scraped surface chillers, spraying oil and solvent into the building. The chiller was isolated but a spark from a faulty electric drill cable ignited the leaked fluid. The six tonne CO2 fire extinguisher system was actuated but did not extinguish the fire and much equipment was damaged.

[light hydrocarbon, cooling, maintenance, start-up, heat exchanger, crystalliser, seal, fire - consequence, damage to equipment, explosion, seal failure, arcing, safety procedures inadequate, design inadequate]

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**Lessons**

1. The most likely time for unit leads is during a start up. Therefore all electrical equipment for shutdown use to be unplugged and work permits withdrawn during this short period.
  2. Portable electric equipment for use on process units should be checked frequently to ensure it remains in safe condition.
  3. Process equipment containing large amounts of flammable materials is best installed outdoors. If this is not practical the roof should have large vents and the walls should start 3 metres above the floor.
-

Source : ICHEME

Location : , USA

Injured : -      Dead : -

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**Abstract**

During a hydrocracker start-up, when hydrogen pressure rose above 70 bar, two shell to shell nozzle flanges on the charge/effluent heat exchangers started to leak heavily. These had not been unbolted in the shutdown. With the pressure at 70 bar maintenance workers started to tighten the flange bolts, as was the normal practice. However on this occasion the hydrogen ignited almost immediately. The unit was depressed to put out the fire.  
[hydrogen, shell and tube heat exchanger, fire - consequence, flange leak, safety procedures inadequate, maintenance inadequate, spark]

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**Lessons**

1. The cause of ignition was probably a spark from the bolt tightening operation. However high pressure hydrogen leaks have been known to ignite with no external cause evident.
  2. To reduce the risk of dangerous leaks like this, flange bolting procedures were improved by use of hydraulic torque wrenches and a strict order for tightening the bolts.
  3. If serious leaks still occurred the pressure was reduced to minimise the leak before tightening the bolts.
-

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

Due to problems with the turbine drive a recycle gas compressor on a hydrocracker was running at 60% of design speed. Most of the gas was flowing back to the compressor suction to prevent it from surging. The remaining flow to the third recycle gas heater was below the set point of the shutdown which therefore cut off the full gas flow to the burners. An operator opened the shutdown valve bypass to relight the burners. However he set the fuel gas flow too high and a tube ruptured through overheating.

[hydrogen, heating, furnace tube, rupture, fire - consequence, overheating, creep, operator error, safety procedures inadequate, flow rate too low]

---

**Lessons**

1. Operators to be warned against trying to keep a unit online at all costs.
  2. Safety shutdown should not be taken out of service or bypassed unless following pre-set procedures which are known to be safe.
  3. In the present case trying to keep the unit on stream when the problem on the turbine driver was unresolved proved unwise.
-

11822Date Unknown

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

Maintenance work had been completed on the top deck of a cooling tower. Tools had been removed but an energised extension lead had been left in place. Windy conditions damaged the loose end and caused it to arc.

Three cells of the five cell towers were destroyed before the ensuing fire could be extinguished.

[cooling tower, fire - consequence, damage to equipment, electrical equipment failure, arcing, safety procedures inadequate, weather effects]

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**Lessons**

[None Reported]

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Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

During charging with propylene of an isopropyl alcohol plant after shutdown, a leak occurred in a blowdown valve to flare.

The reaction system was then depressured to permit repair of the valve. Included in the system was a reactor after cooler. Water to this was controlled by its outlet temperature and as reaction had not commenced this was closed.

The evaporation of the propylene during depressuring froze the cooling water and ruptured seven of the floating head flange bolting. On containing the start-up propylene leaked into and vaporised in the cooling water returned header. The resultant slugging tore loosened the 400 mm riser at the cooling tower, the propylene ignited.

[water, propylene, start-up, venting, cooler, cooling water system, rupture, fire - consequence, freezing, safety procedures inadequate]

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**Lessons**

1. Whenever depressuring equipment containing liquefied gases the effect of the low temperatures produced must be considered. Brittle failure as well as freezing can be a problem.
  2. In the present case it would have been adequate to manually open the cooling water control valve. It was calculated that the flow of water would have provided enough heat to prevent freezing.
  3. There are a variety of failures which can result in liquefied gases entering cooling water returns. The possible effects should be considered in designing the system. A possibility considered in this case was the installation of vapour disengaging stand pipes.
-

11820Date Unknown

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

An upset operation of a butane water wash system resulted in poor interface level control. The control valve did not have a tight shutoff, therefore, small amounts of butane flowed with the wash water into the cooling water return. The cooling tower riser pulled away from its supports and water loss caused a refinery shutdown. The riser supports were weak and had previously moved slightly.

Water slugging caused by the presence of butane vapour increased the strain on it.

[cooling water system, separation, pipe, level meter/control, rupture, water slug, design inadequate, safety procedures inadequate, operation inadequate]

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**Lessons**

[None Reported]

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11819Date Unknown

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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#### Abstract

During commissioning of a hydrocracker, a release of liquid light hydrocarbons to the flare header caused a non return valve to freeze shut. There was a none return valve on the sub header from each of the several units connected to the main flare header. This was to isolate units which were shutdown individually. Also connected to the flare sub header were the outlets from bursting discs on the cooling water return header. These were to protect the water header in case of a tube rupture in water coolers which contained product at up to 100 bar pressure. Because of the frozen check valve, pressure built up in the hydrocracker flare sub header and caused the bursting discs to fail in reverse flow. The severe slugging caused by the hydrocarbon vapour in the water header caused a riser at the cooling tower to rupture and collapse. Water from the header shorted out an adjacent electrical substation. Fortunately the hydrocarbon did not ignite.

[commissioning, cooling water system, non return valve, bursting disc, rupture, damage to equipment, design inadequate, freezing, LPG]

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#### Lessons

Valving in flare headers to be minimised. Any valve installed there is to be designed so that it cannot fail or freeze in a closed position, e.g. gate levels should be installed with the stem horizon or up side down.

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Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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### Abstract

Overpressurisation of a cryogenic unit.

The incident occurred as 20 bar ethane was fed through a pressure controller to allow pressure system of a vessel and plate exchangers. These were protected from over pressuring by a relief valve on the vessel. To permit replacement of a section of pipe downstream, valves A,B,C,D,E and F were closed and the system depressured.

However, valve A was leaking and valves B and D prevented the relief valves from protecting the system. The blocked in exchanger was overpressured and ruptured.

[maintenance, heat exchanger, safety relief valve, rupture, safety procedures inadequate]

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### Lessons

The report stated the following conclusions and lessons:

1. Pressure system codes do not permit block valves in lines between relief valves and equipment which they are supposed to protect.
  2. The system would have been safer if by pass valves C had not been present.
  3. The problem was eliminated by installing a relief valve on the exchanger.
  4. The possible hazards of any abnormal operation or maintenance work should always be evaluated in advance of issuing a work permit.
-

11774Date Unknown

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

A small leak occurred in the return header box of a furnace, on a crude oil distillation unit, which had been in service for four years.

A steam purge put out the fire but the leak increased and after none months the plant had to be shut down. The leak was found to be due to severe corrosion in one return bend. This was due to the bend being made of mild steel rather 9% chrome alloy specified.

[heating, furnace tube, plant shutdown, corrosion, incorrect material of construction, inspection inadequate]

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**Lessons**

[None Reported]

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11770Date Unknown

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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#### Abstract

In a crude oil distillation unit the still overhead vapour/crude oil preheat exchangers were fitted with shell side impingement baffles on the tube bundle at both inlet and outlet.

This made it impossible to rotate the bundles 180 degrees to even out corrosion. One of the outlet impingement plates cam loose and fell blocking the vapour outlet. The still relief valves lifted and the unit had to be shut down.

[heat transfer, modification, hydrocarbons, gas / vapour, design inadequate]

---

#### Lessons

1. The outlet impingement baffles were removed.
  2. When any new feature or improvement is added to a proven design a careful study is required to ensure that there are no detrimental consequences.
-

11768Date Unknown

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

---

**Abstract**

An HF (hydrofluoric acid) stripper preheat exchanger was liquid full and still shut in when heat was applied. There was no relief valve and the exchanger ruptured causing substantial damage.

[propane, start-up, heating, heat exchanger, rupture, overpressurisation, design inadequate, operator error, safety procedures inadequate]

---

**Lessons**

1. The use of a process furnace to incinerate this waste was discontinued as it was difficult to guarantee that combustion would always be complete.
  2. HF is an extremely corrosive material and streams which contain any must be handles with special care.
  3. A HAZOP should detect a problem such as this.
-

**6954 Date Unknown**

**Source :** LOSS PREVENTION BULLETIN, 011, 6.

**Location :** ,

**Injured :** 0      **Dead :** 0

---

**Abstract**

Gas passed into the steam side through leaking tubes in a vaporiser. Both steam and process fluid were normally at the same pressure but, at the time of the incident, the heat exchanger was under valve isolation for maintenance. In spite of this, gas passed through a valve on the steam trap bypass, escaped to atmosphere and ignited.

[fire - consequence, tube failure, leak]

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**Lessons**

[None Reported]

---

**6854 Date Unknown**

**Source :** LOSS PREVENTION BULLETIN, 001, 3-4.

**Location :** ,

**Injured :** 0     **Dead :** 0

---

**Abstract**

A process stream passed through a series of heat exchangers into a vessel. The relief valve on the vessel protected the whole series of exchangers operating at pressures between 500 and 50 psig.

The start-up team had a new valve fitted during plant construction as they thought it might be useful in preventing back flow.

On start-up this new valve was closed and the heat exchanger train was subjected to the full upstream pressure. One exchanger burst causing a major fire and a long delay in start-up.

[fire - consequence]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : , USA

Injured :      Dead :

---

**Abstract**

This report covers failures of two cooling towers caused by icing during severe weather.

In each case severe damage occurred to the windward side louvred panels resulting from accumulations of ice, which broke the panels loose from the structure. Ice formation resulted from water trickling down from the distribution tray (at the top of the tower) and contacting the cold louvres chilled to freezing point by cold winds.

The cooling tower fans were fitted with reverse speed gear, intended to permit periodical reversal of air flow during extremely cold weather to de-ice the tower louvres. However, this proved to be inadequate.

[damage to equipment, weather effects, damage to equipment]

---

**Lessons**

The following changes were recommended:

1. Improved water distribution to force a larger volume of warm water down near the louvres.
  2. Water barriers to protect the louvre supports.
  3. Provision of high-speed reverse fan operation for de-icing.
-



Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Lumps of a pigment had been dried at 60 degrees C in an air (tray) drier and were then discharged immediately into 180 litre polyethylene drums. The drums were stored in the warehouse. 36 hours after the discharge operation, a smouldering fire was discovered in the warehouse. The fire developed to a major blaze within a very short time. All stocks and the entire warehouse were lost in the fire.

[solids processing, drier, drying oven, fire - consequence, damage to equipment, safety procedures inadequate, high temperature, thermal degradation]

---

**Lessons**

The cause of the incident was thermal decomposition due to heat accumulation in the product, which was discharged at elevated temperature and immediately stored.

