**Incident description: gas leak 2015**

This description covers three separate incidents and musterings which provide a continuous course.

Incident 1: Air compressor B tripped. During efforts to restart it, arcing and a short-circuit occurred in the starter element and vertical busbars. Smoke therefore developed in the switchboard room. The general alarm was activated and mustering began. Several utilities lost power as a result of the short-circuit, but oil and gas production was not affected by the incident. The emergency was normalised after 30 minutes.

Incident 2: Following incident 1, the switchboard was cleaned. In that connection, the starter element was removed and isolation resistance measured. Although measurement results were poor, an attempt was made to restore power to the switchboard. Arcing and short-circuiting in the switchboard led to smoke and fire in the switchboard room. The general alarm was activated and mustering began. The Profibus cable between the starter element for the air compressor and the control logic was burnt/damaged. A $CO_2$ extinguisher was used to extinguish the fire in the switchboard room. Shut-down of a number of wells was initiated. The emergency was normalised.

Incident 3: Air compressor A tripped several times. At the final drop-out, instrument air began to be lost. Unstable operation of the air compressor caused the $N_2$ package to trip. The bank of $N_2$ bottles took over but was emptied in 10 minutes. This caused the loss of gaskets on the fourth- and sixth-stage compressors. The risk of gasket failure prompted the halting of the compressor train. To avoid hydrate in the pipeline, MEG inhibition was initiated. The low low alarm for instrument air activated. Process shutdown was initiated. This in turn tripped the MEG pump. Efforts were made to restart air compressor A, but these failed. Process shutdown was re-set. A process shutdown block was applied to an ESD valve in order to open this so that depressurisation/rundown of the pipeline could continue. The bypass (ESD) valve to the first-stage separator opened. Another ESD valve to the first-stage separator opened. The choke to the pipeline was opened to 20 per cent. The high high alarm on the choke to the pipeline activated. The high high alarm for the first-stage separator activated. Isolation of the first-stage separator was initiated. Process shutdown to the pipeline was blocked. ESD valves to the first-stage separator opened because their process shutdown function had been blocked earlier. In addition, the choke to the pipeline was opened to 30 per cent in order to continue depressurisation/rundown of the pipeline. The high high alarm for the first-stage separator activated again. Efforts were made to open a pressure relief valve. The pressure safety relief valve (PZV) in the first-stage separator lifted for the first time. MEG injection was initiated. The PZV lifted for the second time. Gas was detected by a single detector in the process area. An alarm reaction team was sent out to check. Confirmed gas was detected in the process area. ESD 2 was initiated. The MEG pump tripped. The ESD valve on the inlet to the first-stage separator closed as a result of the emergency shutdown. The general alarm was activated and mustering began. The high high alarm on the first-stage separator activated again. Detectors in the process area were no longer activating, and an alarm reaction team was sent out to check. The fire damper closed because of low instrument air. This caused main power to be lost. Three monitors in the control room went down. Control of the ballast pumps was lost, along with the hydraulics. The emergency was normalised after about 50 minutes. ESD 1 was unintentionally initiated owing to leakage in butterfly valves inside the deluge skid and the lack of instrument air. The installation was depressurised manually with the aid of hand pumps. Main power restarted.

The gas leak occurred because the adjusting pin ring on the PZV had become dislodged, probably as a result of a faulty gasket and insufficient mounting of a seal in the valve cavity. After the incident, the leak was estimated to have been 0.6 kg/s.

**Causes**

Direct causes

Incident 1: Short-circuit and arcing in starter element for air compressor B.
Incident 2: Short-circuit in switchboard B (busbars) and combustible material (isolation carpet) in the switchboard.
Incident 3

- Adjusting pin ring (on the PZV) had become dislodged.
- PZV for the first stage lifted.

Underlying causes

Incident 1

- Heat generation in the starter element while starting air compressor B.
- More frequent starts of air compressor B before it stopped completely.
- Inadequate procedure for operating the air compressor.
- Repeated tripping of the air compressor because of high air outlet temperatures.
- Leak in the air compressor cooler.
- Inadequate reporting of faults through maintenance notifications.
- Inadequate risk assessment/change management.

Incident 2

- Short-circuit in the starter element.
- Arcing deposition between phases in vertical busbars.
- Wrong method used to clarify the switchboard.
- No account taken of poor isolation measurements.
- Decision to restore power after consultation with land.
- Inadequate risk assessment/change management.
- Need to get auxiliary systems from switchboard B back on line.
- Maintain ability to keep the platform in a safe condition.
- Inappropriate use of isolation carpets.
- Inadequate risk assessment.

Incident 3

- The gasket on the PZV is assumed to have been unsuitable.
- Varying practice for use of gaskets.
- Sealing not fixed to the valve body.
- Inadequate design from supplier.
- Overpressure of first stage.
- Depressurisation of pipeline by using first-stage separator.
- Manual depressurisation of pipeline.
- Process shutdown with immediate reset.
- Air compressor A tripped.
- Damaged Profibus cable.
- Inadequate risk assessment/change management.

**Lessons and recommendations**

- Reduce the probability of pressure alarm low level (PALL) for instrument air.
  - Assess converting the instrument air compressors to three *50 per cent systems with
    - a robust power supply system
    - soft start for at least two of the compressors
    - a minimum of two coolers in the system
    - the control system with accompanying alarms should be located in the central control room (CCR), and start/stop of compressors must be available from the CCR.
  - The organisation must clearly define what constitutes operational disturbance/deviation. The OIM must report back that the concept of operational disturbance/deviation is understood by all shifts.
  - Procedure for compressed air should include starter restrictions for the compressors.
  - The causes of systematic faults have not been found. Recommend appointing a work group to identify the root cause in order to prevent similar incidents in future, since instrument air is significant for operation of the installation.

- Reduce the probability that safety systems are circumvented without adequate compensatory measures.
  - Drill on scenarios with loss of instrument air.
  - The procedure for depressurisation should be updated so that it includes unplanned shutdowns where insufficient time is available to depressurise or inhibit MEG. Action to be taken to avoid major consequences must be specified.
  - Compensatory measures for disconnecting the deluge system must be similar to or better than if the system is not disconnected.
  - All valves in the deluge system should be tagged to be included in the preventive maintenance program
  - Air leaks in the deluge system should be identified and improved.
  - Investigate whether faults exist in output signals on pressure relief valves and/or consider ensuring an understanding of the functions of pressure relief valves and other similar valves with an eye to mode errors.

- Electrical
  - Clarify roles and responsibilities for electrical systems up to the platform management.
  - Consider installing short-circuit protection to the 690V switchboard in order to minimise disconnection time.
  - Consider installing arc protection in the 690V switchboards.
  - Assess capacity in similar starter elements.
  - Give special consideration to upgrading the starter elements for air compressor A.

- Review the impact of unauthorised changes and the consequences these could have. Take this up with all shifts and with the project organisation.

- A procedure/plan should be drawn up to permit dealing with the loss of anchor winches for more than six hours (beyond next weather window).