Incident

Managing the risks of stored energy – always expect the unexpected.

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Summary

Stored energy has a habit of catching us out. We instinctively perceive operating equipment as hazardous and stopped equipment as safe. We direct our attention to handling flammable or toxic substances and view inert substances as harmless.

Three people were injured, two seriously when hot water condensate was released whilst preparing a non-return valve for maintenance. The method used to verify the system's safety created a strong-but-wrong indication that there was no stored energy in the system, erroneously suggesting it was safe to break containment.

Keywords: Stored energy

Hazards of stored energy

We may encounter potentially hazardous stored energy in many places. Spinning flywheels and springs or cables under tension can be a source of mechanical energy. Batteries and capacitors may hold hazardous electrical charge. Hot water and steam, and non-hazardous gases including air and nitrogen under high pressure can be very hazardous. Hydraulic systems can be held at very high pressures (several hundred bar) and hydraulic injection injuries can be horrific (images on Google of these injuries is blurred out by default as potentially explicit).

Common accidents

Some accidents occur fairly frequently due to releases of stored energy whilst performing routine tasks.

Hose whip injuries when disconnecting a flexible hose can be fatal. Well designed connection rigs with a depressurisation facility and reliable gauges should be a requirement, with whip checks as an additional control.

Releases of pressure when removing blank flanges can lead to technicians being sprayed with chemicals or hot fluids. Valves only need to pass a very small amount to allow full plant pressure to be built up between the blank flange and the closed valves. Bleed valves and/or vented blank flanges can be used to confirm there is no pressure before the joint is broken.

Even a small release of energy can be hazardous if it is unexpected and startles the technician, especially if they are working at height.

Good practices

Lock-Out Tag-Out Try-Out (LOTOTO) is a safety procedure for ensuring that hazardous equipment has been properly shut down and made safe before work can take place. Locks and tags are used to prevent hazards being reintroduced after preparation is complete and the Try-Out stage is verification that preparation has been successful. However, the case study below will illustrate how this can fail if the sequence of steps required to prepare equipment are not completed and in the correct sequence.

A 'First Break' procedure should be followed when breaking containment on any system that handles hazardous substances and/or conditions. It should ensure only people essential to the task are in the vicinity and that they are protected against the potential hazard (including the use of appropriate Personal Protective Equipment). Wherever possible, the break of integrity should be carried out in a way that can be recovered if a hazard is discovered (e.g. partial unbolting that can be reversed) and ensuring people are not in the 'line of fire'. Someone from the operating team should physically inspect the equipment immediately before containment is to be broken to ensure all preparations have been completed correctly.

Case study

Rye House power station uses combined cycle gas turbine technology to generate megawatts of electrical power. On 23 January 2009 three people were badly burned by a release of hot steam condensate when a valve was being prepared for maintenance. One casualty suffered life-threatening injuries.

This accident summary is based on details presented in a video created by ScottishPower and widely circulated to employees, contractors and industry colleagues.

Timeline

The power station was being shut down for maintenance on the gas supply pipeline. The opportunity was used to progress maintenance in other areas, including repairs to a non-return valve on the discharge side of a high-pressure condensate recirculating pump. This required the system to be isolated and drained. Access to the valve was by scaffolding erected at a height of approximately 3 m.

- **9:42 p.m (22 January — night before the accident):** Station shuts down and preparations begin for the following day's maintenance. A team was tasked with isolating and draining the system to make it safe for the planned

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maintenance. Information was provided to them in shift instructions and a detailed drainage schedule.

- **2:30 a.m.:** It became clear that the pressure was not decaying quickly enough for preparation work to be completed by the end of the night shift. Consequently, the system would be handed over in a partially isolated and drained state.
- **6:00 a.m.:** The day shift arrives to receive a handover. At this time the system pressure was 3 barg.
  The drainage schedule was referred to during the handover. It had been marked up with a highlighter pen and some handwritten notes. Two sets of valves remained to be open. The first was the group of drainage valves that the night shift had been unable to operate. The second was a pair of 'tell-tale' valves that would provide visual confirmation that the system had been fully drained. The shift instruction stated that these could be opened when the boiler pressure had fallen to 2 barg.
- **7:10 a.m.:** The pressure had fallen below 2 barg. This was taken as a cue to open the tell-tale valves.
  When the tell-tale valves were opened a small amount of steam was observed to flow to drain, which quickly stopped. This created a strong-but-wrong indication that the whole system had been drained and depressured successfully. However, this was not the case because the group of drainage valves were still closed, which meant the tell-tales were isolated from the main system.
  The day shift team leader visited the site and inspected the telltale valves. Seeing no steam or water he assumed that the system was in a safe state for maintenance to commence.
- **9:40 a.m.** A permit for work was issued to the maintenance team member for the valve repairs.
- **3.40 p.m.** Two contractors, working from the scaffold, started to break the pressure seal on the non-return valve. Suddenly hot condensate escaped from the seal and engulfed both men.

Consequences

One man was able to escape from the scaffold, but his colleague was not. Another contractor from the same company witnessed the incident and went to rescue his trapped colleague.

First aiders rushed to the scene and emergency services were called. A paramedic was on site within 20 minutes followed by the first ambulance a few minutes later.

The more seriously injured man had to be rescued from the scaffold using a mobile elevated working platform. All three men were taken to hospital. The man who had been trapped on the scaffold received 60% burns and spent several days in a critical condition on a high dependency ward. Thankfully he pulled through, but he spent six weeks in hospital. His colleague who had been working with him on the scaffold received 26% burns and was hospitalised for two weeks. The third man who went to the rescue of his colleague was allowed home after treatment that night.

Investigation

An internal inquiry found the cause of the incident was a failure to drain the discharge side of the high-pressure recirculating pump where the non-return valve was situated. This occurred due to communication errors from night to day shift that meant the status of the system's drains valves was misunderstood. Whilst the status was indicated on the drainage schedule, use of a highlighter pen and hand-written notes may have contributed to the error.

Inexperience of the maintenance personnel also contributed. They interpreted the small steam flow from the tell-tale valves as a positive sign that the stored energy in the system (hot condensate) had been removed. However, they should have first seen a quite significant flow that subsided as the residual 2 barg pressure decayed.

Conclusions

The hazards of stored energy can be easily be overlooked. Even when recognised, the indications used to verify system safety can be unreliable or prone to misinterpretation. It is always inherently much safer to work on systems after eliminating all potential hazards, including stored energy. If this is not considered at the design phase it may be difficult to achieve or confirm reliably.

Good procedures for removal of energy and personnel who understand the hazards and how they are controlled are essential for managing residual risks. Communication errors can significantly contribute to these risks, as common place administrative controls such as permit to work and lock-out tag-out may inadvertently reinforce errors due to the high regard in which people hold them, making individuals less inclined to question or challenge their effectiveness.

systems and procedures

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