Testing safety valves

Following an incident involving a major steam release after safety valve testing at a UK coal-fired power station, new guidance has been issued. Alan Fitzpatrick explains

Late in 2006, an RSA (Royal & SunAlliance) engineer surveyor was involved in the testing of safety valves at a coal-fired power station on a boiler return service. After testing was complete, a major failure occurred on the plant. The engineer surveyor, the station engineer and an engineer from the safety valve test company were enveloped in a huge steam cloud. Unfortunately, the engineer surveyor and safety valve test engineer were seriously hurt.

This horrific incident led to a major review of the risks associated with safety valve testing. Its objectives were to establish current practice in the UK power industry for main boiler safety valve testing, and to determine better, more appropriate, testing methods. The review also needed to take into account the age and condition of the UK power station fleet, noting that the coal-fired plants were well beyond the design lifetime set by the original manufacturers.

When the review was complete, it would issue guidance to the power industry and competent persons involved with power stations to foster a common standard throughout the industry. During 2007 and into 2008, no fewer than 38 major power stations were surveyed for the review, which was carried out by RSA engineer surveyors, with the help of E.On, RWE, Scottish & Southern, Furminate and Seetru – and the following represents some of its key findings.

Stepping back a moment, all pressure plant, whatever its function, is designed with safe operating limits (SOLs), which for new power station boilers invokes design codes such as EN 12952 Water Tube Boilers and Auxiliary Installations – the standard used in EU countries. As far as the UK is concerned, most coal-fired power stations were built to the earlier design code (now replaced) BS 1113, Specification for design and manufacture of water tube steam generating plant.

Hydraulic test equipment in place, ready for testing the safety valve

Safe operating limits

In both cases, SOLs for a power station boiler mostly concern pressure, temperature, plant cycles and creep life – and plainly the manufacturers' design values must, in theory, not be exceeded. That said, the manufacturer builds the boiler in accordance with the design code, so that it is safe to operate and protective devices, such as safety valves, are fitted to prevent operating conditions leading to the design values – in this case, pressure – being exceeded.

The manufacturer then provides the user with information on how to operate the plant within the design limits, as part of which the protective devices, including safety valves, need to be regularly overhauled and tested to ensure effective operation and correct setting.

How frequently safety valves should be tested is detailed in the owner's Written Scheme of Examination, drawn up by the competent person, as required under UK legislation (Pressure Systems Safety Regulations 2000, for safety valves). For a small boiler, this interval is typically 14 months, while for safety valves on large coal-fired power stations the period is 50 months, with a 25 month mid-term test to prove that operation of the valve continues to be effective.

At the time of this incident, when it came to the 50-month thorough examination of the boiler, the safety valve was normally overhauled by the manufacturer, under a full QA (quality assurance) programme. This was to ensure that the condition of the valve and its components was known at the strip-down stage, and to determine which components needed to be changed for the rebuild. The valve was then assembled and cold set at the boiler SOL. When the boiler was returned to service, the safety valve would be live tested as soon as possible, to cater for the fact that it had different properties when hot compared to cold – so needed to be reset to lift at the correct pressure.

Valve testing problems

Prior to the 1980s, safety valves where floated by over-firing the boiler to raise the pressure and thus test the safety valve. This method had a number of advantages, but the most significant disadvantage was that the safety valve sealing faces could become badly damaged by particles picked up by the steam and deposited on the seat faces. This meant that the valve would not seal correctly, leading to leaking steam, causing further erosion on the seat sealing faces and ultimately an early requirement for overhaul.

In the 1980s, however, a company called Furmanite developed hydraulic pull and emergency shut test equipment called Trevi test, which enabled safety valves to be tested at 90% of the safe operating limit. It meant a very quick lift, compared to the old live test, and the boiler no longer had to be raised to maximum pressure – with the added benefit that damage to the safety valve seat faces did not normally occur.

Under this regime, standard practice was for the engineer surveyor, station personnel and the safety valve tester to be next to the safety valve under test to observe the lift and note the readings. On the day of the incident, however, failure of a major component on the boiler itself allowed water to flash off to steam at very high temperature and pressure – with steam quickly and completely filling the main boiler house (comparable in size to the Houses of Parliament in length and width, and to the full height of Big Ben).

In effect, the boiler house became a confined space, not helped by the steam making it impossible for the engineers to see clearly to escape the steam clouds and get to the safety exits fast.

The review recommended several key changes to improve current practice:

- Lighting should be improved in the boiler houses; it had previously been limited to conserve power and reduce maintenance
- The escape routes should be clearly marked, probably by special coloured paint, visible in an emergency situation. Several stairways in boiler houses lead only to boiler parts to be operated, and do not provide escape routes
- The safety valve test equipment should be moved as far away as possible from the boiler. One method would be to increase the length of the hydraulic hoses on the testing equipment, typically doubling the existing test length. The calibration gauge may also be replaced by a pressure reading device, to be read remotely
- Operation of the safety valve should be monitored by remote camera, rather than by personnel nearby
- Prior to any testing, all other non-essential personnel must vacate the boiler house
- People conducting the test should be shown the main escape routes. Incidentally, previous risk assessments had concluded that the risk was to personnel getting into the boiler house during the test, so some escape doors were locked
- Use of the Trevi test method was still best practice and would be recommended. A number of companies now provide this service. However, if the safety valve design or vent pipes have been altered, a full lift over-pressure test will be required.

RSA presented its conclusions at the SOE/IMechE power industry conference in November last year and has since gone on to up-date all RSA engineer surveyors at a recent power station safety training seminar. PE

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Superheater escape pipe flange for a safety valve, showing typical defect. Under legislation, no inspection is required, since it is part of an open vented line – but no engineer would want to be near, if it failed

Pointers

- Lighting must be improved in boiler houses
- Escape routes must be clearly marked with paint
- Safety valve test equipment must be as far as possible from the boiler
- Operation of the safety valve should be verified by remote camera
- Prior to testing, all non-essential staff must leave the boiler house
- People conducting the test must be shown the escape routes
- Use of the Trevi test is still best practice