Bundesstelle für Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation
Bundesoberbehörde im Geschäftsbereich des Bundesministeriums
für Verkehr, Bau- und Wohnungswesen

Investigation Report 202/04

Serious Marine Casualty

Explosion on board FC HARMONIE on 2 August 2004 off Baltrum

1 March 2005

The investigation was conducted in conformity with the law to improve safety of shipping by investigating marine casualties and other incidents (Maritime Safety Investigation Law - SUG) of 24 June 2002.

According to this the sole objective of the investigation is to prevent future accidents and malfunctions. The investigation does not serve to ascertain fault, liability or claims.

The German version shall prevail in the interpretation of the Investigation Report.

issued by:
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1 Summary of the Marine Casualty

A fire broke out in the engine room and wheelhouse of FC HARMONIE north of Baltrum at about 01:00 h CEST[1] on 2 August 2004, as a result of which the wheelhouse installations were badly damaged.

The Master sustained very serious burns and jumped overboard in order to extinguish the flames on his body.

Thanks to the swift action by the deck hand no major damage was sustained by the vessel and it was possible to rescue the Master.

[1] Time data without special suffix are always local time in the following.

2 Scene of the Accident

Nature of the incident:	Serious marine casualty, fire on board, one injured person
Date/time:	2 August 2004/01:00 h CEST
Location:	North of Baltrum
Latitude/longitude:	At position approx. φ 53°45' N λ 007°23' E