It is necessary to measure Maximum Discharge Temperatures for such substances, and to enforce these through operating instructions and monitoring. If in a given case, the MDT is exceeded, the receiving container must be kept under observation until the temperature drops.

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

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[solids processing, drier, drying oven, fire - consequence, damage to equipment, safety procedures inadequate, high temperature, thermal degradation]

---

**Lessons**

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---

12890Date Unknown

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A catastrophic failure and collapse of one of two return headers occurred causing total loss of cooling water supply from the main cooling tower. Damage to equipment and some product loss occurred.

An investigation into the incident is being carried out.

[mechanical equipment failure, damage to equipment]

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**Lessons**

[None Reported]

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**Source :** LOSS PREVENTION BULLETIN, 026, 45.**Location :** ,**Injured :** 0     **Dead :** 0**Abstract**

This was a new column designed to operate under a slight vacuum. The plant manager, instead of ordering a leak test, i.e. maximum 5 p.s.i.g air followed by soap solution testing, decided on a full hydrostatic test. The column, 15 ft dia x 60 ft high, was approximately three quarters full of water when suddenly it commenced sinking in its support structure. Fortunately, the rate of movement was not too great do that personnel were able to escape without injury. Nevertheless, although only sinking about 7 ft, extensive damage to pipework, pumps and heat exchangers was incurred. Start up was delayed by nine months. The plant manager had not consulted his engineering colleagues before carrying out the test.

[testing, acrolein, collapse]

**Lessons**

[None Reported]

Source : QUARTERLY SAFETY SUMMARY, 1977, VOL.47, NO. 187.

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A fire occurred during the shutdown of a plant containing liquid propylene. The incident occurred as the cooling water to a cooler was isolated, the pressure in the plant was reduced, the propylene became colder and the water in the tubes froze, breaking seven bolts in the floating head.

Operators saw ice forming on the outside of the cooler but did not realise that there was any danger from this.

As the plant started up propylene entered the cooling water system and the pressure blew out a section of 16-inch line. The escaping gas ignited at the furnace causing severe damage.

[fire - consequence, leak, damage to equipment]

---

**Lessons**

Cooling water should have been kept flowing through the cooler while the plant was depressurised. If this had been done the water would not have frozen so long as depressurising took longer than 10 minutes.

Evaporative cooling can cause accidents in two ways:

1. The vessel can become so cold that the metal becomes brittle and cracks.
  2. Heat exchangers, if liquefied gas on one side of a heat exchanger is allowed to cool, then water, or even steam, on the other side of the heat exchanger can freeze and this can damage the exchanger and cause it to leak.
-

**Source :** LOSS PREVENTION BULLETIN, 004, 4-5.**Location :** ,**Injured :** 1     **Dead :** 0

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**Abstract**

Steam was condensed in a small (2000 gallon) tank from three heat exchangers before disposal to the main condensate tank.

The tank was vented to atmosphere, the discharge from the vent being close to an access stairway to a distillation column, as a consequence of which visibility on the stairway was impeded.

The plant manager decided to correct this situation and extend the vent to the top of the structure. The extended vent line created additional condensing surface and acted as a wetted wall column. Unfortunately, the vent diameter was not large enough, such that the column was flooded.

Within 24 hours of the modification an operator was badly scalded by condensate emission from the vent.

At the design stage the electrical engineers had requested float control of the condensate pumps such that the in line pump switched on when the level in the tank was high and switched off when the level in the tank was low. This system failed to operate and the tank was continually overflowing to drain.

The plant manager decided that the net positive suction head on the pumps was inadequate so he shut down the plant, had a pit dug and concrete lined below the tank in which the existing pumps were installed. Still the pumps did not work, so he ordered new pumps of extra low NPSH requirement and installed these in the pit. Every time the pumps had to be inspected, it necessitated shutting down of the system.

Investigation revealed that the pressure drop in the condensate disposal line was high and the pressure was 17 psig. Thus when the pump was stopped by low level in the tank, condensate at 140 degrees C took the path of least resistance and flashed back through the pump and tank, the static head in the tank increased and the pump started again, the pump and discharge line were full of flashing condensate and consequently the pump cavitated. Severe erosion of the pump impeller was found.

The system was modified to conventional level control, with a 'kick-back' line so that the pump did not operate against a closed control valve.

[design inadequate]

---

**Lessons**

[None Reported]

---

Source : LOSS PREVENTION BULLETIN, 003, 6.

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

1,200 litres of aqueous solution of acidic hydroxylamine sulphate were stored in a Cr-Ni-Mo steel tank at 55 degrees C. The solution was heated by circulation through a steam heated Cr-Ni-Mo steel tube. The solution decomposed in the tank with heavy frothing. Due to the violent frothing formation, the vent could not prevent build-up of pressure which resulted in breaking the sight glass in the man-hole cover and bursting of the welded seam on the vent. The contents of the tank erupted 15 meters into the building. No personnel was injured. The examination of a sample of the contents showed the presence of large quantities of iron and nickel.

It is estimated that the decomposition was caused by local overheating in the heater tube. The reaction could have been catalysed by metal ions as well as by organic lubricants containing colloidal copper.

[weld failure, overpressurisation, rupture, storage, gauge glass failure]

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**Lessons**

[None Reported]

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**6833 Date Unknown**

**Source :** LOSS PREVENTION BULLETIN, 003, 4.

**Location :** ,

**Injured :** 0      **Dead :** 0

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**Abstract**

A carbate heat exchanger failed and allowed cooling tower water containing chromate to leak into a line which fed concentrated brine to mercury cells for electrolysis. The chromate ion in the brine caused massive evolution of hydrogen in the cell. The mixture of hydrogen and chlorine burned inside an electrostatic precipitator and damaged it as well as adjacent equipment.

[damage to equipment]

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**Lessons**

[None Reported]

---



6953 Date Unknown

Source : LOSS PREVENTION BULLETIN, 011, 6.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Fatalities were caused by an explosion following a plant upset. A tubular heat exchanger heating a light hydrocarbon gas with steam on the tube side, chilled well below freezing point, ice formed inside the tubes and fractured some of them, the fractures remaining undetected when the plant was brought back on line. The hydrocarbon pressure being higher than that of the steam, gas leaked back into the main and escaped via a tap on a central heating installation into the basement of a control room.

An operator noticed the leak and switched off electrical equipment, thereby possibly providing the source of ignition for an explosion which wrecked the building and killed other operators. Fatality.

[tube failure, low temperature]

---

**Lessons**

[None Reported]

---

Source : LOSS PREVENTION BULLETIN, 005, 8.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A tube burst in the convection section of a heat transfer medium heater and caused a large fire which continued until all the heat transfer medium was destroyed. The flow could not be isolated, the pump could not be switched off as the valves and switch were too close to the furnace.

Creep failure of the tube was due to prolonged though not necessarily continuous overheating of the tubes during period of maximum capacity operation. Instrumentation of the furnace was inadequate for optimum monitoring of its condition and it was not appreciated how overheated furnace tubes behave.

[tube failure, design inadequate, spill, fire - consequence, heating]

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**Lessons**

Furnace tubes are usually designed to last for about ten years. Kept at or below design temperature, they will last ten years, but the life will be shortened by overheating.

---

Source : LOSS PREVENTION BULLETIN, 005, 9.

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A number of products were separated from a crude feed by fractional distillation. Because of the low vapour pressure involved, it was necessary to employ a high vacuum, together with steam stripping in conjunction with heating by a heat transfer medium. The flash points of the various feeds and products were high at approximately 200 degrees C or greater and despite the presence of the heat transfer medium in the plant area (flash point 116 degrees C) the plant was considered to be a low fire risk in view of the presence of steam.

After some years operation a serious incident occurred which resulted in extensive damage particularly to one column but no personnel injury. The subsequent shut-down lasted nine months.

Eye witnesses reported a collapse of the vacuum followed by flames at the base of one column which rapidly increased to envelope the surrounding area.

The heat developed was sufficient to weaken the column supports so that the column fell over.

Due to the extent of the damage, it was not possible to determine precisely the cause, nevertheless, the sequence of events was believed to be as follows:

An item of equipment, probably a heat exchanger suddenly split causing the collapse of the vacuum. After the pressures equalised in the column the hot liquid/vapour at 250 degrees C approximately, probably mixed with the heat transfer medium (from fractured heat exchanger) gushed out and were ignited probably by "shorting" a welding point.

No indications of future mechanical failure were noticed at the annual shut down five months previously.

When the plant was restarted, welding points had been moved away from immediate vicinity of the plant area and a comprehensive automatic fire protection system was installed.

[fire - consequence, rupture, damage to equipment]

---

**Lessons**

The incident demonstrated how under certain conditions, materials having a low fire risk can become hazardous.

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**6875 Date Unknown**

**Source :** LOSS PREVENTION BULLETIN, 005, 12-13.

**Location :** ,

**Injured :** 0      **Dead :** 0

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**Abstract**

The bellows in a heat exchanger shell was supplied with an external support ring to support the convolutions against internal pressure, but still allowing the bellows to move axially with increasing temperature.

The ring was removed and the bellows were deformed. Fortunately, this was observed before fatigue failure occurred.

[damage to equipment, near miss]

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**Lessons**

[None Reported]

---

**6876 Date Unknown**

**Source :** LOSS PREVENTION BULLETIN, 005,13-14.

**Location :** ,

**Injured :** 0      **Dead :** 0

---

**Abstract**

A shell and tube heat exchanger used to condense vapour on the tube side (with slight fouling duty) was fitted with an expansion bellows on the water cooled shell-side. The tube deposits were removed on a routine basis by boiling them out with vapour at 260 degrees C after first draining the shell-side of water. This procedure had been in use for several years, and no mishaps had previously occurred. During a recent 'boil-out', the bellows ruptured, a segment was blown out and a large amount of steam was evolved. Fortunately, there was no injury to personnel.

[mechanical equipment failure]

---

**Lessons**

[None Reported]

---

**6911 Date Unknown**

**Source :** LOSS PREVENTION BULLETIN, 008,16.

**Location :** ,

**Injured :** 0      **Dead :** 0

---

**Abstract**

Several fires have occurred in the spray drying of human and animal foodstuff. Layers of dried material can build up on the upper part of the walls or on the roof of the sprayer although the atomiser and the flow of drying air should direct the product downwards.

Unless deposits are removed regularly, they may over-heat and eventually spontaneously ignite, even though the oxygen concentration in the drier is depressed by steam formed during the drying process. Burning dried product can also be transferred downstream to further plants units.

[spray drier, fire - consequence]

---

**Lessons**

Black specks in the product from a spray drier are important evidence of malfunction.

---

**6913 Date Unknown**

**Source :** LOSS PREVENTION BULLETIN, 008, 17.

**Location :** ,

**Injured :** 0      **Dead :** 0

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**Abstract**

During the maintenance of a spray drier for dairy products, the atomiser was given too much lubricating oil. The oil soaked into powder deposited on the underside of the roof of the drier and during subsequent operation, the oil-soaked powder spontaneously ignited. The burning material fell to the bottom of the drier, but fortunately no explosion occurred. However, the entire batch of product had to be discarded.

