Incident description: gas leak 2017

A diffuse gas leak from an instrument connection to a pressure transmitter (45 PT 003) in the fuel gas system was to be repaired. In connection with approving the work permit, it was decided that the job could be done by closing one valve and that no isolation plan was therefore required. The area operator and automation technician conducted a toolbox talk in the control room. A check was made with the engineer for safety and automation systems to confirm that the work could be done without disrupting fuel gas regulation. Step-by-step communication between the workers in the field and the control room was agreed, so that the latter could monitor the position and intervene if fuel gas was disrupted.

After their talk in the control room, the area operator and automation technician went into the field. The plan was to repair the leak by opening the connection, cleaning the thread on the nipple, installing new thread tape and reassembling. The pair ascended the scaffolding installed over the fuel gas scrubber, and verified the leak point with soapy liquid. Four parallel shutoff valves were installed next to each other. These lacked their own valve tag number, but were labelled with the tag number for the instruments as shown in the diagram below. The instrument tube to the pressure transmitter was lagged together with three other pipes, as shown in the photograph. That made it impossible to follow the instrument tube to be worked on physically from the shutoff valve on the fuel gas pipeline to the instrument cabinet for the pressure transmitter. Both operator and instrument technician checked that the tags on the valve wheel and in the pressure transmitter cabinet corresponded, and confirmed with the control room that they had checked and verified the correct shutoff valve for the work. However, they were not aware that two of the tags had been swapped when the plant was built.

The area operator reported by walkie-talkie to the control room that they were ready to start shutting off to the pressure transmitter. The control room confirmed that it was OK to shut off and asked to be informed when this had been done. The operator then closed the valve with the tag number for the pressure transmitter. Because of the erroneous tagging noted above, he actually closed the wrong valve. The work site therefore remained pressurised. The operator asked the control room to overbridge gas detection, since they were going to bleed off a little gas to the open air. There was a trapped gas volume of about 1.5 metres in an instrument tube with an internal diameter of nine millimetres and a system pressure of 37 bar.

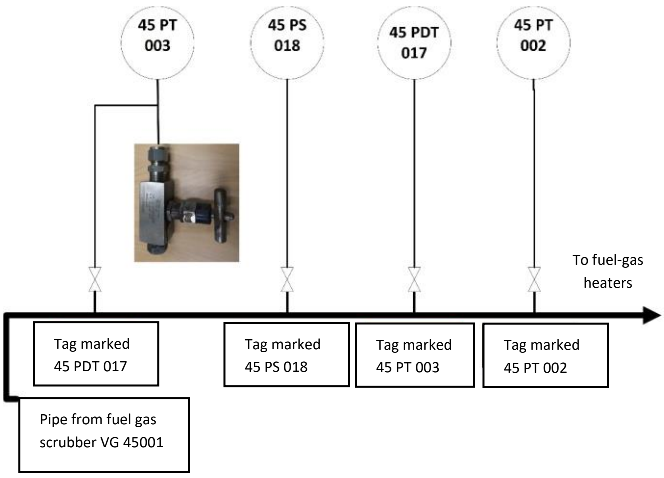
The control room overbridged shutdown from the gas detectors, which blocked opportunities for automatic alarm, shutdown, disconnection of ignition sources and initiation of water/foam deluge if gas was detected in the area. The control room confirmed that the operator could bleed off the trapped volume, and the operator notified the control room that they were starting to bleed off. It was decided to do this by unscrewing the nut on the instrument tube rather than using the bleed-off valve. The automation technician unscrewed the nut about half a turn, and they heard gas escaping. The automation technician further loosened the nut, with the result that the instrument connection blew off the instrument tube and the valve block was shot forward between his legs to land on the scaffolding below. Gas flowed very noisily to the air from the open end of the instrument tube.

