

SYNOPSIS

(All times are UTC + 4)

During the late evening of 10 October 2003, two boiler, chemical cleaning specialists, one UK national and one Danish national, were preparing to examine the starboard boiler on board the LNG carrier *Hilli*. At 2200 a halogen lamp was placed inside the boiler steam drum. An explosion immediately followed, injuring both men. The UK specialist's injuries were fatal. The Danish specialist, although seriously injured, recovered 3 months later.

Hilli entered the Grand Bahama Shipyard Ltd at Freeport, Grand Bahama, on 4 September 2003, to undergo repairs to her starboard main boiler. The boiler had previously been damaged, twice before, following fuel-related explosions which were due to mal-operation.

Harris Pye Marine Ltd (HPML) of Barry, South Wales was contracted as the boiler repair specialists. They had good knowledge of the ship, having carried out previous work on board. As part of an extensive boiler tube replacement programme, HPML sub-contracted the post-repair chemical clean of the boiler to Mr Derek Walton, a chemical cleaning specialist well known to HPML. Mr Walton had earlier, chemically cleaned the boilers in June 2003, while *Hilli* was in Bazan Shipyard in Spain.

Mr Walton arrived in Freeport on 26 September. He undertook safety training with the shipyard's Health and Safety Department. Training included the use of Permits to Work, entry into confined spaces and accident reporting procedures. He also set up his chemical cleaning equipment to clean the starboard boiler in the same configuration as he had previously used in Spain. However, it is unclear what arrangements were made to ventilate the boiler, to release the evolved gases to atmosphere.

The chemical used to remove the boiler scale and corrosion was Unitor's Descalex. This inhibited sulphamic acid cleaner also contained a colouring agent to indicate the acid strength. The inhibitor provided a protective coating on the internal steel surfaces of the boiler, so that it was protected from acid attack which produces hydrogen gas.

On 9 October, the starboard boiler passed its pressure test. Mr Walton then started to internally clean the boiler of oils and greases using a proprietary alkaline cleaner. This work was completed early on 10 October. In the meantime, Golar Management (UK) Ltd arranged for an overseer, a Danish chemical cleaning expert, to fly to the Bahamas and oversee the chemical cleaning operation on their behalf, and produce a report on completion. Neither HPMC nor Mr Walton was informed of this arrangement. The overseer arrived at Freeport at about midnight on 9 October.

Mr Walton started to heat up the water in the water/acid mixing tank at about 0800 on 10 October. He then circulated the water to check the system integrity. Mr Walton was introduced to the overseer later that morning. The overseer mentioned that he had not previously used sulphamic acid and was sceptical that it would clean the boiler. Mr Walton discussed the cleaning procedure and gave the overseer a copy of the procedure he was using. The instructions were not for the Descalex product but for the Drew Marine (UK) Ltd cleaner – SAF-Acid. At 1300, the temperature of the water/acid mixing tank was 57°C, and the overseer recommended that heating be stopped. By mid afternoon, 800kg of the cleaning chemical had been added and was being circulated around the boiler. At 1700 the overseer tested the water/acid mixture; the result confirmed that the inhibitors were still protecting the steel surfaces. At 2100 a further test was carried out, and this time the indications were that protection had ceased and the acid was dissolving the boiler steel. Although Mr Walton was sceptical of the result, he agreed to stop circulating the water/acid, as recommended by the overseer.

At 2145 Mr Walton arranged for the steam drum door to be removed, having already reduced the water/acid mixture level in the boiler. At 2200 both Mr Walton and the overseer approached the steam drum door. No tests were conducted to check the steam drum atmosphere for either toxic or flammable gases. Mr Walton picked up a nearby, non-intrinsically safe, halogen lamp and placed it just inside the steam drum. The overseer saw a small flame, and an explosion immediately followed. Mr Walton was thrown backwards by about 4.5 metres; he was unconscious and had severe burns. The overseer was also burnt, but less severely. There was no fire or severe damage to either paintwork or structure.

Both men were evacuated, first to a local hospital and then on to Florida, USA. The overseer eventually recovered, but Mr Walton died of his injuries on 19 October.

All the evidence points to an accumulation of hydrogen gas in the steam drum which evolved during the cleaning procedure. As the steam drum door was opened, the air combined with the hydrogen to create a mixture that was within the hydrogen explosive limits. As Mr Walton introduced the halogen lamp, either the hot lens or bulb, or an electrical spark from the lamp, ignited the mixture, causing the explosion.

Had the boiler been properly ventilated, the hydrogen build-up would not have occurred. The introduction of the hot halogen lamp into the untested, confined space of the steam drum, which was known to have possibly contained flammable gases, was a serious error of judgment.

Recommendations have been made to help prevent this type of accident re-occurring. They focus on:

- Revising acid suppliers' Product and Material Safety Data Sheets, to highlight the risk of hydrogen evolving and the importance of effective ventilation of closed systems and equipment.
- A review of cleaning procedures to include filling boilers with fresh water after any chemical clean to purge the boiler of flammable gases.
- The need to re-iterate the importance of closely adhering to confined space routines and the need to test these atmospheres for toxic and flammable gases including, specifically, hydrogen.
- The importance of comprehensive risk assessments and method statements for dangerous operations.
- Promulgating safety issues from this investigation in professional publications.