[spontaneous combustion, fire - consequence]

---

**Lessons**

There was insufficient supervision of the maintenance staff, who were unaware of the potentially serious consequences of an apparently slight mishap.

---

Source : LOSS PREVENTION BULLETIN, 011, 10.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A company had two incidents involving lagging fires on systems where the heat exchanger fluid had been changed from one fluid to another. The report of the first fire emphasised that the auto ignition temperature of the new fluid was only 374 degrees C, compared with 640 degrees C, for the original fluid. Thus a mildly exothermic degradation in contaminated lagging could reach this temperature, with the inevitable fire quickly following. After the second fire, attempts were made to find a satisfactory non-porous lagging. These were unsuccessful, the works deciding to continue using established lagging materials but to ensure that all places where a leak is likely (flanges etc.) remain un-lagged.

---

**Lessons**

[None Reported]

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Source : LOSS PREVENTION BULLETIN, 011, 10.

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

A break-in was required into a heat transfer system. The break-in could not be carried out with adequate valve isolation, as it was known that these were leaking. It was decided therefore to freeze the liquid behind the point of break-in. Manufacturer's data gives the pour point of the fluid as minus 35 degrees C. The 1 inch ID pipe was surrounded with a solid carbon dioxide/acetone mixture for 2 hours and the blank removed. While removing the last bolt, cold thick heat transfer medium started to flow from the line and this was soon followed by hot fluid. As a result the system was shut down.

Laboratory tests showed that even at minus 40 degrees C the fluid was a relatively mobile grease. Although it would seem that the manufacturer's data is dangerously incorrect, this may be due to a melting point depression caused by degradation products.

[heat exchanger, faulty instructions]

---

**Lessons**

The works concerned have decided that the freezing of the heat transfer fluid as an isolation technique must be vigorously avoided.

---

Source : LOSS PREVENTION BULLETIN, 014, 6.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

The shell-side of a heat exchanger was isolated for maintenance, leaving the high pressure tube side in use. When the vessel was fully isolated, a number of flange joints started to leak. This unexpected evidence of pressure in the shell was dealt with by venting. Subsequent investigations revealed that material from the high pressure tubes had leaked into the shell, and that the resulting pressure rise became excessive because the safety relief valve was wedged shut (gagged).

No satisfactory explanation was found as to why the relief valve had been gagged.

[flange leak]

---

**Lessons**

Although very special care was taken by the works when relief valves needed to be wedged shut, this incident showed that tightening up was necessary in the systems governing their use. In future, the works propose to register all gags, store them in place with restricted access and to ensure that they are only used when properly authorised. Relief valves must be given absolute security, a requirement that in some cases is reinforced by the law. Where on occasions they are defeated, such as in certain testing operations, then their restoration to operating conditions must take top priority.

---

Source : LOSS PREVENTION BULLETIN, 069, 17-24.

Location : ,

Injured : 0      Dead : 0

### Abstract

A fire occurred on a refinery when a heat exchanger channel head separated from the shell allowing hot atmospheric resid and 42 bar (600 lbf /in<sup>2</sup>) steam to release to the atmosphere. The vapour cloud autoignited approximately 30 seconds later. The cause of the leak was due to failure of the shell/channel head joint bolts. The first of the bolts to fail were cracked by caustic stress corrosion cracking. The remaining bolts failed due to mechanical overload. There were no injuries, fire damage occurred on equipment in the area. Damage was estimated at £1.1 million (year not stated in report).

Investigation found that:

The steam generator channel head separated from the shell due to failure of the channel/shell flange bolts. Caustic stress corrosion cracking reduced the strength of the bolts which eventually resulted in mechanical failure. There were two basic causes for the caustic cracking:

1. The boiler water was ineffectively treated.
2. The extended use of the leak repair clamp facilitated caustic concentration through repeated leaking and evaporation.

Caustic was present in the boiler water due to ineffective water treatment in the pipe still area. Procedures for boiler water phosphate treatment were established but were not adequate. Phosphate addition was only emphasised for prevention of material deposits, not the prevention of caustic stress corrosion cracking. As a result, lower emphasis was placed on maintaining the phosphate injection system.

The leak repair clamp was not treated as a temporary repair. It had been installed for over three and a half years. Extended use of the clamp allowed caustic from the boiler water to concentrate around the bolts (which were highly stressed).

[fire - consequence, gas / vapour release, vapour cloud explosion, mechanical equipment failure, refining, damage to equipment]

### Lessons

The following recommendations were made:

1. The use of leak repair clamps has increased significantly over the past several years. Leak repair clamps should be treated as temporary repairs, not permanent solutions. The root cause for repeatedly leaking joints in critical services should be determined in order to develop a permanent repair. When it becomes necessary to use a clamp as a temporary repair, care should be exercised to ensure proper clamp application and maintenance. Procedures for clamp applications should be developed. These procedures should require: adequate mechanical analysis of the initial clamp installation, documentation of the date installed and contractor used, and documentation on repumps of existing clamps. A maximum number of repumps should be specified to ensure adequate mechanical analysis is completed on joints that repeatedly leak. Consideration should also be given as to whether or not a contractor should be allowed to work on another contractor's clamp.
2. Survey all units to identify the locations of existing clamps. Prioritise the lists beginning with the clamps most susceptible to caustic stress-corrosion cracking and replace the clamps with permanent repairs as soon as practical. Use enhanced exchanger make-up procedures where appropriate for permanent repairs.
3. Develop a program to systematically inspect bolts in flanges with clamps. Inspections should be completed using the process development prioritised list.
4. Develop guidelines for evaluating bolt replacement or reuse when making mechanical repairs.
5. Evaluate phosphate treating Area boiler feedwater at the utilities control centre. Develop an effective program for co-ordinated pH-phosphate treatment of the Area boiler water. Train Area personnel on the correct implementation of this program.
6. Review phosphate treating procedures
7. Assure that the correct phosphate treating compounds are available at the storehouse and that these compounds are symbolised properly.
8. Evaluate alternative gasket designs (e.g. spiral-wound gaskets) and applicability of enhanced exchanger make-up procedures (e.g. flange flatness testing, use of bolt extensometer).

6971 Date Unknown

Source : LOSS PREVENTION BULLETIN, 016, 5.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A caustic leak from a drain valve left open unintentionally caused corrosion in an electrical line tracing heater. An arc occurred causing the circuit breaker to trip. This was a near miss because the arc was a potential source of ignition in an area that handled flammable materials.

To prevent a recurrence, a hose was connected to the drain point.

[caustic soda]

---

**Lessons**

Drain points and sample points should generally be located at ground floor level in caustic and acid handling systems to reduce corrosion hazard to the plant and to reduce the hazard to personnel from splashing and drips. A hazard in the above case.

---

11050Date Unknown

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

Hot air for start-up of a catalytic cracking unit was supplied by an air blower feeding through a gas fired air heater. Faulty and/or inadequate instrumentation permitted heavy surging of the air blower which blew out the flame in the air heater. The fuel gas was on temperature control so the control valve now opened wide. The gas ignited possible from hot refractory and the explosion cracked the blower case.  
[fu, cracking equipment, hot surface, safety equipment failure, flamout, heating]

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**Lessons**

1. Heaters of this type to be fitted with a fire eye to shutoff the fuel gas in case of flame failure.
  2. Large, high pressure air blowers require adequate surge protection independent of the normal plant control system.
-

**Source :** MANAGING FOR SAFETY, ICHEME, TRAINING PACKAGES, 017, 4.103.**Location :** ,**Injured :** 2      **Dead :** 0**Abstract**

An operator in charge of the alkoxylation reactor erroneously assumed that the precharged glycerine was on circulation via the external dual purpose heat exchanger (for heating up the starting polyol or removing the reaction heat of the alkoxylation). He then catalysed it with potassium hydroxide, which made the system ready for the addition of ethylene oxide.

Shortly after the addition of ethylene oxide, the oxide feed flow was tripped by the reactor temperature trip/alarm. As the operator was convinced that the relevant temperature indication was wrong, he did not check whether the other indicated process conditions had deviated from normal. He had to do without the record of the reactor circulation flow as the instrument was defective. The operator did however in consultation with the shift foreman raise the temperature alarm/trip setting and raised this twice whilst continuing with the oxide feed.

The operator's plant manager made the operator aware that something was wrong. The operator went outside to check the line up of the system and found the reactor was not on circulation. Without consulting his superiors, he switched on the circulation and by doing so, he catalysed the system at the same time. The free ethylene oxide in the system started to react violently, increasing the pressure. Neither the reactor vent, which had meanwhile been opened, nor the safety relief valve could cope with the vapour supply, resulting in a violent rupture of the reactor. It is possible that the ethylene oxide reached a temperature of 560 degrees C and so decomposed explosively.

Metal parts and valves were propelled over a distance of about 700m. As the immediate surroundings of the reactor had been cleared of people only two men were seriously injured by flying objects.

[decomposition, reactors and reaction equipment, operator error, injury]

**Lessons**

[None Reported]

**Source :** DUST EXPLOSION HAZARDS, ICHEME, TRAINING PACKAGES, 022, 4.23.**Location :** ,**Injured :** 0      **Dead :** 0**Abstract**

Within one year, two explosions occurred in a large spray drier handling dairy products. The incidents caused both fire and explosion damage. Explosion relief vents at the top of the drier opened into the building causing fire damage to nearby instrumentation. Burnt material also spread to associated fluidised beds and cyclones.

An investigation was made and it appeared that excessive deposits of process material had collected on the walls and roof of the spray drier and had self-heated until combustion occurred spontaneously. Although flammable dust clouds are normally only found in the lower section of co-current driers, the burning fragments at the top (hotter section) may have caused ignition directly when falling through the cloud or by starting a fire in the hopper section.

The following conclusions was made:

Laboratory data after the event indicated that the product being dried was capable of self-heating to a level at which spontaneous combustion occurred, when exposed to temperatures similar to the drier (hot air) inlet.

[fire - consequence, solids deposition, explosion suppression, heating, ]

**Lessons**

The following recommendations were made:

The disruption to the plant was severe and resulted in closure for a considerable period. When the plant was rebuilt, an explosion suppression system was installed to provide the necessary level of protection and overcome the problem of venting inside the building. A study of the thermal decomposition behaviour of the range of products was also required in order to specify safe drying conditions (in terms of temperature and exposure period).

Test needed:

1. MIE (minimum ignition energy) to evaluate electrostatic risk, e.g. (discharge risk from highly charged powder).
2. MIT (minimum ignition temperature) to determine sensitivity of dust cloud to hot surfaces.
3. Thermal stability to examine behaviour when heated.
4. 20 litter sphere test for explosion relief design.
5. Train firing tests for assessment of flame propagation risks from layers of material within the system.
6. Test powder for resistivity and charge decay time.