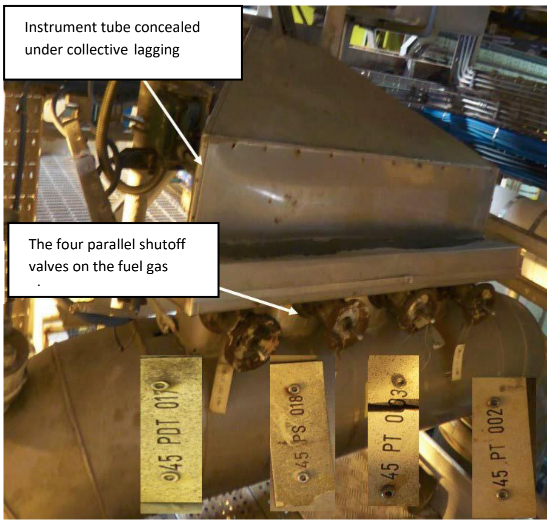
Two gas detectors activated in the control room with a red alarm at more than 20 per cent of the lower explosion limit (LEL), and the level rose rapidly. The two detectors were located about five metres from the leak point. The control room reported by walkie-talkie that it had received a gas alarm and asked if the two in the field had things under control or if emergency shutdown (ESD) should be initiated. The operator was understood to say that “the plug had blown off” and that gas was blowing. The control room heard a lot of noise over the walkie-talkie and perceived it as gas escaping to the air. The automation technician requested an announcement over the PA system that hot work should cease, and this was done.

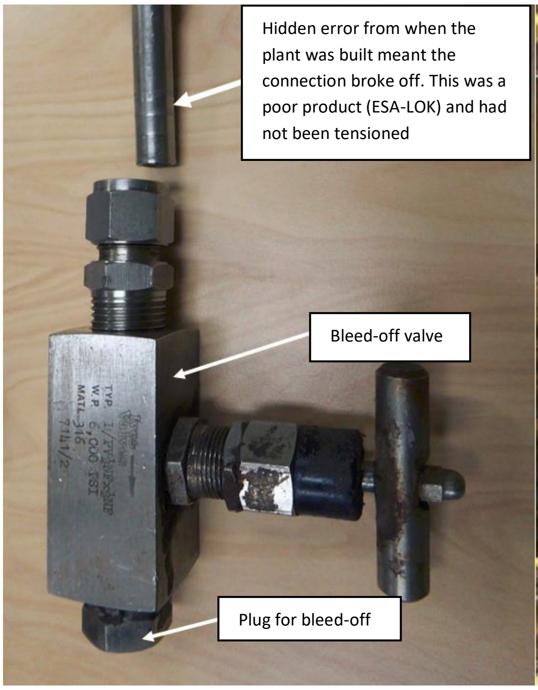
A third detector activated with a red alarm above 20 per cent LEL, and the level rose quickly. This detector was placed about six metres from the leak point. The operator and technician tried to exert more leverage on the shutoff valve they had closed earlier, but the leak did not stop. It was too noisy to communicate by walkie-talkie. They therefore descended from the scaffolding and walked a short distance away so they could communicate with the control room and explain what was happening. The control room asked again if they could shut off in the field or if ESD should be initiated. The operator responded that “there was nothing more to shut off”. The technician asked the control room to wait while they tried to close more valves first. The operator asked the control room if it was OK to shut off the other three valves installed in the same location. He wanted permission for this in order to avoid an unintentional shutdown because of disruptions to the fuel gas system. The control room gave the green light to close the other valves. “Close everything.”

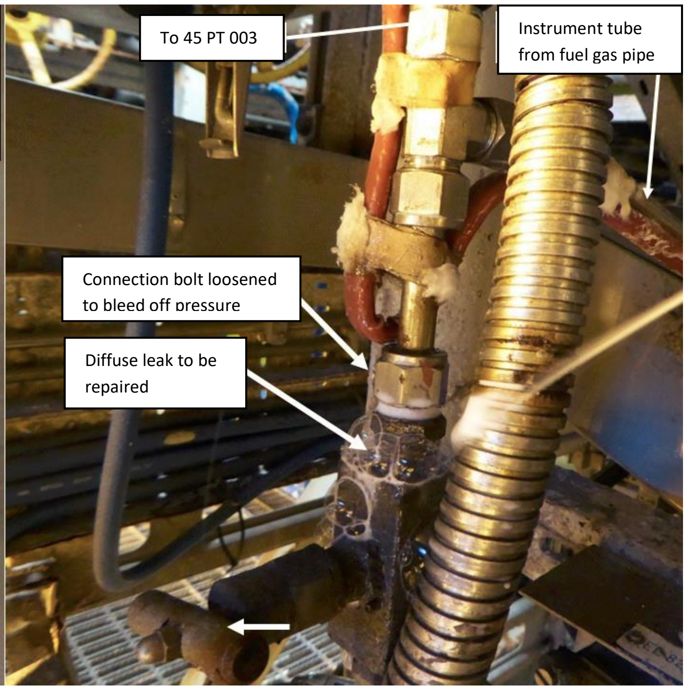
The operator in the field asked the control room to send out the process supervisor to assist. The control room observed that there were three detectors with red alarms, and that no other detectors were activating. It waited on events and did not initiate ESD, but called in the process supervisor and the operations and maintenance (O&M) supervisor. The process supervisor came to the control room and then ran to the relevant area. Another operator, who was in an office, heard there was noise over the radio and also ran to the area. The O&M supervisor came to the control room and was shown the three red gas detectors. He understood that ESD had not been initiated, and was told that those in the field were closing down manually. He discussed with the control room operators whether they should initiate ESD, and said this had to be done if more detectors were activated.

