Australian Government
Australian Transport Safety Bureau

Boiler Explosion at Geelong, Victoria– 17 May 2003

ISSN: 1447-087X
ISBN: 1 877071 53 6

Australian Transport Safety Bureau
PO Box 967,
Civic Square ACT 2608
Australia
1800 621 372
www.atsb.gov.au

April 2004

Medi Monaco: Engineers burned by boiler explosions

On 17 May 2003, three engineers were burned, one severely, while the Panama flag bulk carrier *Medi Monaco* was alongside in the port of Geelong, Victoria. The engineers were burned when the auxiliary boiler furnace 'flashed back' four times in succession during maintenance.

Medi Monaco

Medi Monaco (figure 1) is a Panama flag, 'handymax' bulk carrier of 52 523 deadweight tonnes at its summer draught of 12.041 m. The vessel is owned and managed by Misuga Kaiun Company of Japan. It is classed with Nippon Kaiji Kyokai as Bulk Carrier, Strengthened for Heavy Cargoes, with an ESP[1] notation.

Built in 2001 by Sanoyas Hishino Meisho Corporation in Mizushima Japan, *Medi Monaco* has an overall length of 189.90 m, a moulded breadth of 32.26 m and a moulded depth of 17.10 m. The ship is powered by a slow speed single-acting Sulzer 6RTA48 main engine of 7800 kW which gives the ship a service speed of 14 knots.

FIGURE 1:
Medi Monaco

At the time of the incident, *Medi Monaco* had a complement of 21. All the officers and crew were Filipino except the chief engineer who was Korean.

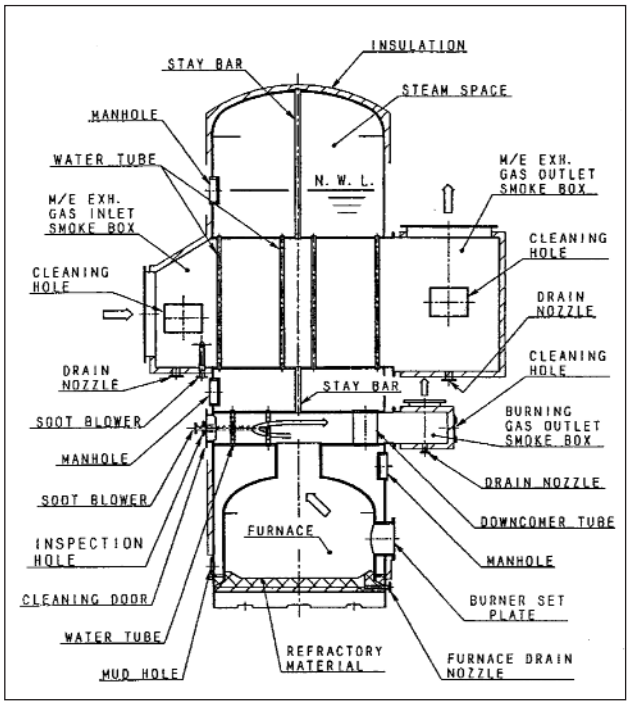
The engineers on *Medi Monaco* maintain a traditional 'four on, eight off' watchkeeping routine while at sea, and break watches in port to perform day work. *Medi Monaco*'s chief engineer had 44 years of seagoing experience and held a class one certificate of competency issued in Korea, endorsed for both motor and steamships. He had been chief engineer for 27 years and had been on the vessel for the previous four weeks. The third engineer had been at sea for a total of 11 years. He had been sailing as third engineer since gaining a third engineer's certificate of competency in the Philippines some 18 months previously. He had been on the ship since November 2002.

The boiler

Medi Monaco is fitted with a vertical composite boiler (figure 2) manufactured in Japan by the Osaka Boiler Mfg Company (type OEVC2-100/95-18). The boiler has a working pressure of 5.9 bar and uses main engine exhaust gas and/or a packaged oil burner unit, burning heavy oil, to produce steam. The upper section of the water space in the boiler houses the economiser section, with main engine exhaust gas passing over a bank of boiler water tubes. Beneath the economiser section is the burner smoke box which has a hot gas inlet from the furnace, another bank of boiler water tubes, and an exhaust gas outlet. The truncated hemispherical steel furnace lies below the smoke box. The bottom of the furnace is lined with refractory and it has a circular opening on one side to accept the oil burner unit.