**7865 Date Unknown**

**Source :** DUST EXPLOSION HAZARDS, ICHEME, TRAINING PACKAGES, 022, 4.52.

**Location :** ,

**Injured :** 0      **Dead :** 0

---

**Abstract**

Over lubrication caused spontaneous ignition. During maintenance of a spray drier for dairy products the atomizer was given too much lubricating oil. The oil soaked into powder deposited on the underside of the roof of the drier. During subsequent operation the oil-soaked powder ignited spontaneously. The burning material fell to the bottom of the drier, but fortunately no explosion occurred. However, the entire batch of product had to be discarded.  
[spontaneous combustion]

---

**Lessons**

[None Reported]

---



**7866 Date Unknown**

**Source :** DUST EXPLOSION HAZARDS, ICHEME, TRAINING PACKAGES, 022, 4.52.

**Location :** ,

**Injured :** 0      **Dead :** 0

---

**Abstract**

A spray drier explosion occurred. A fire broke out inside a large spray drier handling herbicide. There was suspicion of a mild dust explosion. The thick layer of about 25 tonnes of product on the drier walls was consumed by the fire. All pressure relief doors opened. The escaping flames barred the escape ways of three operators on the roof of the drier. They had to clamber down the side of the steel structure.

The fire broke out during the test run of a recently installed atomiser unit. The upper one of four atomiser discs, rotating at 15,000 rpm, scraped the housing of the gearbox and was heated locally up to the melting point of the material (Hastelloy, 6b). The atomiser finally broke with the pieces being hurled with full force against the drier walls.

[fire - consequence, commissioning]

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**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : 2      Dead : 0

---

**Abstract**

Two operators were burned by an explosion in a furfural unit extract vacuum flash heater following a surge of gas into the firebox.

The investigation showed that a reduction in the load on the burner heater had resulted in the closure of the fuel gas controller, which had jammed in the closed position due to the presence of ammonium chloride deposit and did not respond until the signal pressure was near maximum: in addition, the pilot burners were fouled with ammonium chloride. The source of ammonium chloride was the excessive carry-over of liquid into the fuel gas system from the ferrofiner knock-out drum.

[processing, heater, solids deposition, explosion, burns, ammonium chloride, injury]

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**Lessons**

[None Reported]

---

Source : DUST EXPLOSION HAZARDS, ICHEME, TRAINING PACKAGES, 022, 4.53.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Stopping conveyor causes explosion. At a food manufacturing plant, rusks were being dried in a natural gas fired conveyor belt type oven. The conveyor stopped, the rusks overheated and ignited. The fire spread to involve the timber and hardwood casing enclosing glass fibre insulating material. [overheating, fire - consequence]

---

**Lessons**

The fire could probably have been prevented by an interlock between the conveyor and the burners, provided the fans were kept running.

---

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

---

**Abstract**

As the morning shift was taking up its duties a leak of ammonia was reported in the refrigeration area of the ammonia plant. The Fire/Safety department responded and found an ammonia vapour cloud was issuing from a vent on the refrigeration compressor. The fire department made an initial attempt to control and dilute the vapour cloud using the well tried method of water fog. After approximately 10 minutes one of the fireman who was wearing a full face mask with ammonia absorbent canister collapsed. He was removed instantly and recovered within minutes of being taken to fresh air.

After the incident had been controlled an investigation was started as to why the man had collapsed.

The immediate opinion of the operation staff was that the man had either not put on his mask properly or had not removed the seal on the canister thus indicating poor training of this man.

The latter reason was disposed of as the man had already been in the vapour cloud for 10 minutes with no ill effect. Therefore he must have removed the canister seal prior to donning the mask.

The first cause of lack of training was taken quite hard by the safety department who felt that the man, who had been with them for 2 years, was quite adequately trained. They then re-enacted the incident with the man who was involved to ascertain the cause of the collapse. No apparent cause was found until they decided to cut open the canister to check the level of ammonia contamination of the filters.

The examination showed that where the man had been working behind a water fog curtain the filters in the canister had become sodden with water, the fibres had expanded and oxygen was prevented from reaching the user. Tests showed that only a small amount of water (1 teaspoon) was sufficient to clog the filter and prevent air flow.

The plant safety department has since issued a directive that air supplied Breathing Apparatus must be used at all times when tackling toxic gas releases and not filtration type of canisters which could become clogged with water.

[refrigeration unit, gas / vapour release]

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**Lessons**

[None Reported]

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Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A serious release of LPG gas occurred on an HF (hydrogen fluoride) Alkylation Unit in a refinery.

The gas was released over a period of one and a half hours and required the attendance of the refinery and local authority fire services. Fortunately the gas cloud did not ignite. There were no injuries to personnel inside or outside the refinery.

An investigation into the incident concluded that the LPG gas had been released from a hole caused by excessive localised internal corrosion of the outlet pipework of one of the two parallel isobutane recycle heat exchangers. A build up of iron fluoride deposits over a period of time in the outlet pipework had set up an environment which had allowed rapid localised corrosion to take place which had not been identified as a problem.

The investigation highlighted several factors which were believed to have contributed to the incident:

1. Inadequate engineering design and installation features that encouraged the build up of iron fluoride deposits, i.e.
2. The exchangers were designed to operate with shells in parallel and with an extremely low pressure drop (0.01 bar) which encouraged the deposition of sludge deposits in the shell sides of the exchanger.
3. The exchanger outlet pipework being the low point on the recycle loop encouraged the collection of deposits from the process stream.
4. Operating techniques and practices adopted following several start up and shut down situations, during previous months, had dislodged scale and corrosion products which accumulated in the recycle exchanger outlet pipework.
5. The corrosion inspection programme in force was not sufficiently comprehensive in that it failed to identify the area of severe localised corrosion.

[design inadequate, installation inadequate, solids deposition, inspection inadequate, gas / vapour release, refining]

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**Lessons**

[None Reported]

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8015 Date Unknown

Source : ICHEME

Location : ,

Injured : 0      Dead : 1

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**Abstract**

A welder was fatally injured by a falling metal plate, dislodged by a small explosion in the spirally wound cryogenic heat exchanger he was working on. Despite air purging it appears the incident resulted from the ignition of a small pocket of flammable gas in the exchanger when the welder struck an arc. This highlights the need for rigorous procedures for gas freeing and testing of all equipment prior to hot work, always taking careful consideration of possible dead spots in the equipment concerned. Fatality.  
[welding, cryogenic equipment, testing inadequate]

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**Lessons**

[None Reported]

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9050 Date Unknown

Source : ENVIRONMENTAL PROTECTION BULLETIN, 045, 22-23.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A company operating a coating process, part of which comprised the product passing through an oven during curing. Complaints were received from a residential property approximately 500 m away. However other residents did not complain. The area in which the company operates is heavily industrialised and contains a number of paint spraying processes in close proximity to one another. The problem was believed to have originated from the company itself as it had the largest processing site. An environmental strategy was implemented whereby only low odour, low solvent coatings were used and the curing temperature was reduced.

It was found that although emissions were discharged at height, the turbulence of nearby buildings resulted in grounding of the plumes. The process modifications reduced the odour radius to less than 500m.

[processing, gas / vapour release]

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**Lessons**

[None Reported]

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**Source :** CONSTRUCTIVE LOSSES, 1981, JAN, 15.**Location :** ,**Injured :** -      **Dead :** 4+**Abstract**

Fifty thousand pounds of flammable hydrocarbons gushed from an open bonnet flange on a plug valve and exploded catastrophically in an open air fireball. At least four fatalities, many injuries and many millions of dollars in property damage and business interruption resulted from the explosion and ensuing fires.

The cause of the explosion was the decision to unbolt the bonnet from a plug valve while there was line pressure against one side of the closed valve. The bonnet was unbolted so that the valve actuator could be removed in order to accomplish a safety "lock out" of the valve during a shutdown, thereby violating the established lock out procedure of only removing the actuator.

The source of the hydrocarbon spill was a batch reactor with an external cooling circuit. The reactor contained approximately 50,000 pounds of flammable hydrocarbons at a pressure of approximately 100 psig.

The heat exchanger frequently became fouled and needed cleaning. In order to minimise production outage time for cleaning, the plug valves were closed to block in the reactor so it would not have to be de-pressured or drained. The plug valves then were locked out by physically removing the air actuators so that the valves could not be operated while the heat exchanger was being cleaned. The air actuator for the plug valve is bolted to a bracket. On the type and size of valve used in this accident, the bracket is bolted to the valve by using the same four bolts that hold the valve bonnet on the valve. The original or standard "lock out" procedure called for unbolting the air actuator from the bracket, thus leaving the bracket bolted to the valve. However, it was quite difficult and time consuming to line up the matching bolts in the actuator with the bracket when the actuator was being re-installed after the heat exchanger had been cleaned. In order to simplify and speed up the job, two maintenance people removed the air actuator by unbolting the more accessible bolts that connected the bracket and the valve bonnet to the valve. For some time the now unsecured plug stayed in the valve body with 100 psig pressure. Suddenly the plug blew out and about 50,000 pounds of a hydrocarbon vapour and mist gushed out and ignited. The explosion demolished a control room and other buildings up to 500 feet away

[leak, fire - consequence, human causes, fatality, injury]

**Lessons**

Any modification to a procedure must be subjected to a detailed risk assessment.



Source : MANAGING FOR SAFETY, ICHEME, TRAINING PACKAGES, 017, 4.19.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A salt water cooling tower collapsed. There were no witnesses, but one operator on a routine check close to the furnace heard the noise and reached the tower immediately afterwards. He then informed the Control Room. The collapse took about approximately 20 seconds.

The Plant was shut down in accordance with the operating procedures for the loss of cooling water. The collapse was not related to any sudden event or cause outside the tower. There were no unusual occurrences or plant operations going on at the time of the event.

The shut down of the plant took place without any injuries or hydrocarbon release.

A month and a half later the plant was back in operation. A temporary once through salt water system had been installed during the plant shutdown.

After investigation it was found that bolts on the tower had suffered from corrosion/erosion.

[plant shutdown]

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**Lessons**

The following recommendations were made:

1. A formal system must be in place for documenting recommendations and effectively communicating them to the appropriate level of management.
2. The time required to correct any deficiencies identified by a plant inspection, must be defined and understood by plant personnel. A system must be established to ensure that all outstanding inspection recommendations are either carried out or have had the appropriate authorisation not to be carried out.

An update is required on the following safety management systems:

The plant should have a systematic and formally documented inspection plan for every year. Deviations from this plan should need management approval and operations, maintenance and technical personnel need to be involved in the assessment of the deviation.

---

Source : ICHEME

Location : ,

Injured : 1      Dead : 0

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**Abstract**

A small amount of light gas oil used to pressure test a heat exchanger escaped whilst swinging pressure test spades.

The bulk of the light gas oil had been drained off and only the amount lying between the heat exchanger bottom nozzle drain valve and the closed spade escaped. However, this oil was ignited by hot pipework below and a technician received minor burns.