The operator and technician in the field ascended the scaffolding again. The operator began to close two of the valves, while the technician handled the third. Once the valve tagged 45 PDT 017 was closed, the leak stopped and the area operator reported this to the control room. The three gas detectors shortly returned to zero gas detection. The gas leak is calculated at 0.25 kilograms per second (kg/s) for three-four minutes. The flammable gas cloud could have extended over about 30 metres in the local area with flammable gas in the order of 16 cubic metres.









Causes

<u>Causes which contributed to the gas leak</u>

- No closure towards the work site because valves in the plant were incorrectly tagged.
  - Incorrect tagging when the plant was built.
- The instrument connection was of poor quality, insufficiently tensioned and came loose.
  - The connection was an ESA-LOK type. A number of problems have been experienced with this product, including leaks, and production has therefore ceased. Had the connection been the right quality and correctly tensioned, it should not have come loose.
- Work was conducted on the instrument connection under pressure.
  - The automation technician opted to bleed off the trapped pressure by unscrewing the nut on the connection even though the management system specifies that no work must be done on pressurised fittings and that the connection nut must never be unscrewed to release or bleed off system pressure. He was aware that this was not good practice nor in line with the training in the mandatory course on instrument connections. Good work practice would have been to screw open the bleed-off plug and bleed off the pressure in a controlled manner with the bleed-off valve. The area technician was also aware that the chosen method was not good practice.

The investigation team conducted an ABC analysis to understand this behaviour from the standpoint of those involved. This method builds on the fact that when rules are consciously broken, the position is often influenced by *antecedents* which activate such *behaviour* and by the possible *consequences* of such behaviour. The model assumes that consequences which are positive, which occur quickly and which those concerned are certain will happen influence human behaviour much more than possible negative consequences which are uncertain and occur later.

Antecedents: The automation technician was aware of the hazards and risks involved in the activity, but assessed the risk as small since he was convinced that the valve was shut off and that only a small trapped volume had to be bled off. He was aware that pressurised instrument connections were not to be bled off, but had found that no other option was available in many cases. Pressurised connections are then bled off as a silent nonconformity.

Consequences: The automation technician wanted to avoid extra work (positive, certain, immediate consequence). In his experience, the bleed-off plug has often been screwed tight and this occasionally causes the thread to shear. That would mean replacing the valve, which he wanted to avoid. In addition, doing it this way was simpler (positive, certain, immediate consequence), particularly if the bleed-off plug was stuck. The consequences of causing injury to himself or others or of causing other types of loss or damage were negative and uncertain, and thereby carried less weight in the decision.

To sum up, bleeding off the limited volume was regarded as low-risk. The area operator could have stopped the technician when he wanted to blow off pressure in the instrument connection, but hesitated to do so because he regarded his colleague as the specialist in this area.