1 Enhanced Survey Program

FIGURE 2:
Boiler schematic



When the main engine is stopped, or is providing insufficient exhaust gas energy to supply the steam demand, *Medi Monaco*'s boiler is fired using oil. The oil firing unit is a Volcano VJ-90-1, fully automatic, pressure jet oil burner manufactured by the Volcano Company of Japan (figures 3 and 4). The oil burner is fully integrated with a single electric motor driving both the forced draft fan and the fuel feed pump. Air control is provided by a single two-position damper on the fan's air inlet housing. The burner, which may be fired using either diesel or heavy fuel, has an integrated electric heater for use when firing on heavy fuel. The burner controls and monitoring system are located in a panel adjacent to the burner unit.

The burner head assembly (figure 5) is fitted inside the 'flame funnel' at the boiler furnace opening. It consists of a single nozzle attached to the 'atomiser block', the flame 'stabilisation ring' (air swirling disk) and ignition electrodes. The atomiser block has three fuel connections, one line which is led from an electric solenoid valve which feeds the fuel nozzle, and two other lines which allow fuel circulation through the atomiser block. The burner head assembly may be easily removed from the burner unit via a maintenance cover at the top of the burner after the igniter electrode leads and the three fuel pipes attached to the atomiser block are disconnected.

The Incident

At 1900 on 16 May 2003, *Medi Monaco* arrived at number two Lascelles wharf in Geelong after a voyage from Townsville. The ship was loaded with fertiliser and it was intended to discharge part of the cargo.

On the morning of 17 May, the engineers received lubricating oil bunkers. During this time some flame failure problems arose with the auxiliary boiler burner unit but these were rectified. After lunch the engineers continued normal engine room maintenance routines.

At around 1344 the boiler burner flame failed again. One of the engine room ratings accepted the alarm and made several attempts to relight the burner. During the process, he changed over the burner's fuel supply from heavy fuel to diesel before making more, unsuccessful, attempts to relight the burner. The rating then contacted the third engineer, who was responsible for maintenance on the boiler, and told him that the burner was igniting but he could not establish a flame. He told the third engineer that he had had five attempts to restart the burner.

The third engineer went to the boiler and noted that the boiler steam pressure was falling. He decided to start cleaning the burner head assembly immediately. He turned the control switch at the front of the burner control panel to 'off' and then isolated the fuel to the burner by closing the fuel inlet and outlet valves. After opening the maintenance cover on the top of the burner, he disconnected the two igniter leads and the three fuel lines attached to the atomiser block. While disconnecting the fuel lines, he noticed that a small, but usual, amount of fuel in the lines leaked into the burner housing. He then

FIGURE 3:
Oil burner unit

FIGURE 4:
Oil burner maintenance opening

FIGURE 5:
Burner head assembly

withdrew the burner head assembly from the burner unit and placed it in a container.

At that moment, as he was bending over the burner unit, there was an explosion, or flashback, from the boiler furnace. The third engineer's face and upper body were sprayed with burning fuel which had been blown out of the maintenance opening at the top of the burner unit. The third engineer knew that he had been badly burned and ran to wash his face, before going quickly to the upper deck to get assistance.

The second engineer, who was working on the top platform at the after end of the main engine, heard the boiler explosion and saw that the third engineer had been burned. He called the chief engineer working below him on the middle platform and both men made their way the boiler to see what had happened. As they were inspecting the burner unit, there was a second explosion. Both men sustained burns to their faces when more burning fuel and hot gas was blown out through the maintenance opening at the top of the burner. The second engineer then went to the control room, called the bridge, and then made his way out of the engine room to get assistance.