[fire - consequence, leak, hot surface, testing]

---

**Lessons**

The following recommendations were made:

1. Pressure testing equipment with hydrocarbon always carried the risk of major spillage and fire, should loss of containment occur. Wherever possible, water to be used to conduct pressure tests where the equipment mechanical strength is being proved by approaching the yield stress of the metal. This testing is normally done at the equipment construction stage or when a structural modification is made. Should a weld or parent metal fail due to poor design or fabrication only water will be released. Clearly arrangements to be made to contain released water where large systems are being tested.
  2. Leak testing on the other hand, is done to prove the integrity of joints on established equipment which has been dismantled for cleaning, maintenance or inspection. Heat exchangers are a good example. Catastrophic failure of the equipment is not expected to occur, given good maintenance and inspection, with any release being limited to that passing through a failed joint. However, this incident demonstrates that the use of hydrocarbon for this testing does have an attendant hazard, and again advocate the use of water. A second issue is that should a leak occur during testing it is highly likely that a mist could be developed, which with even high flash point hydrocarbons is easily ignitable.
  3. This incident demonstrates the need for extreme care when dismantling any hydrocarbon containing equipment irrespective of whether testing is involved or not. Escaping hydrocarbon can be ignited immediately by adjacent hot equipment, soak into lagging with the risk of a delayed ignition, or cause a physical safety or occupational hygiene problems.
  4. Arrangements to be made to remove hydrocarbon by draining to a safe location, water washing, steaming, nitrogen blowing, etc. prior to breaking containment.
-

11040Date Unknown

Source : PETROLEUM REVIEW, JULY 1985, PAGE 32.

Location : ,

Injured : 1      Dead : 0

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#### Abstract

An explosion occurred in the firebox of a heater used to pre-heat heavy hydrocarbons. The furnace could be dual fired from refinery fuel gas or fuel oil. The furnace pilot light is fed from the fuel gas supply. Prior to the incident the furnace was being fired on fuel gas only to all burners and the fuel oil supply was isolated. The enquiry found that the incident was caused by incombustible gas (probably nitrogen) entering the furnace from an associated catalyst cracking unit via the fuel gas main and extinguishing the burner. An explosive re-ignition then followed. Nitrogen was found to have passed closed isolations and accumulated in a bypass line feeding the fuel gas main. When the unit was subsequently restarted and a control valve opened, the slug of nitrogen was swept forward to the furnace.

[cracking equipment, operation inadequate]

---

#### Lessons

The refinery avoided recurrence by ensuring all furnaces were operated using mixed fuel burning. The plant had been subjected to HAZOP and a range of safety interlocks had been provided. The potential for nitrogen entering the fuel gas main had not been considered.

---

9503 Date Unknown

Source : ICHEME

Location : , FRANCE

Injured : 0      Dead : 0

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**Abstract**

Failure of heat exchanger and pipe due to stress corrosion from chlorine ions.

The following conclusions were made:

This is a case of corrosion under stress in both instances.

1. On the elbow, the heat insulation composed of glass wool is to blame.
2. On the exchanger, the cooling water is the cause of the incident (the water contains 10mg/1 of chlorine).

---

**Lessons**

[None Reported]

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Source : HEALTH & SAFETY AT WORK, MAY 1987.

Location : ,

Injured : 0      Dead : 0

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#### Abstract

An explosion in a laboratory occurred while a researcher was treating a sample of baby milk food in a teflon-coated stainless steel digestion vessel. The explosion destroyed the oven in which it was being heated and sent debris flying across the laboratory. No one was reported injured.

After evacuating the area, a trained safety worker in breathing apparatus approached the oven to switch it off and try and stop other samples going up.

The air was laden with concentrated nitric acid, vaporised in the explosion. The safety worker cautiously switched off the power supply with a stick, but was unable to stop the third sample exploding.

The stainless steel reaction vessel disintegrated in the explosion and fragments had torn like shrapnel through the oven sides and steel cladding panels on the ceiling.

It is thought that the explosion occurred due to the adiabatic combustion of the milk food and an oxidising agent (nitric acid) such that the fat content of such biological material would act as a high energy fuel, especially under conditions of pressure containment within the digestion vessel.

[laboratory work, sampling, evacuation, gas / vapour release, unwanted chemical reaction]

---

#### Lessons

The following recommendations were made:

1. Knowledge of the major chemical/biochemical components, especially fat, carbohydrate and protein content.
  2. Sample sizes should be restricted to less than 100mg dry weight.
  3. Reactant solution should be added in excess of dry material within the chamber, which would increase the speed of reaction.
  4. Oxidising agents such as nitric acid should be diluted.
-

9640 Date Unknown

Source : LOSS PREVENTION IN THE PROCESS INDUSTRIES, F. LEES.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A catalyst bed was regenerated by circulating nitrogen through an electric heater, the bed and a cooler. The flowmeter on the nitrogen line choked with dust early on and the process operators learned to make do without it, controlling the plant by the nitrogen temperature at the bed inlet. One day the cooler blocked with dust and the temperature at the bed inlet stuck at its normal value. The heater overheated and cut off the power. The operator, seeing that the other instrument readings were normal, assumed the trip to be faulty and switched the power back on. The trip operated and was overridden three times in one hour. There was a shift change during this hour. Finally the heater burst.

[overheating, human causes, explosion]

---

**Lessons**

[None Reported]

---

Source : ICHEME

Location : ,

Injured : -      Dead : 0

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**Abstract**

A 6 inch outlet elbow of a first stage reactor effluent air cooler on a hydrocracking unit of a refinery failed. The failure mechanism was long term erosion/corrosion due to ammonium bisulfide.

Only minor injuries were sustained, but damage occurred in the hydrocracker and an adjacent hydrogen generation unit.

Conclusions:

The failure was due to long term erosion/corrosion due to aqueous ammonium bisulfide in the first stage reactor effluent cooler system. This corrosion can be very localised and is dependent on flow distribution and wash water distribution in each cooler bank.

The cooler pipework system was modified to obtain symmetrical flow distribution and individual water injection points installed, which may develop.

[damage to equipment, reactors and reaction equipment, injury]

---

**Lessons**

1. Hydrocracker/hydrotreater systems with hydrogen sulphide present and significant nitrogen in feeds, (resulting in the production of ammonia and subsequently ammonium bisulfide), can suffer substantial corrosion/ erosion leading to failure. Such attack is likely to be most dramatic at specific locations rather than general.

2. Limitations on flow velocities in reactor effluent systems, adequate injection of good quality wash water to reach all parts of the system, and possibly changes to unit severity operating conditions are parameters to limit attack.

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9776 Date Unknown

Source : LOSS PREVENTION, VOL. 3.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

When reinstalling a cleaned heat exchanger used to vaporise butane at 80 lb/sq. inch, gauge, a workman removed a blank from a flange left for future installation instead of the correct blank on a flange backed up by a closed valve. A butane vapour cloud was ignited by a heater 60 ft away. Water spray protected equipment but air, water, gas, electricity and instrument lines on a sprinklered pipe rack were severely damaged.  
[cleaning, gas / vapour release, damage to equipment]

---

**Lessons**

[None Reported]

---



Source : SEDGWICK, LOSS CONTROL NEWSLETTER, 1991, PAGE 8-9.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A runaway reaction occurred in a small shell and tube heat exchanger upstream in the hydrogen methanator reactor associated with an ethylene unit. This resulted in the rupture of the exchanger shell.

The incident occurred about one week after initial start-up with the operation still being debugged. With no warning, the exchanger shell ruptured, releasing gas at 450 psig with ignited. The methanator trip system was initiated manually which successfully isolated and depressurised the equipment involved. Flames initially estimated at about 30 feet high, died to 3 feet within 5 minutes. The equipment was finally isolated manually and the fire put out. There were no injuries and damage was limited to the exchanger and some minor overhead cable trays.

An investigation revealed that level instrumentation malfunctioned on an upstream separator drum and allowed ethylene-rich liquid into the hydrogen vapour stream, despite there being three separator level instruments shared a common impulse line and liquid accumulation had created a false reading in all instruments. Modification and procedures were implemented to resolve the problems.

Although the separator overflowed the exothermic reaction would not have been expected

[reactors and reaction equipment, gas / vapour release, fire - consequence]

---

**Lessons**

This incident indicates an accumulation of rust is capable of catalysing ethylene and possible other exothermic hydrogenation reactions. These reactions have the potential for high-temperature excursions at locations not anticipated in the design and thereby instigating a failure.

Not only should this potential be evaluated in the design and start-up preparations of new plant but also precautions should be taken in the restart of significant accumulation of rust.

The incident also clearly demonstrates:

1. The need for redundancy and diversity in critical instrument design.
  2. The value of trip systems that automatically isolated and depressure sections of plant.
-

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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**Abstract**

Hot air for start-up of a catalytic cracking unit was supplied by an air blower feeding through a gas fired in line air heater. Faulty and/or inadequate instrumentation permitted heavy surging of the air blower which blew out the flame in the air heater. The fuel gas was on temperature control so the control valve now opened wide. The gas ignited possibly from the hot refractory causing an explosion which cracked the blower case.  
[catalytic cracker, instrumentation failure, fire - consequence, gas / vapour release]

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**Lessons**

1. Heaters of this type should be fitted with a fire eye to shut off the fuel gas in case of flame failure.
  2. Large, high pressure air blowers require adequate surge protection independent of the normal plant control system.
-

10568Date Unknown

Source : INSTRUMENTATION TECHNOLOGY, 1972, 19 (10): 38.

Location :

Injured : 0      Dead : 0

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#### Abstract

A case history of inadequate instrumentation (undetected leak).

To improve efficiency in a furnace which cracked ethylene dichloride to vinyl chloride, computer control of the fired furnace was put into effect. One part of the control system regulated ethylene dichloride flow into the furnace to maintain an optimum temperature in the cracked gas exit line.

When a split tube in the furnace reduced the cracked gas flow, the outlet temperature dropped, causing the computer to call for increased ethylene dichloride feed. With the normal fire in the furnace intensified by the extra fuel from the cracked tube, the furnace tubes burned up.

[instrument/controller, damage to equipment, leak, instrumentation failure, heating]

---

#### Lessons

The following recommendation was made:

Redesign of the safety control system to provide better measurements of important variables and more reliable control through redundancy or by diversity of the systems.

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10646Date Unknown

Source : ICHEME

Location : , USA

Injured : 0      Dead : 0

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### Abstract

The report covers two (similar) incidents in which failures of tubes in HF alkylation units led to heater fires. In one case the fire virtually destroyed the heater and endangered the rest of the alkylation unit and its operating personnel. The other fire was more minor in nature.

In each case, the fire occurred because of failure of a carbon steel convection tube in the (gas fired) depropanizer reboiler. This was due to corrosion caused by the disposal of acid contaminated oils by burning in these heaters. This caused severe (but very localised) thinning of the tube walls, which was not picked up by routine inspections.

[oil waste, heat transfer, fire - consequence, damage to equipment, corrosion, contamination, material of construction failure]

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### Lessons

The following recommendations were made:

1. Minimise the burning of acid-contaminated oils "by process changes or other means"
  2. Inspect the heater tubes thoroughly, "especially in the convection section where the tubes are almost inaccessible"
-

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Shortly after the discovery of a minor leak in a tube of an air cooled heat exchanger bundle on the isocracker at a refinery, the tube ruptured. The unit was quickly depressured and shutdown without fire or injury. The incident cost \$1.6 million (1993) - \$1.1 million (1993) in lost opportunity and \$0.5 million (1993) for repair.

