2018-D: Crude oil entered the service water system when using a hose

A crude oil heater was to be readied after maintenance. Blinds were reversed three days before the incident, and the blind list was verified by an operator. On the day the incident occurred, the day shift had planned to conduct a leak test of the crude oil heater but did not have the time to do so because of an ongoing partial shutdown of a compressor train. During the handover, the day shift sought the night shift's help to fill the heater with water so that the day shift could later apply heat and leak-test the flanges.

An operator on the night shift checked the isolation plan, located the heater in the field and decided to start water-filling while doing another job in an adjacent area. Both the isolation plan and the valves checked by the operator indicated that the heater was depressurised. The operator connected a fresh-water hose and turned on the service water supply to flow to the heater. A gas detector was immediately activated in another module. The operator closed the valve and disconnected the hose. Oil emerged from the hose and the operator informed the central control room (CCR) that the job he had been doing was the cause of the alarm. At the same time, more gas detectors activated and a general alarm was initiated with consequent mustering.

It transpired subsequently that about 25 bar of pressure had built up in the heater over the three days since the blinds were reversed. When the eight-bar fresh-water hose was connected and the valve opened for water-filling, unstabilised crude flowed into the service water system and up into the module where the gas alarm was activated. Gas escaped to the air via a high-pressure washer.

The initial leak rate is estimated at around 2.8 kilograms per second, of which about 2.6 kg/s was oil and roughly 0.2 kg/s gas. A total of 480 kilograms of hydrocarbons are estimated to have escaped during the incident. The leak lasted an estimated three minutes or so. Table 1 presents decisions and action which combined to cause the incident.

Table 1 Decisions and actions which combined to cause the incident.

No	Barriers which failed	Explanation
0	Inadequate implementation of new internal company requirements	Check valve not mounted on fresh water outlet
1	Job which required continuity was interrupted	It was decided to pull the blinds on the heater before starting a partial shutdown of the compressor train. No priority was given to conducting a leak test of the flanges immediately afterwards
2	Inadequate quality in handover between shifts	The day shift decided to ask the night shift for help to initiate water filling of the heater. The day shift had postponed this for several days because the compressor shutdown involved a lot of work. That three days had passed since the blinds were pulled on the heater was not communicated or flagged as a risk at the handover
3	Insufficient history for planning and executing job	The night-shift operator decided to initiate water-filling of the heater in parallel with other jobs in order to assist the day shift. He regarded the job of filling the heater with fresh water as minor and uncomplicated
4	Inadequately updated valve list gave wrong information about valve status	Valves for the instrumentation had been operated during maintenance or in connection with reversing the blinds. The new valve status was not shown by the change log in the isolation plan or marked in the field
5	Inadequate status check meant valves in the wrong position went unnoticed	The operator decided to check two blowdown valves to verify the system status, but both were in the depressurised segment of the instrument tubing and 25-bar oil in the heater was not noticed
6	Guidelines on using check valve when connecting systems were not observed	The operator decided not to install a check valve on the hose at the connection point to the heater because the system was assumed to be completely depressurised

Causes

<u>Direct cause</u>

Unstabilised oil entered the service water system and escaped to an unclassified area via a high-pressure washer.

<u>Underlying causes</u>

1. **It was not known that the crude oil heater had a pressure of up to 25 bar**
   - *Three days passed between pulling the blinds and starting the leak test*: A leak test should normally be performed immediately after mechanical completion and under observation.
   - *Leak testing was not conducted because a partial shutdown was given priority for the use of resources.*
   - *Management concentrated on completing heavy mechanical work on the heater before starting a partial shutdown.*
   - *Lack of attention paid to postponement of part-activities which are normally done in sequence:* Leak testing was not done because a partial shutdown was given priority for the use of resources.
2. **Fresh-water hose was connected to a pressurised crude oil heater**
   - *The heater was assumed to be depressurised:* The preparations made by the operator before admitting service water to the heater gave the operator the impression that the heater was fully depressurised.
   - *Inadequate checking of valves upstream from the blowdown point (local line-up):* If all the valves upstream from the blowdown point (local line-up) had been checked, the operator would have seen that several of them stood in the wrong position compared with the isolation plan. The pressure in the heater would then have been discovered.
   - *Valves were operated without this being shown in the isolation plan or marked in the field.*
   - *Inadequate preparation, updating and use of the isolation plan:* The isolation plan did not include all the valves which were significant for the plan's function. Valves not included in the list but which had been operated were not specified. These should have been added to the valve list and marked with their correct status.
   - *Unclear requirements and guidelines in the work process for normally pressurised systems:* The work process for normally pressurised systems is unclear about which valves should be included in the isolation plan. This could have been a contributory reason why valves upstream from the blowdown point were not specified in the isolation plan.
   - *Insufficient history for planning and executing the job:* The operator wanted to assist the day shift after handover with leak testing the heater, but did not know that it was three days since the blinds were pulled and therefore did not expect any pressure buildup in the heater. The operator chose to start water-filling the heater in parallel with another job, since he regarded this as minor and uncomplicated.
   - *Inadequate information at handover between day and night shifts:* Challenges with leaks in input and output valves on the heater were specified in the operations log three and five days earlier. It is unclear whether/how this was communicated/grasped at the handover, together with information that three days had passed since the blinds were pulled.
   - *Inadequate attention paid to the postponement of part-activities normally performed in sequence:* The risk of pressure buildup in the heater was identified and known to everyone involved in the job earlier. If more attention had been paid to the three-day delay since the blinds were reversed, the operator would have expected the heater to be pressurised. This would probably have prompted him to check the isolation valves upstream from the blowdown valves more carefully, since the blowdown valves showed no pressure.
3. **No check valve was installed**