After the second engineer had left, the chief engineer stayed in the vicinity of the boiler to secure the boiler burner. While he was checking the burner, he stood at a distance and looked into the furnace via the maintenance cover opening. He could see that there was a small fire burning in the bottom of the boiler furnace. He then checked to ensure that the burner was properly isolated and went to the workshop. While he was in the workshop he heard two more flashbacks from the boiler furnace.

During this time a fire alarm was initiated and the ship's crew started to muster on the main deck.

The master on the bridge had heard the explosions and the fire alarm. After speaking with the second engineer, he alerted the ship's agent who called the emergency services. The master then went down to the main deck and saw the second and third engineers come out

of the engine room. He could see that the men were injured and told them that there was an ambulance coming.

At about 1405, three fire appliances arrived at the ship followed, at approximately 1425 by two ambulances. The fire crews boarded the vessel and, after conferring with the master, made their way to the engine room. They later declared that there was no fire.

The third engineer was attended by paramedics and taken to Geelong hospital by the first ambulance. He was later transferred to the burns unit of The Alfred Hospital in Melbourne where he received treatment for the following two weeks. The chief and second engineers were taken to Geelong hospital by the second ambulance and were discharged the following morning.

Contributing factors

Medi Monaco's engineers were injured on 17 May 2003 by burning fuel and hot gas which was blown out of the open maintenance cover on the top of the burner unit by a succession of furnace explosions (or flashbacks). The explosions were caused when unburnt fuel in the boiler furnace was vaporised and ignited by the hot refractory lining the floor of the combustion chamber. The fuel had been deposited on the furnace floor, and wall opposite the burner, by the unsuccessful attempts to relight the burner. A small quantity of fuel was also spilled into the furnace when the third engineer disconnected the fuel pipes on the burner head assembly. The design of the boiler's furnace and the manner in which the burner service was conducted both contributed to the incident.

Furnace design

The boiler furnace design contributed to the incident on *Medi Monaco*. The furnace floor was not water-cooled (many auxiliary boiler designs have a water space around the entire furnace) and is lined with refractory which cools relatively slowly after the boiler has been firing. In addition, the locations of the burner opening and the smoke box inlet make the furnace prone to the accumulation of pockets of unswept gas.

The furnace chamber has a single burner opening at the side and a single outlet at the top leading to the smoke box. When the burner is running, the flame is directed at the furnace wall opposite the burner opening with the flow of hot gas sweeping the periphery of the cylindrical furnace chamber before rising to the smoke box inlet. When the burner is stopped, there is no flow of air through the furnace until the maintenance cover on the burner is opened. With the maintenance cover removed, the airflow through the furnace depends on the pressure differential between the engine room and the uptakes, and increases, due to natural updraught, when the furnace and boiler uptake is hot. At this time, the airflow is limited and would tend to pass directly from the burner opening to the smoke box inlet, leaving areas adjacent to the furnace walls relatively unswept.

The unsuccessful attempts to relight the burner deposited a mix of heavy fuel and diesel on the furnace floor and on the wall opposite the burner opening. The residual heat in the refractory lining and furnace walls in this area was sufficient to vaporise this fuel mix with its relatively low flashpoint. When the third engineer removed the maintenance cover, the air draught through the oil burning unit was insufficient to purge the whole furnace and bypassed this relatively still, hot, area of the furnace. Thus the fuel vapour accumulated until it was rich enough to ignite, causing the first flashback. The succeeding flashbacks were caused in the same way ie. the fuel vapour concentration increased until it reached the point where it was ignited either by the hot refractory or the small, self-sustaining, fire (probably started by the first explosion) on the furnace floor, as described by the chief engineer. The explosions

continued until the fuel was either exhausted, or the temperature of the refractory had cooled to below the ignition temperature of the fuel vapour.

Servicing the burner

During the previous months the engineers had experienced problems with the auxiliary boiler's oil burner unit whenever the ship was in port. The burner flame was failing regularly and, although they had tried several times to rectify the problem, the engineers had not determined the cause.

The regular flame failures meant that the engineers, particularly the third engineer, were servicing the burner several times each day the ship was in port. The evidence is that there had been several other occasions when the engineers had experienced furnace flashbacks while performing the burner service in the past. Despite these previous incidents the engineers had not learned the lesson and had not taken adequate precautions to either prevent the flashbacks or to protect themselves in the event of such an occurrence.