Failure of the tube was due to acid conditions in the system. Subtle changes in operating conditions had produced "wet" conditions in the cooler bundle which in reaction with ammonium chloride deposits accelerated corrosion.

[mechanical equipment failure, contamination, piping & fittings]

---

**Lessons**

The report stated the following recommendations:

1. Even small changes in operating conditions/modifications to plant, small changes in feedstock composition, etc., can produce accelerated corrosion conditions which may occur between inspection periods and hence lead to unexpected plant failure.
  2. Regular removal of deposits from air cooled heat exchanger bundles/header boxes is recommended.
  3. Ensure any water flushing is done with chloride free water, and the bundle thoroughly air dried before return to service.
-

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A fire resulted from the ignition of about a tonne of vaporised hydrocarbon which had been released through a water drainage system.

The source of ignition was a transfer line exchanger associated with a cracking furnace. The flash fire caused a number of other fires. One such fire, on an ethylene hydrogenation area heat exchanger joint, rapidly escalated due to relaxation of the bolting. This led to failure of an ethylene line and the subsequent rupture of other lines in an overhead gantry. These lines provided the energy for the fire responsible for the major damage.

The response of the operating and fire fighting teams was prompt and efficient and the image was contained within a small area of the plant.

The initial hydrocarbon release is attributed to the operation of an automatic water dump valve, on the fourth stage suction drum of the cracked gas compressor, which failed to close before releasing hydrocarbon to the drainage system. The delayed response from the interface level controller followed from emulsification and/or vortexing in the drum. The local hydrocarbon monitors alarmed but ignition followed very rapidly.

[fire - consequence, drains & sewers, spill]

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**Lessons**

[None Reported]

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**Source :** LOSS PREVENTION BULLETIN, 083, 11-12.**Location :** ,**Injured :** 0      **Dead :** 0**Abstract**

Scheduled maintenance of a refrigeration unit was in progress. The first phase involving work on the unit's compressor and evaporator had been completed. In order to allow work to continue, the local engineering department (mechanical) had requested that the ammonia liquor stored in the condenser liquid receiver unit be transferred to the evaporator. The procedures to be used in this transfer were agreed, the need for a leak test before admitting ammonia (NH<sub>3</sub>) was not identified.

On the day of the incident, brine solution was fed to a refrigeration unit's evaporator which was rectified by the shift fitter. The process supervisor started the transfer of liquid ammonia after the brine solution had been circulating to the evaporator for one hour. Later the liquid receiver's outlet valve was closed. An ammonia leak was detected at the flange after the open valve on the evaporator side. The process supervisor donned a self-contained air set and attempted to tighten the flange, although local visibility was poor. He was unsuccessful as the leaking ammonia froze his gloves making manipulation impossible. The shift manager was notified of the ammonia release, and also personnel on the control panel and on arrival found the panel operator in the air line respirator. Measures were taken to prevent anyone entering the building and the operation of the plant was stopped.

[flange leak, gas / vapour release, spill]

**Lessons**

The following recommendations were made:

1. Following mechanical maintenance and/or repair on the units, liquid ammonia should not be introduced into the appropriate equipment before a leak test is carried out.
2. A formal written procedure should be issued specifying a leak test method and identifying the role of engineering and production department personnel.
3. It needs to be re-iterated that flange sealing faces should be in good condition before making a joint.
4. It should be re-iterated that written operating instructions must be issued for non-standard operations in the format agreed for normal operation instructions.

Source : LOSS PREVENTION BULLETIN, 010, 1.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A serious fire started with a leak on a residue pump. Situated above the pump was a bank of fin fan coolers. The up-draft created by the fans caused serious damage to the coolers.

The remotely operated isolation valve on the pump suction was quickly operated and the initial fire extinguished. However, by this time the cooler was leaking and the fire continued for a long time.

This accident happened on one of several similar units laid out in this manner. The layout philosophy has now been changed.

The same company have also found that natural air currents can cause fan blades to rotate when the fan motor is isolated. The fans must therefore be prevented from moving before any maintenance work is carried out on the system.

[fire - consequence]

---

**Lessons**

The following recommendations were made:

1. The updraft from the fans can disperse a small toxic or flammable leak so that it is not noticed until a serious leak develops.
  2. The updraft can disperse a large leak of flammable material into the atmosphere and cause a hazardous situation.
  3. The updraft can deflect a fire away from a flame detector which is sensitive to condition or convection.
  4. If Vee belts are used on the drive mechanism, static charges can be built up and be a source of ignition.
  5. If stainless steel pipes are required, then the fins should not be made of galvanised steel.
  6. Isolation of the fan motors and securing of the blades must be considered. As the fin fan coolers are often situated in banks high up in a plant with electrical isolators at ground level, local isolators are required in addition to prevent starting the motor when maintenance work is being carried out. Accidents have occurred when the isolators at ground level have been incorrectly numbered. The stop buttons should be located at least 30 feet from the fans or duplicated in a safe area so that they can be reached when there is a fire under the fans.
  7. If hot product continues to flow through the tubes a natural updraft will make fan blades rotate and could injure a person working on the motor.
-



Source : LOSS PREVENTION BULLETIN, 010, 1.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

The duty of a distillation column equipped with fin-fan condensers was to be changed from purifying a material, boiling point 160 degrees C, flash point 50-90 degrees C, depending on trace impurity level to distilling a hydrocarbon boiling point 85 degrees C, flash point minus 6 degrees C.

Immediately below the fin-fan condensers were two very large pumps which were to handle the hydrocarbon.

The problem was whether to retain the fin-fan condenser and risk a major fire, or replace the fin fan cooler by water cooled shell and tube condenser at additional capital cost. An economic study justified the latter course of action, the pay back time being approximately four years. This is not too attractive on these days of financial stringency, but the elimination of the risk was considered very well worth while.

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**Lessons**

The following recommendations were made:

1. The updraft from the fans can disperse a small toxic or flammable leak so that it is not noticed until a serious leak develops.
  2. The updraft can disperse a large leak of flammable material into the atmosphere and cause a hazardous situation.
  3. The updraft can deflect a fire away from a flame detector which is sensitive to condition or convection.
  4. If Vee belts are used on the drive mechanism, static charges can be built up and be a source of ignition.
  5. If stainless steel pipes are required, then the fins should not be made of galvanised steel.
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  7. If hot product continues to flow through the tubes a natural updraft will make fan blades rotate and could injure a person working on the motor.
-

**Source :** LOSS PREVENTION BULLETIN, 017, 7-8.**Location :** ,**Injured :** 0      **Dead :** 0**Abstract**

The plant concerned was large spray drier installation directly heated from a combustion chamber. The plant was newly erected and the combustion chamber had been running only some twenty-four hours on manual control at very low fire to the burner. Oil in excess of the burner requirements was returned to the upstream side of the pump and recycled. The whole of the heater and flow and re-circulation system was lagged.

The accident occurred early in the morning after the firing had been continuing unsupervised for some hours. There was a sudden eruption of flame through a hinged explosion panel close to the combustion chamber which enveloped a shift electrician as he was walking by.

Investigation revealed that the only explanation for the eruption of flame was gross overfuelling of the furnace and yet the manual valve controlling the burner was still at its original setting, indeed combustion was found to be continuing as peacefully after the event as it had been previously. Apparently in one aspect only was there a change, a considerable run of the lagging surrounding the oil flow and re-circulation pipes was on fire.

The explanation appeared to be that the lagging had caught fire as the primary event, it was discovered that this lagging had been saturated with fuel oil shortly after installation due to pipe joints leaking when the first pressure test was applied. Although the joints were tightened, the original contaminated lagging was not replaced. Because of the almost closed loop operation the flow and return oil lines were raised to high temperatures and ignited as a consequence. The lagging fire then raised the fuel oil temperature to greatly in excess of the control value, with a concomitant reduction in viscosity. When this superheated oil reached the fixed aperture of the manual burner valve, it flowed through rapidly, thus overfuelling the combustion chamber. In doing so it discharged the overheated oil from the pipe system and conditions were restored to normal when oil at normal temperature reached the valve once more. The rate of flow, whilst the over heated oil was entering the combustion chamber, was such that little temperature rise occurred in the fresh oil as a result of the lagging fire. Had the burner not been extinguished at that point a subsequent outburst of flame would probably have happened.

[joint leak]

**Lessons**

[None Reported]

Source : LOSS PREVENTION BULLETIN, 021, 76-77.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

An electrical heater heats a circulating nitrogen system. A choke occurred elsewhere in the system and caused the circulation to stop. The flowmeter was not working so this was not apparent to the operators. The heater got too hot and a high temperature trip shut off the electrical supply. The operator assumed that the trip was faulty and reset it. Ten minutes later it tripped out again. The operator again assumed it was faulty and reset it for the second time. After another ten minutes the power was tripped out for the third time and for the third time the operator reset the trip. Soon afterwards the shell of the heater split open.

The immediate cause of the rupture was the readiness of the operator to assume that the trip was faulty. Even though it repeatedly tripped out he did not investigate. Contributory factors were:

1. The temperature setting on the trip was too high.
2. During the time the accident took place the supervisor was not present. He was handing over his job to the next shift and this is traditionally done, not in the control room, but in a distance office.

[flow meter/control, instrumentation failure]

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**Lessons**

[None Reported]

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11660Date Unknown

Source : ICHEME

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Minor, localised damage was caused when the bottom joint of an extreme high pressure (EHP) superheater failed while the steam was at about 1850 psig and 960 degrees F. The superheater was isolated by shutting in the boiler stop valve on two boilers, since the manually operated isolating valves at the EHP header could not be reached. Investigation showed that the failure occurred because a small leak at the joint had not been dealt with quickly enough, leading to a deterioration in its condition.

[mechanical equipment failure, damage to equipment, corrosion]

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**Lessons**

EHP leaks should be given immediate maintenance.

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Source : ICHEME

Location : ,

Injured : 2      Dead : 0

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**Abstract**

Two operators were burned by an explosion in a furfural unit extract vacuum flash heater. The explosion was caused by a surge of gas into the firebox, which investigation subsequently showed was the result of the fuel gas controller becoming jammed closed due to the presence of aluminium chloride deposits. The pilot burners were also fouled with aluminium chloride, the source of which was found to be excessive carry-over of liquid into the fuel gas system from the ferrofiner knock out drum.

[mechanical equipment failure, contamination, burns]

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**Lessons**

The pilot gas to the heater to be taken from a point upstream of the ferrofiner off-gas line.

The demister panel to be fitted to the fuel gas knock out drum. A sweet gas supply to the refinery pilot gas system to be considered.

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7168 Date Unknown

Source : LOSS PREVENTION BULLETIN, 048, 28.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Incomplete detontamination. A heat exchanger was received from an ethylene dichloride plant and some of the tubes were blanked off. These tubes were opened by drilling with a compressed air drill. A liquid escaped which contained two phases. On analysis the liquids were shown to be water and ethylene dichloride.

