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GUILD OF CLEANERS AND LAUNDERERS

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WATER HAMMER IN A PRESSURISED STEAM SYSTEM

Recently three people were injured following a release of steam, not in a business related to our industry, and investigations are ongoing, but early indications suggest a failure in the pressure boundary of the steam system, potentially caused by a water hammer event.

Water hammer is a known vulnerability in steam systems, and this is sometimes referred to as 'Condensate Induced Water Hammer'. It most commonly occurs when steam is introduced into cold pipe-work that has not been sufficiently drained. As the steam cools, it turns into condensate which takes up less volume in the pipework than the steam. This produces a vacuum or pocket into which the water rapidly flows, creating an impact against the pipework. Water hammer can occur when steam flow increases, but you should also be aware that condensate induced water hammer also occurs with a relatively steady flow of steam.

Duty of care holders should remind themselves about this phenomenon in steam systems and ensure suitable measures are taken to prevent the occurrence of such events, including the appropriate operation and maintenance of such systems on their sites.
HSE recommends a 5 point action plan this includes taking into account the following:
1. Enhanced training of boiler operators;
2. Slope of pipework and drainage;
3. Positions where condensate could collect;
4. Operation of traps;
5. Isolation valves.

Pressure Systems Safety Regulations 2000 (PSSR) - By law, Duty holders have a number of responsibilities under the Pressure Systems Safety Regulations (PSSR) 2000, including the following related to Operation and Maintenance: which are **Regulation 11 – Operation, Regulation 12 – Maintenance**

Effective maintenance is essential to prevent condensate induced water hammer. The maintenance routine should include any steam traps in order to avoid condensate build up, and thus reduce the likelihood of condensate induced water hammer occurring.
Causes of Water Hammer - Water hammer is most frequently caused during the introduction of steam into cold pipework that has not been sufficiently drained. It may happen as follows:
Condensate Driven by Steam - When steam is admitted via an isolating valve into cold pipework containing water, the steam - which is travelling faster than the water - causes the water to form a plug which is accelerated along the pipework until it meets the next downstream closed valve or obstruction. The water hits the closed valve or obstruction like a hammer and rebounds back within the pipework into the vacuum.
Condensate Moving into a vacuum - When steam is admitted into a cool space, or if it is in contact with water, it may condense rapidly and create a vacuum. If the steam has been trapped *eg* against an isolating valve - condensate may be drawn into the vacuum at a speed high enough to deliver a hammer blow to the valve.
The speed at which an isolation valve is opened in order to introduce steam into cold pipework is instrumental in dictating the likelihood of creating water hammer; should the isolating valve be opened too quickly without allowing the cold pipework to warm through gradually - there is a high risk that water hammer will result.

If an isolating valve is manufactured from a brittle material - such as cast iron - any resulting water hammer is highly likely to cause the valve to shatter with the potential to cause severe, even fatal injury to the valve operator and any other personnel in the vicinity.

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Another factor contributing to the increased number of water hammer incidents is the change being adopted by companies in the operational cycle of boilers.

Instead of operating plant continuously - *ie* 24 hours per day, 7 days per week - it is now usual for boilers to be shut down overnight and at weekends; this necessitates more frequent warming through of steam systems and increases the risk of introducing steam into insufficiently warmed pipework.
The increased number of water hammer - induced valve failures has been recognised by the British Standards Institution - BSi; the technical committee responsible for creating and maintaining the Standard for Shell Boilers - BS 2790 - has introduced an amendment to that Standard which disallows the use of valves manufactured from grey cast iron.

The HSE Approved Code of Practice to the Pressure Systems and Transportable Gas Containers Regulations 1989 states that cast iron stop valves are not recommended.

In light of the above, and taking into account the firm stance adopted by HSE at recent prosecutions involving the failure of cast iron crown valves caused by water hammer, The authority strongly recommends the replacement of cast iron crown valves on steam boilers with valves manufactured from more ductile materials *eg* spheroidal graphite (SG) cast iron, or cast steel.

The first priority must be to remove the cause of water hammer; it is recognised however that this may not always be practicable and the fitting of valves of a more ductile material would reduce the risk of serious injury should water hammer occur.

To avoid the risk of thermal shock and reduce the chance of *water* hammer, boiler operators should be trained to warm through a system gradually; they should be taught to:

1. recognise the significance of loud banging noises from the system; and
2. take appropriate action should such noises occur

Ensure pipework has a suitable fall in the direction of the steam flow and that drainage points are situated at appropriate positions; in particular check that the system permits complete drainage when cold.
Under these conditions there will be no steam pressure to push condensate into the return system.

Reduce or eliminate points where condensate could collect - *eg* sagging lengths of pipework, vertical legs, changes of slope, dead ends, fittings in pipes *etc.* Where such features are unavoidable, fit suitable drainage.

Operation of Steam Traps - Maintain steam traps in accordance with the manufacturer's instructions and test them regularly to ensure they are operating correctly.

Steam systems may be fitted with automatic 'trapped' drainage arrangements suitable during normal operation; however **when a system has cooled down there can be up to six times more condensate remaining in the system** and automatic drains may not be able to handle this quantity of water. In such circumstances manual by-pass drains should be fitted, left open during the warming through stage and closed only when all water has ceased to flow from them.

Operators should be trained to operate manual by-pass drains correctly.

Isolation Valves - Ensure that suitable valves are fitted to permit gradual warming through of the system; automated warming through systems are available.

NOTE: Manual control of *power-operated valves* is *unlikely* to *be effective.*