<u>Causes which contributed to ESD not being initiated</u>

- Transfer of responsibility for safety-critical jobs when disconnecting the safety system.
    - When safety systems are overbridged, a safety-critical job is transferred from the control system to individuals or teams. In this case, the safety-critical job was monitoring gas detection and activating barrier functions when gas was detected. A performance requirement was that ignition sources should have been disconnected on gas detection (single detector above 20 per cent LEL). Another was that ESD should have been activated on confirmed gas detection (two detectors above 20 per cent LEL). That would have activated alarms in the area, a general alarm, shutdown of the process plant and initiation of water/foam deluge in the area. In this incident, confirmed gas existed for three-four minutes without disconnection of ignition sources or ESD initiation.
- Position assessments and decisions.
    - For those involved, things changed suddenly from normal conditions to an unexpected event. Within a few minutes, they had to seek to understand and assess the position continuously on the basis of the information and sensory impressions they acquired, make decisions and take action. The position was affected by varying conditions and acute stress factors.
- Personnel in the field wanted to try to halt the leak.
    - The leak arose unexpectedly, and it was initially difficult for the two in the field to grasp and interpret the position. They quickly decided they had to halt the leak. The noise level was high, but no smell of gas or visible gas cloud. The original job plan and a desire to avoid shutting down the facility took precedence over their own safety and the requirement to request that the control room initiated ESD.
- The control room postponed the ESD decision to give time to halt the leak.
    - The control room contacted the operators in the field by walkie-talkie as soon as the gas alarms had been received. It checked whether they were in control or whether it should initiate ESD. It was clear that gas was escaping to the air, but it was difficult to grasp and interpret the cause. Several factors contributed to the failure to shut down, including the fact that those at the work site asked the control room to wait, concerns that those on the scaffolding could fall off if deluge was initiated with ESD, the original job plan affected attention, a desire to avoid further escalation by shutting down the facility and associated fields, and a lack of training in such critical decisions since ESD normally happens automatically and no training or courses had been provided for dealing with stressful conditions.
- The control room did not activate disconnection of ignition sources.
    - The automation technician in the field asked the control room to announce a halt to hot work when the leak occurred, and this was done. Ignition source disconnection would normally have occurred on gas detection (single detector above 20 per cent LEL).

Overbridging prevented this happening. Ignition sources could have been disconnected manually from the control room, but this was forgotten in the hectic conditions. The fact that such disconnection is normally automatic increases the probability that it will be forgotten under stress, in that operators do not train normally and in everyday conditions on making assessments and taking action related to ignition source disconnection.
    - The O&M supervisor postponed a decision on ESD. Together with the control-room team, he set a limit for the position by deciding that the control room had to initiate ESD if more detectors activated. However, the leak was shut off and stopped less than a minute after he entered the control room and no more detectors were activated.
- Organisational effect and risk control when overbridging gas detection.
    - The management system specifies requirements for measures to be taken in connection with planned or anticipated weakening of safety systems. The basic principle is that safety systems may not be weakened unless compensatory measures are taken which ensure a prudent level of safety. The process provides in part for brief disconnection of detectors for routine drainage/blowdown by area operators. That means the company permits responsibility for safety-critical barrier functions to be transferred from an automated control system to operations personnel. This responsibility could lead to conditions requiring decisions which are difficult to handle.
    - When a planned operation involving disconnection of gas detection actions changes from a normal condition to circumstances which are out of control and involve gas leaks, assessing the position and taking decisions are demanding for those involved – particularly if the team has not trained on dealing with such challenges. Courses on mastering stress have earlier been conducted for control room personnel, and the latter have called for such training. As far as the investigation team is aware, such courses have not been provided in recent years.

Lessons learnt and recommendations

- Review performance requirements/requirements for manual actions in conditions involving confirmed gas detection with personnel on every shift.
- Where work requires a permit: criteria for activating ignition source disconnection and ESD in the event of gas detection must always be entered on the permit and reviewed during the toolbox talk in the field and in the control room when gas detection is overbridged for an area/module.
- Where operational overbridging is done without a requirement in the work permit: criteria for activating ignition source disconnection and ESD in the event of gas detection must always be reviewed during the toolbox talk in the field and in the control room before gas detection is overbridged for an area/module.
- Develop and implement a course for control-room operators.
- Prohibit work on pressurised fittings – ensure conformity with consistent practice across shifts, as well as precautions where the plant has not been built with bleed-off points and nonconformity is therefore necessary to carry out the work.
- Measures to ensure conformity between the plant as built, drawings and markings in the field.
- Secure an overview of where ESA-LOK fittings could still be found, inform automation and operational personnel about the risk associated with this type of fitting, and replace them during planned interventions.