[spill, cleaning inadequate]

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**Lessons**

[None Reported]

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Source : LOSS PREVENTION BULLETIN, 074, 15.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

The start-up of a superheater worked fairly well, but the temperature indicator in the stack was off scale, high. At the time this was wrongly diagnosed as a faulty instrument. The thermocouple probe was withdrawn and found to be red hot. As the reason for this was a mystery the superheater was immediately shut down. Nothing obvious was found to be wrong, so it was cautiously re-started on low fire, with the cooling air turned off. The superheater worked well, and this time the indicated stack temperature remained low and close to its design value.

The firing rate was increased and following the operating procedure, turned on the cooling air fan. There was an explosion in the furnace. Flames were ejected through all the air inlets and some damage was caused.

The subsequent investigation showed that the settings on the burner had been disturbed and the furnace was running very rich, giving incomplete combustion.

Secondary combustion was occurring above the heat shield at the point of cooling air injection. This was the reason for the very high stack temperature.

On low fire there was no secondary combustion, but when the cooling air fan was restarted, a flammable mixture formed in the top of the furnace and the stack, with unfortunate results.

The black smoke which the superheater had produced at low fire was not noticed because of the large amount of dilution occurring in the main stack.

[damage to equipment, fire - consequence]

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**Lessons**

[None Reported]

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Source : LOSS PREVENTION BULLETIN, 075, 22.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A chlorine plant was in the process of being demolished. Where flame cutting equipment was being used a hot work permit had been issued. The shell of a heat exchanger was being cut up using flame cutting equipment when there was a violent fire in the tube bundle. The nearby water hose which was required by the hot work permit, was immediately used on the burning tubes. There was then a loud explosion in another part of the heat exchanger. The investigation of the incident quickly discovered the cause of the incident. The heat exchanger was used for cooling liquid chlorine. It consisted of a carbon steel shell with thin walled titanium tubes and titanium tube plate facing. The cutting flame heated the titanium tubes to the point they burned in the presence of air. The water used to extinguish the flame reacted with the titanium at 700 degrees C, to evolve hydrogen. This hydrogen then ignited in the air at another part of the heat exchanger, causing the explosion which bent the tubes.

[demolition, unwanted chemical reaction]

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**Lessons**

1. Thin walled titanium can be ignited by a hot flame from flame cutting operations to give an intense flame. This hot flame will react with water to give the hydrogen and titanium dioxide. The hydrogen can then be ignited.
  2. The writer of the Permit to Work and Hot Work Permit were not fully aware of the hazards of flame cutting near thin walled titanium nor the reaction of burning titanium with water. This emphasises the necessity to identify hazards when carrying out a risk assessment and the usefulness of an accident database to help in the process of hazard identification.
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Source : LOSS PREVENTION BULLETIN, 081, 17-18.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

An explosion occurred in a sulphur plant incinerator. There were no injuries to personnel.

Due to both the incinerator burner and pilot flames being extinguished. Following this flameout, fuel gas was still being introduced into the firebox. The fuel gas ignited on the hot incinerator lining resulting in the explosion. The incinerator sustained mechanical damage to the air ventilation system and the lining of the firebox and stack.

[damage to equipment, heating]

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**Lessons**

The following recommendations were made:

1. Evaluate and recommend improvements to incinerator pilots, burners, natural gas systems and fuel gas systems. This should include hardware improvements including central control and/or local instrumentation as well as shutdown systems and appropriate inspections.
2. Install natural gas to incinerator burners in place of fuel gas. Fuel gas firing capability should be left intact but blanked out.
3. Provide a reliable way to check incinerator flames for both pilots and burners.
4. Expand maintenance programme to include appropriate incinerator inspections. These inspections should be consistent with changes made resulting from the above recommendation.

The prime cause of this incident was that the original system, both control valves and burners, had been allowed to become plugged up and fouled. Perhaps more frequent inspection and cleaning could have averted the explosion.

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Source : PETROLEUM REVIEW, OCTOBER 1986.

Location : ,

Injured : 1      Dead : 0

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**Abstract**

A leak of ammonia was discovered in the refrigeration area of an ammonia plant, the vapour cloud being emitted from a vent on the refrigeration compressor. An attempt was made to control and dilute the emission. After about ten minutes a site fireman, wearing a full-face mask, with ammonia absorbent canister, collapsed. He was removed from the scene and taken to recover in fresh air.

On examination of the filters in the ammonia canister, taken from the mask, it was found that they were soaked with water, the fibres had expanded and therefore air had been unable to reach the user. The fireman had been working behind a water fog curtain.

[refrigeration unit, gas / vapour release, asphyxiation]

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**Lessons**

A test identified that a teaspoonful of water was sufficient to clog the filter and prevent airflow.

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Source : LEARNING FROM ACCIDENTS, ICHEME, SAFETY TRAINING PACKAGE, 020, 43.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A tray drying oven, of type commonly used in the pharmaceutical and fine chemicals industries, was used to evaporate methanol from a crystalline powder which was spread out in a number of trays in the oven. The oven was heated by drawing hot air through it by means of an induced draught fan. The air was heated by passing it over a number of steam heated finned tube heat exchangers which comprised one side of the oven. These were not, however, visible, being covered with a steel sheet which formed the outer wall of the oven. The heated air had two purposes, (a) to provide latent heat of evaporation of the methanol and (b) to dilute the methanol vapour to a safe concentration, below the lower flammable limit. The oven had been operated safely for a number of years, but one day it blew up unexpectedly and caused serious damage to the process building.

Examination of the oven and associated equipment revealed that, over a long period of time, various chemical powders had been drawn on to, and accumulated on, the fins of the heat exchangers. This deposit had built up and hardened and had virtually completely blocked the spaces between the fins.

This caused,

1. The total air flow through the oven to be diminished until it was no longer sufficient to dilute the methanol vapour to a safe level and
2. The solid deposits prevented heat from leaving, gradually heating up the deposits, leading to decomposition, smouldering and eventually fire, thus igniting the methanol vapour. The explosion then occurred.

[solids deposition, cleaning inadequate, solids deposition]

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**Lessons**

The finned tube heat exchangers were inside the structure of the oven and not easily visible. The vital dismantling and cleaning had apparently not been carried out for a considerable period of time.

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Source : LOSS PREVENTION BULLETIN, 080, 20.

Location : ,

Injured : 1      Dead : 0

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**Abstract**

An operator fell from a one foot high stepladder and broke a bone in his foot whilst painting using a solvent based aluminium paint.

The operator was painting two air heaters at the beginning of the afternoon shift. The heater steam valves were closed, but the heaters had not cooled down before painting started.

When he had finished the first heater, he complained to his foreman about the smell of solvent from the paint. His foreman told him to use his halfmask (gasmask).

After a break the operator started to paint the second air heater which was located above the kettle floor in a narrow space between two walls and under a mezzanine floor. The air heater was still warm when he started to paint standing on a 0.4 m stepladder. After about one hour he felt dizzy and fell, inuring his foot.

The operator had breathed in too much solvent when he was painting the first heater without using his gasmask. The break had been too short to vent out his lungs and when he returned to work in a warm area and in an awkward position, he became dizzy and fell.

[fall, maintenance]

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**Lessons**

To prevent accidents such as this:

1. Painting should not be done on a warm surface.
  2. An artificial respirator should be worn when solvent odour is strong.
  3. A platform should be used even for such a low height.
-

**Source :** LOSS PREVENTION BULLETIN, 089, 9-10.**Location :** ,**Injured :** 1      **Dead :** 0**Abstract**

The fin fan coolers of a plant were to be cleaned by entering the plenum chamber below the finned tubes and blowing them with compressed air. This was an accepted requirement during a shutdown and involved firstly a scaffolder entering the chamber to place boards over the air fan duct and to fix a scaffold pole to prevent rotation of the fan blade even though the fan motor was isolated. Secondly, a man would enter the plenum chamber to air blow the finned tubes to remove dust and deposits. To do this he would walk across the whole chamber floor including the boards placed over the air aperture. After completion of the cleaning, the boards and scaffold poles would be removed from the chamber.

On the day of the accident, a scaffolder entered the eleventh fin fan heat exchanger of the plant after being issued with a hand-over certificate and an entry permit for the confined space. The air aperture was partly covered with boards when the place the scaffolder was standing on gave way and he fell 11.2 metres (37ft) on to hard-core ground.

The accident was a case where initial designed weakness coupled with a deteriorating condition resulted in the deck plates becoming unsafe for use as a walkway. Access to the areas was infrequent, once per 2 years, and was controlled by an entry permit. The hazard had gradually worsened due to adverse operating conditions which had not been appreciated.

[fall, entry into confined space, design inadequate]

**Lessons**

The recommendations:

1. All activities in plenum chambers, ducting etc. which utilise the deck plates as a walkway should be reviewed to ensure design/condition makes for safe entry or where not suitable, appropriate, alternative methods are available and warning notices employed.
2. Consideration should be given at the design stage to improvements of chamber, plenums and ducts, either to avoid the need for entry or where necessary, to ensure they are incorporated into the structure.
3. Site practice with respect to walkways/access ways when the flooring is solid should be reviewed.
4. Methods of working practise must be communicated to those carrying out the work, in order that they fully understand and appreciate the hazards of the work involved, and the precautions that must be taken.

Source : LOSS PREVENTION BULLETIN, 095, 6.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A spray drier was fitted with adequately dimensioned, self-closing pressure vents, which, in the case of a dust explosion developing in the drier, could open and immediately close again.

The spray drier and also the relevant filter were earthed in accordance with regulations and the filter bags were electrostatically conductive. All the electrical equipment coming in contact with the product was designed to be proof against dust explosions.

Diverter plates were placed in the region of steps leading to the installation, these were to ensure that workers finding themselves on the steps could not be injured by any flames from the pressure vents. As a further measure, the firm had placed chains with plates at all exits leading from this servicing stairway to the stages and these notices prohibited access to the stages while the drier was in operation.

Although it was believed that all measures had been taken for safety against dust explosions, a dust explosion did occur in the spray drier and in the filter, and the pressure vents in the spray drier duly reacted. The cause of the explosion is not quite clear, it was presumed that a dust deposit was ignited by a smouldering fire.

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**Lessons**

[None Reported]

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Source : LOSS PREVENTION BULLETIN, 093, 11.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

The shell of a methanol product condenser ruptured whilst one of the water channels was being removed in preparation for inspection and seven men sustained minor burns. This was a horizontal fixed tube heat exchanger constructed of copper. The shell (process) side had been steamed-out and been left open to atmosphere for several hours over a period of three days.

The explosion emitted a blue-green flame and a black deposit subsequently found in the shell contained 9% cuprous acetylide. The explosion was concluded to have been due to copper acetylide decomposition, the source of acetylene being a minor process stream containing 300 ppm acetylene which was used intermittently.

[copper acetylide]

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**Lessons**

[None Reported]

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Source : LOSS PREVENTION BULLETIN, 119, 8.

