potential hazards created by water hammer in steam systems
background

- Incidents involving water hammer in steam systems have resulted in serious and, in a number of cases, fatal injuries to operating personnel and others working in the vicinity of steam plant.

- A recent increase in the numbers of such incidents has been attributed in part to a reduction in the number of properly trained and experienced boiler operators and in part to a reduction in the levels of maintenance being undertaken on steam and condensate systems.

- This Factsheet has been produced as result of SAFed’s increasing concern about the potential hazards of water hammer in steam systems.

the 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:

a. 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 created by the condensing steam.

b. 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.

- 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.

reducing the known hazards associated with water hammer

- 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, SAFed 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.
a five point action plan to minimise the hazards of water hammer

• In addition to the precautions outlined in the previous section, the following basic steps are recommended:

**Enhanced training of boiler operators**
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:
- recognise the significance of loud banging noises from the system; and
- take appropriate action should such noises occur

**Slope of pipework and drainage**
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.

**Positions where condensate could collect**
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 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.*

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**conclusions**

• The Pressure Systems and Transportable Gas Containers Regulations 1989 place duties on designers, installers and users - as well as on competent persons - to ensure that steam systems are designed, manufactured, installed and maintained such that they can be operated in a safe manner.

• Reducing to an absolute minimum - as outlined in the Five Point Action Plan - the potentially lethal effects of water hammer, and replacing existing cast iron crown valves with valves manufactured from more ductile materials, will assist the duty holders listed to fulfill their statutory obligations.
The Safety Assessment Federation - SAFed - represents the interests of companies engaged in independent inspection and safety assessment of engineering and manufacturing plant, systems and machinery.