- *Inadequate implementation of new requirements:* When the operator connected the fresh-water hose to the heater, a check valve should have been installed as a secondary barrier on the hose where it connected to the heater. A new internal guideline for hoses and couplings was published in the management system earlier that month. The recommendations in this document are that a check valve must always be installed when connecting a low-pressure hose to a depressurised hydrocarbon system where a threat of pressure buildup exists. The guidelines also specify that the check valve installed between the utility hose and equipment with a higher design pressure should have an adequate pressure rating and blowdown. If a hose is used between the check valve and the process equipment, it must also have an adequate pressure rating. Since check valves never provide a complete seal, it is important not to rely on such valves as a long-term barrier.

Lessons learnt and recommendations

1. **Ensure that sufficient attention is paid when postponing jobs normally carried out in a close sequence**
   - *Postponing activities normally carried out in close sequence must be risk-assessed and given attention:* The risk must be made clear to everyone involved (on the noticeboard, for instance), and steps must be taken to reduce possible consequences (possibly by monitoring in the field). It must be ensured that a leak test is conducted as soon as possible after reversing to avoid leak testing with hydrocarbons when nobody is monitoring the job.
   - *The company's computer programme for following up work permits treats valve and blind lists as two separate systems:* After pulling blinds, steps must be taken to ensure that individual valves and process safety functions are set in operational condition (pressure safety valves and pressure monitoring, for example). The valve list must always therefore be approved immediately after the whole blind list has been reversed.
   - *Ensure that experience from this incident is taken into account in further development and implementation of the company's computer programme for following up work permits:* Special emphasis should be given to tailoring the tool to ensure that equipment and systems are in safe condition in all phases of isolation plans and that process safety for partly reversed systems has been taken care of.
2. **Ensure identical practice and safe use of check valves across installations and shifts**
   - *Make internal guidelines for hoses and couplings known in the organisation:* The recommendations in the guidelines are that a check valve must always be installed when connecting a low-pressure hose to a depressurised hydrocarbon system where a threat of pressure buildup exists. Use this and similar incidents to discuss how applying the guidelines could have prevented them. Establish a practice and a harmonised use of temporary check valves.
   - *Assess the installation of check valves on all outlets at utility stations.*
3. **Ensure organisational redundancy by reinforcing the established pattern of collaboration**
   - *Conduct a workshop/review with the operators in operations and discuss how to achieve good quality and structure with the information flow at personnel and shift changes:* Discuss measures for achieving even better collaboration by using leaders, colleagues and discipline managers for advice, correctives and checks.
4. **Review the work process for normally pressurised systems and assess whether it could be made clearer and function to a greater extent as a good aid for the operators**
   - *Clarify the procedure for producing an isolation plan by specifying that all valves with significance for the isolation plan's function (such as isolation valves upstream from the blowdown valves), including drain points, hose connections, siphon breakers and all other relevant information (such as leaking valves), must be entered in the plan.*

- *With more extensive maintenance and maintenance on hydrocarbon systems where equipment is to be opened, requirements should be specified that the isolation plan should contain a plan for leak testing:* Choosing the method for the leak test should also be described.
- *The investigation team takes the view that checks should also be required to ensure the system is in safe condition at all the various phases during reversing, such as preparing and executing a leak test:* After pulling the blinds, the system is partially reversed and a risk of internal pressure buildup exists. It is therefore important that certain valves and process safety functions are set as operative (pressure safety valves and pressure monitoring, for example).

5. **Ensure shared understanding of how, and with what medium, the crude oil heater is to be tested**
    - *Seawater, service water and nitrogen are all mentioned:* Many people believed it was best to use seawater, but this can create problems with scale and corrosion challenges.