Lessons Learned Database
Individual Incident Summary Report

IChemE
Safety & Loss Prevention
Special Interest Group

Incident Title	**Steam Explosion During Valve Maintenance**	
Incident Type	Explosion	
Date	19th November 2013	
Country	Belgium	
Location	Antwerp, VAN	
Fatalities	**Injuries**	**Cost**
2	0	Unknown

Incident Description

Credit: TEAM® Industrial Services

Two technicians were re-injecting sealant into a leak-sealing clamp around the 400 DN (16" NS) 900# bonnet-to-body flange of a motorised valve in the circulating water circuit of the CCR Platformer steam generation system. The valve was in the open position with boiler water at 70 barg (1015 psig) and 290 °C (554 °F) flowing through it. The bonnet-to-body flange was a ring type joint (RTJ) and the clamp surrounding the joint was originally fitted in 2011.

Soon after the technicians started re-injecting sealant, all 20 of the 1½" chrome/moly steel (ASTM A193 Gr. B7) stud bolts securing the bonnet failed catastrophically causing the bonnet-motor assembly to separate from the body with great force. The sudden release of boiler water resulted in a boiling liquid expanding vapour explosion (BLEVE). The two technicians were killed.

Incident Analysis

Basic cause was stud bolt failure due to caustic stress corrosion cracking (SCC) and tensile overload (14 bolts severely degraded by caustic SCC).

Critical factors included: 1) Poor boiler water quality control since 2009 had caused several leaks in the steam generation system requiring installation of clamps to seal them, 2) The groove in the bonnet flange of the failed valve was too small so the ring did not fit properly and extra torque was applied to the bolts to create a parallel flange connection (increasing load and risk of galling), 3) Internal leakage between the bonnet flange and clamp assembly caused general corrosion of the stud bolts and a reduction in resistance to caustic SCC when this section of the circulating water circuit was taken out of service for several months in 2011 and 2012, leaving the valve under pressure at relatively low temperature (dead end), 4) When the isolated section of the circuit was returned to service in 2012, the boiler water evaporated, leaving a corrosive residue on the already-degraded stud bolts.

Root causes included: 1) Inadequate valve design or fabrication error (bonnet flange groove), 2) Inadequate monitoring and control of boiler water quality (frequent leaks, caustic residue), 3) Inadequate flange management procedures (documentation and communication of bolt torque history), 4) Inadequate risk assessment (condition of bolts, bolt torque load and spread), 5) Inadequate repair (bolts at leaking flanges not replaced before clamping).

Lessons Learned

1) Boiler water/steam leaks tend to concentrate caustic where evaporation occurs causing caustic stress corrosion cracking (SCC) of highly stressed bolts (caustic soda is used for pH control).
2) White crystalline deposits (caustic residue) on flanges and bolts in leaking boiler water/steam lines may indicate elevated risk of caustic SCC.
3) Injection of sealant into a leak-sealing clamp can increase tensile stress on stud bolts by 10 – 20%.
4) Leak-sealing clamps should only be installed as a temporary repair (use strong back clamps if bolt condition uncertain) and should be replaced by a permanent repair at the first opportunity (e.g. planned outage or turnaround).

More Information

1) "Accident Description & Lessons Learned", TEAM® Industrial Services, April 2014, Steam explosion during a re-injection into a leak sealing clamp.pdf (belgie.be).
2) "Steam Release", European Process Safety Centre (EPSC), Learning Sheet, December 2017, Flange Leakage (epsc.be).

Industry Sector	Process Type	Incident Type
Oil & Gas	Catalytic Reforming	Explosion
Equipment Category	**Equipment Class**	**Equipment Type**
Safety & Control	Valves - Actuated	Gate

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