Generally, the burner services performed by *Medi Monaco*'s engineers prior to the incident involved stopping the burner and removing the burner head assembly from the unit to clean carbon residue from the flame stabilisation disc and igniter electrodes. Each service was taking up to 30 minutes. During the time the burner was being serviced, the boiler steam pressure would fall continuously. The falling boiler pressure was often causing alarms and problems with other equipment using the boiler steam, particularly the purifiers and the generator fuel system. As a result, the engineers were under considerable pressure to complete the burner service as quickly as possible in order to minimise the loss of steam pressure.

Medi Monaco's engineers were routinely opening the burner maintenance cover immediately after several attempts to relight the burner and often while the furnace was still hot. Although there was no ship-specific written procedure for servicing the burner, the burner instruction manual did contain guidance and appropriate warnings for the task. It stipulates that the furnace must be purged with the fan for a minimum of 60 seconds after each flame failure before looking into the cause. Sufficient purging of the boiler furnace prior to opening the burner unit is a basic safety precaution, however in some cases it may not be enough to prevent a flashback. If a number of attempts have been made to relight the burner there may be liquid fuel lying in the furnace even after lengthy purging. At these times it is crucial to let the furnace cool sufficiently before it is opened. On *Medi Monaco* there was no easy way to gauge when to take this precaution as the boiler was not equipped with a quick method of safely sighting the furnace floor. The complete burner unit had to be withdrawn to allow the furnace to be inspected.

Each time *Medi Monaco*'s engineers hurriedly opened the burner maintenance cover, without purging or allowing the furnace to cool, they ran the risk of a boiler flashback and the consequent danger of injury.

Past incidents

There has been at least one other documented incident of the same type on another vessel fitted with this type of boiler/burner combination. On 29 April 2001 the Singapore registered bulk carrier *Alam Mesra* experienced a series of boiler explosions identical to those which occurred on *Medi Monaco*. The boiler and burner units were identical to those fitted to *Medi Monaco* and the incident was remarkably similar. After a succession of burner flame failures, the third engineer and engineer cadet disconnected the burner head assembly and removed it from the burner. While working on the burner assembly in the workshop, the two men heard an explosion from the boiler and went to investigate. While they were examining the boiler, there were several more explosions and furnace flashbacks in succession and both men were burned. The explosions were

attributed to the leakage of fuel, from the fuel connections on the burner head assembly, into the hot furnace.

Conclusions

These conclusions identify the different factors contributing to the incident and should not be read as apportioning blame or liability to any particular organisation or individual.

The following factors are considered to have contributed to the boiler explosions and resultant injuries to the engineers aboard *Medi Monaco* on 17 May 2003.

1. There was unburnt fuel lying in the hot boiler furnace after several unsuccessful attempts to relight the burner.
2. The refractory lining the furnace floor was hot enough to vaporise the fuel and ignite the resultant vapour.
3. The furnace allowed a concentration of fuel vapour to accumulate in areas which were not swept by the flow of air from the burner maintenance opening to the smoke box inlet.
4. The purge time after the burner was shutdown was insufficient to disperse the vapour resulting from the significant quantity of unburnt fuel in the furnace.
5. The third engineer had not allowed the boiler furnace to cool sufficiently before starting the burner service.
6. The boiler burner had a history of persistent flame failures, which required frequent remedial action by the ship's engineers.
7. When servicing the burner the engineers were under a time constraint in order to limit the fall of the boiler steam pressure.
8. There had been occasions in the past when the engineers had experienced boiler flashbacks while servicing the boiler.
9. The engineers had become complacent with regard to safety measures while servicing the boiler burner due to the frequency with which it had to be done.

Recommendations

It is recommended that:

MR 20040007

The Osaka Boiler Mfg Company provide a safety bulletin to operators of OEVC2 boilers warning them of the incidents on *Medi Monaco* and *Alam Mesra* and drawing their attention to the correct safety precautions when servicing the fuel burner unit.