Location : ,

Injured : 1      Dead : 0

### Abstract

A fitter complained of irritation on one of his hands at the end of his shift. His job at the time involved the dismantling of a heat exchanger which had been plugged solid by a corrosive chlorinated slurry in the manufacturing plant. The day following the incident the fitter reported to the Works nurse. His arm was blistered and his hand and other arm showed signs of severe irritation.

The injured employee wore a polyvinyl chloride (PVC) suit over cloth coveralls with gauntlet length nitrile rubber gloves tucked inside the PVC suit sleeves. He started the job by removing the elbows from the exchanger tubes, working from the centre which is at head height, and continuing down the bank of tubes. As the ends of the exchanger had not been removed before, and the bolts were rusted and longer than necessary, a great deal of time and effort was needed to remove the nuts and bolts on each elbow. The production staff cleaned each tube after the elbow was removed. This left the tubing dripping with a dilute corrosive water solution onto the tubing below.

The normal maintenance procedure requires that equipment be decontaminated before opening by circulating a caustic solution followed by a hot water wash and finally sodium disulphite to destroy any residual ingredient. Decontamination was attempted in this case but was unsuccessful as the exchanger was completely blocked with slurry.

After investigation it was concluded that some of the corrosive/water solution most likely ran up the fitter's sleeve, was absorbed by the coveralls and caused the burns and irritation on his forearms.

The following actions were taken as a result of the incident:

1. A procedure is being established and training given to all fitters so that elbows are removed from the bottom to the top.
2. A temporary work platform will be used so that the fitter is always above the elbow he is working on.
3. The nitrile gloves are being retested for permeability to the chlorinated slurry which contains about 80% active ingredient salts and lesser quantities of toluene, chlorotoluene and hydrochloric acid. Ring inserts have also been designed to form a water-tight seal between the glove gauntlet and sleeve of the PVC suit.

[personal protective equipment, cleaning procedure incorrect, caustic soda, injury]

### Lessons

1. Maintenance and repair operations which are not routine, and particularly those involving hazardous tasks or materials, should be subject to some form of risk assessment before proceeding with the job.
2. Process intermediates should in general be handled with great care due to their complex chemistry, troublesome physical properties and poor characterisation in terms of toxicity.
3. The performance of protective clothing is dependent on many factors: barrier quality, chemical and permeation resistance, physical durability and integrity of components as assembled and used. Failure of any one of these features can reduce or eliminate the protection afforded by the clothing system.
4. The skin contact hazard of known active ingredients and other chemicals must always be considered. These materials are intrinsically severe irritants or may be corrosive to the skin or eyes on first contact. Repeated contact to low concentrations may also induce contact allergy in susceptible individuals.



11276Date Unknown

Source : INSTITUTE OF GAS ENGINEERS, COMMUNICATION 451, UNUSUAL INCIDENTS AT GAS WORKS AND THEIR LESSONS, PART 2, 28 SEP, 1954.

Location : , UK

Injured : 0      Dead : 0

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#### Abstract

An explosion occurred in a 24 inch gas main whilst a section was being replaced. The main was isolated using valves available and pressure tested prior to work commencing. The section was removed, capped and yarned ready for leading. As the first ladle of lead was run in, a flame issued from the cap and an explosion occurred damaging a gas heater some 200 ft along the line. An enquiry determined that the section of pipe being cut was 6 ft from a valve on one side, but 200 ft from the nearest isolation valve on the other side. The yarn put in was also found to be inadequate. The probable cause identified was that the hot lead had caused extraneous material in the main to ignite. This was probably yarn or oil condensate. This in turn ignited the gas-air mixture which had accumulated in the un-swept 200 ft length of pipeline.

[maintenance, damage to equipment, hot surface]

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#### Lessons

The following recommendation was made:

Bags should be used to isolate lengths of line exceeding 10 ft to minimise the risk of explosion. This will prevent air mixing with gas in the pipeline to produce an explosive mixture.

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Source : LOSS PREVENTION BULLETIN, 119, 5-6.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Explosion in a large spray drier handling dairy products. The plant normally ran for 2 shifts on production, with an inspection being carried out during the night shift. After an inspection the plant was started up shortly followed by a milk concentrate being fed (mixture comprising of milk with added tallow fat) to the drier at a concentration of 50-52% solids, and the product powder contained 26-27% fat. Air inlet temperatures were steady at 210 - 212 degrees C and outlet temperatures in the range 85.5 - 88.5 degrees C from the time the milk concentrate was added until the explosion which occurred later in the afternoon.

No significant operating problems were noticed during the production run until very shortly before the when a burning smell was noted. The temperature recorder on the first fluid bed outlet air duct jumped from normal to off-scale within two minutes (the time between readings). The atomiser feed was switched to water immediately prior to the explosion.

[start-up]

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**Lessons**

Recommendations included:

1. Operation with a maximum inlet air temperature of 190 degrees C.
  2. Ducting of the explosion vents from the drier to outside.
  3. Thorough cleaning and inspection following any blockage.
  4. Frequent checking of finished product for scorched particles.
  5. Evacuation to a safe place and operation of the water spray extinguishing system should any smell of burning be detected.
  6. Final report specified that for fat filled products the air inlet temperature would be reduced from 210 degrees C to 190 degrees C with a consequent throughput reduction of 8% and that personnel would not be permitted on to the top level of the drier during production.
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Source : LOSS PREVENTION BULLETIN, 119, 6.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Explosion in a large spray drier handling dairy products. Tallow filled milk of 30% fat content was being manufactured. Lecithin was being sprayed onto the powder at the exit to the first fluidised bed. Blockages had occurred on two occasions in the three hours prior to the explosion, so operating temperatures would not have been steady. The air inlet temperature at the time of the explosion was stated as 210 degrees C. Movement of the roof and upper cladding around the drying chamber occurred and the inspection hatches on the fluidised beds had been blown out by the explosion.

[high temperature]

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**Lessons**

Recommendations included:

1. Operation with a maximum inlet air temperature of 190 degrees C.
  2. Ducting of the explosion vents from the drier to outside.
  3. Thorough cleaning and inspection following any blockage.
  4. Frequent checking of finished product for scorched particles.
  5. Evacuation to a safe place and operation of the water spray extinguishing system should any smell of burning be detected.
  6. Final report specified that for fat filled products the air inlet temperature would be reduced from 210 degrees C to 190 degrees C with a consequent throughput reduction of 8% and that personnel would not be permitted on to the top level of the drier during production.
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Source : QUARTERLY SAFETY SUMMARY, 1967, VOL. 38, NO. 149.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

An explosion occurred during furfural hydrogenation. The process involved was a high pressure hydrogenation of furfuraldehyde to furfuryl alcohol, which was carried out in a standard high pressure reactor.

The procedure was to start with the reactor charged with a quantity of furfuryl alcohol and introduce gradually furfuraldehyde containing a small quantity of catalyst and lime, while cold hydrogen supplied by a compressor was being circulated through the reactor.

Under normal conditions the hydrogen heaters are applied to bring the reaction temperature up to 135 degrees C. when the reaction starts, a pressure of 4000 lb. p.s.i. being maintained.

The incident occurred due to a fault developing in a measuring device, the aldehyde was being fed in at a much higher rate than normal, so that the alcohol in the reactor, which should have controlled the hydrogenation, was being diluted with too much aldehyde before the heaters were switched back on.

As a consequence, when the reaction did start the alcohol/aldehyde ratio was sent out of balance and the reaction took place uncontrollably, resulting in a violent explosion.

The lid was blown off the reactor and considerable damage was done in the immediate vicinity but, unfortunately, no one suffered direct injury.

[reactors and reaction equipment, unwanted chemical reaction, process causes, damage to equipment]

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**Lessons**

It should be emphasised that while the high exothermicity associated with the polymerisation of furfuryl alcohol under certain conditions arising, it had not been anticipated that the hydrogen of aldehyde to alcohol, could, in certain circumstances, get out of control.

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Source : HAZARDS OF OVER AND UNDER PRESSURING OF VESSELS, ICHEME, SAFETY TRAINING PACKAGE, 001, 12.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A 200 kW electric heater split open. After the incident the circulating system was found to be choked with catalyst dust so that there was no circulation. The flowmeter which measures the gas circulation rate was out of order. The cooler by-pass was closed at 11.00 and this was probably the time when the circulation stopped.

The high temperature trip operated and the operator reset it. The trip operated again ten minutes later and again eight minutes later, on both occasions the operator reset it. An hour later the shell burst. The operator did not know what action to take if the trip operated and the operating instructions did not cover this point. He therefore assumed that the trip had operated in error.

The pressure was just below 62 bar (900 lbf/in<sup>2</sup>) when the relief valve would lift. As the shell was hot it burst at what is a safe pressure at normal temperature.

[flow meter/control, instrumentation failure, rupture, heating]

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**Lessons**

The following recommendations were made:

1. The thermocouple that operated the trip was fixed to the shell instead of the heating element and set at 400 degrees C, the relief valve setting was lowered, arrangements were made to test the trip every time the equipment was used.
  2. The operators should have been given a better understanding of the purpose of trips in general and this trip in particular.
  3. The supervisor should make the control room his H.Q. His entire area is controlled from this control room.
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Source : FURNACE FIRES AND EXPLOSIONS, ICHEME, TRAINING PACKAGE, 005, 9.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

Before lighting a furnace the atmosphere inside was tested with a combustible gas detector. The instrument indicated that gas was present.

This was no way connected with the furnace. It came from the base of the cooling tower nearby which cools the water from direct contact jet condensers on three vacuum stills. The fan on the cooling tower had been switched off to save electricity as it was not necessary for cooling. When it was switched on, the vapours dispersed.

Near miss.

[testing]

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**Lessons**

The following recommendations were made:

1. Changes made for good reasons may introduce new hazards could arise.
  2. Keep the fan running.
  3. Install an alarm which will sound on fan failure or fit a combustible gas detector between the tower and the furnace.
  4. On a new plant, area classification should draw attention to the hazard. The area round the cooling tower should be e.g. Division 2 and the furnace should be placed outside the Division 2 area.
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7722 Date Unknown

Source : SAFE USE OF CHEMICAL ADDITIVES, ICHEME, SAFETY TRAINING PACKAGE, 018, 3.6.

Location : ,

Injured : 0      Dead : 0

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**Abstract**

A violent polymerisation occurred in one of six horizontal storage tanks of 246 m<sup>3</sup> capacity containing acrolein resulting in an explosion.

1,700 residents in the area of 13 square kilometres were evacuated due to damage to adjacent tanks. Debris from the explosion travelled 150 metres. Four tanks were lost in the subsequent fire.

It was believed that the polymerisation was initiated by radicals which were picked up by the acrolein from a leak when it passed through a heat exchanger cooled by river water.

[fire - consequence, evacuation, contamination, damage to equipment]

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**Lessons**

Radicals which cause the polymerisation may be picked up from many sources and therefore it is important to identify the possible sources of contamination at the design stage. Levels of inhibitors in the product must take into account the contamination that may occur in normal operation.

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