MAIB

MARINE ACCIDENT INVESTIGATION BRANCH

FLYER TO THE SHIPPING INDUSTRY

HILLI:
EXPLOSION DURING BOILER CHEMICAL CLEANING PROCEDURE

During the late evening of 10 October 2003, two boiler, chemical cleaning specialists were preparing to examine the starboard boiler of the LNG tanker, *Hilli.* A halogen lamp was introduced into the boiler steam drum. An explosion immediately followed, resulting in fatal injuries to one of the cleaning specialists and serious injuries to the other.

At the time of the accident, the ship was in a foreign shipyard undergoing large scale repairs to her port and starboard main boilers. The chemical cleaning of the boilers, post repair, was sub-contracted to a UK chemical cleaning specialist who was well known to the boiler repair contractor. On arrival at the site, the specialist undertook safety training with the shipyard's Health and Safety Department. Training included Permit to Work, entry into confined spaces and accident reporting procedures. The cleaning procedure was broadly discussed with the owner's "on site" staff and main repair contractor, but there were no risk assessments or Method Statement to support the cleaning procedure. The ship's staff involvement was also minimal and was largely restricted to witnessing key events such as pressure testing.

After the cleaning equipment was connected to the boiler, system integrity checks were carried out. To remove the boiler scale and corrosion, inhibited sulphamic acid was selected for the clean. The acid contained a pH indicator, to indicate the acid strength, and an inhibitor component to protect the boiler steel from acid attack, a by-product of which is hydrogen gas.

On 9 October the starboard boiler passed its pressure test and a preliminary clean was carried out to rid the boiler of oils and greases using a proprietary alkaline cleaner.

On 10 October, another chemical cleaning specialist, who had been employed by the owner, arrived to oversee the cleaning operation. By 1300 the temperature of the water/acid mixing tank was 57^0C and heating was stopped. By mid afternoon, 800kg of the cleaning chemical had been added and was being circulated around the boiler. Regular pH and inhibitor effectiveness tests were carried out and, at 2100, indications suggested that the inhibitor had ceased to protect the boiler and the acid was dissolving the boiler steel. The circulation was stopped and the boiler was drained down.

At 2145 the steam drum door was removed, and there was a noticeable suction as air was drawn into the drum from the outside. At 2200 both specialists approached the steam drum door. No tests were conducted to check the steam drum atmosphere for either toxic or flammable gases. One of the specialists picked up a conveniently close, non-intrinsically safe, halogen lamp and placed it just inside the steam drum. A small, blue flame or spark was seen and an explosion immediately followed. The

specialist who had positioned the halogen lamp inside the steam drum was thrown backwards by about 4.5 metres; he was unconscious and had suffered fatal burns. The other specialist was also burnt, but less severely. There was no fire or notable damage to either paintwork or structure.

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 the halogen lamp was introduced, 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.

Safety Issues

- There was an acceptance that the boiler repairer's chosen chemical cleaning specialist was the "expert" and there was little need to evaluate his cleaning procedures. Had risk assessments and a Method Statement been submitted, and there had been greater involvement by ship's and technical staffs and the primary contractor, then it is possible that the need to adopt the well known confined space routines, including testing the steam drum atmosphere for toxic and flammable gases, would have made the accident far less likely.
- The evolution of hydrogen gas during chemical cleans is well known. It is unclear how the boiler was ventilated to ensure that the gases were safely discharged to atmosphere to prevent them building up in the steam drum. However, regular checks to confirm that the ventilation arrangements were unrestricted should have been identified in risk assessments, had they been compiled. Filling the boiler with fresh water, to purge the steam drum of gases before opening would have been a safer option than simply draining it.
- Those involved in repairs should be aware that non-intrinsically safe equipment will often be brought onboard. Indeed, in this case, a large amount of hot work had been authorised through Permit to Work procedures. The lamp had been used to illuminate the hot work areas and did not need to be intrinsically safe. However, a momentary lapse of concentration caused the close at hand lamp to be introduced into the steam drum, with devastating effect. Supervisors, ship's staff and contractors need to be vigilant to these risks.

Further details on the accident and the subsequent investigation can be found in the MAIB's investigation report, which is posted on its website: www.maib.gov.uk

Alternatively, a copy of the report will be sent on request, free of charge.

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