Excerpt from the official chart for leisure craft Series 3015, BSH

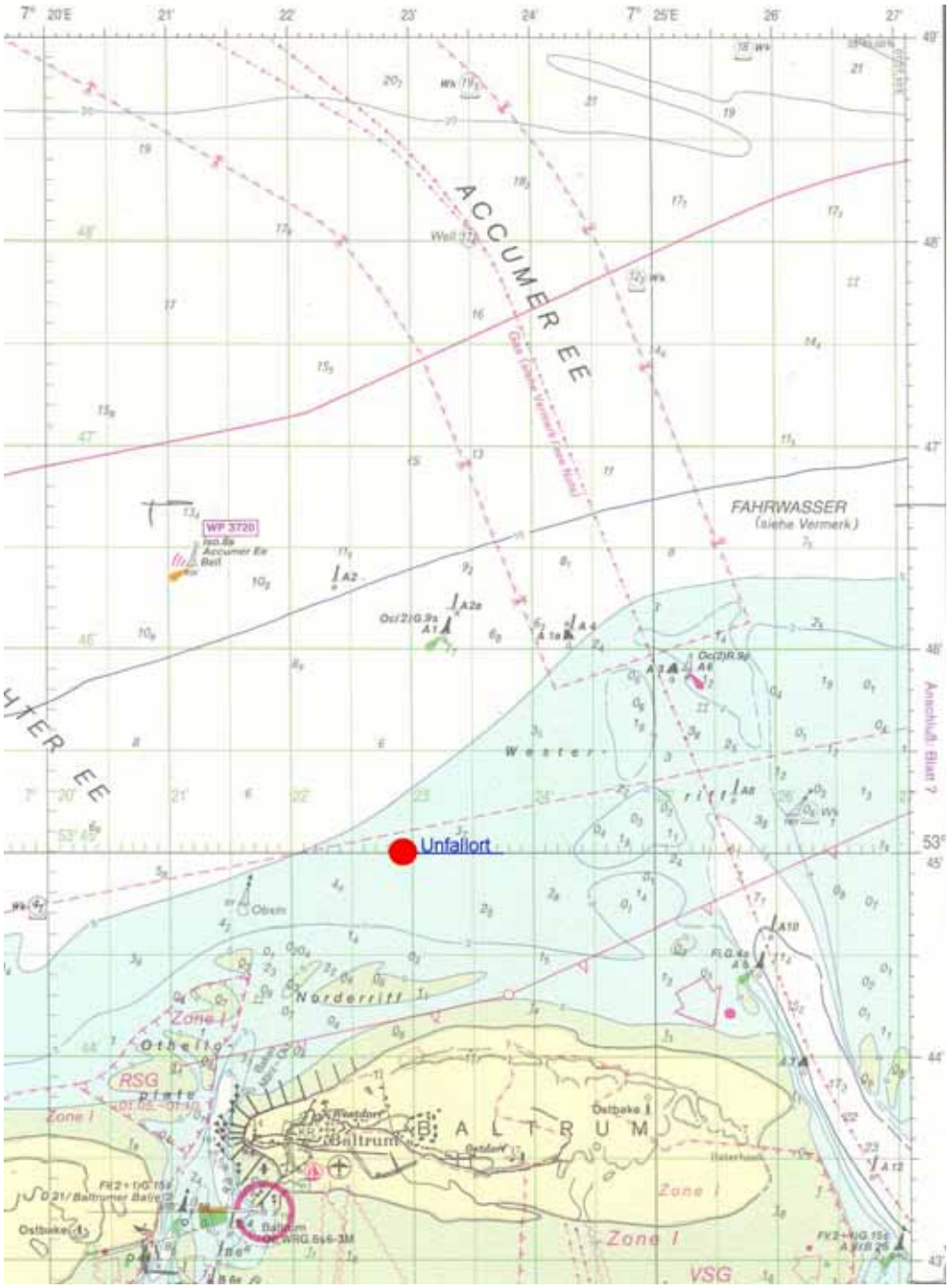

Figure 1: Sea chart

3 Vessel Particulars

3.1 Photo FC HARMONIE

Figure 2: Photo of vessel

3.2 Particulars

Name of vessel:	FC HARMONIE
Type of vessel:	Fishing Cutter
Nationality/flag	Germany
Port of registry:	Accumersiel
Fisher's code:	ACC 3
Call sign:	DCRK
Operator:	(known)
Year built:	1962
Building yard:	Scheepswerf Ton Bodewas Holland
Classification Society:	GL
Length overall:	18.73 m
Width overall:	5.33 m
Gross tonnage:	54 GRT
Net tonnage:	16 NRT
Draft at the time of the accident:	2.50 m
Engine rating:	265 kW
Main engine:	CUMMINS NTA-855-M
Number of revolutions:	1950 RPM
Number of cylinders:	6
Volume of lubricating oil:	26 l
Number of crew:	1+1 deck hand

4 Course of the Accident

4.1 Written statement by the Master of FC HARMONIE

At about 00:30 h he had checked the engine room and ascertained that a high-pressure line from the oil filter to the supercharger was leaky. Accordingly he had tried to tighten the screw connection at the leaking oil filter using a spanner, but the screw had broken off at once. He could not explain why there was an immediate fire explosion. After being surprised by the fire all he had been able to do had been to try and run back up onto the deck as quickly as possible in order to save himself from burning by jumping into the water. The deck hand had then thrown a lifebuoy to him, pulled him back on deck and arranged for medical care.
Regrettably he was unable to make any statement about the cause of the fire.

4.2 Written statement by the deck hand

In the night from Sunday to Monday, 1 August 2004 / 2 August 2004, they had been fishing with the Cutter ACC 3 HARMONIE behind the island of Baltrum. He had been engaged in screening and boiling shrimps on deck. Suddenly his boss had shouted that he was on fire and he, the deck hand, had seen his boss jumping over board, burning. He had thereupon thrown the lifebuoy to his boss and pulled him back on board. Shortly after this he had ascertained that the wheelhouse was on fire. He had also noted that the fire-extinguishing pump was still running and had immediately started to put out the fire. After this he set off a red emergency light (burned a red hand flare).

An enquiry made by the Federal Bureau of Maritime Casualty Investigation (BSU) on board FC HARMONIE in Accumersiel revealed that the emergency signals and the first aid box were ready at hand in the wheelhouse. In this marine casualty the signals and the first aid box were unfortunately lying in the area of the fire, however, and the deck hand first had to recover them from the flames. However, securing the emergency signals made it possible to prevent major damage and also to obtain assistance and provide medical first aid for the Master.

5 Summary of the Damage

Figure 3: Port side door

Figure 4: Galley door aft

Figure 5: Wheelhouse midships/port side

Figure 6: Galley area aft

Figure 7: Companionway ER

6 Analysis

The investigation into the cause of the damage in this marine accident was particularly difficult. Due to the extremely dangerous burns sustained by the Master on over 50 % of his body surface, he was placed in an artificial coma for a relatively long period and was thus initially not available to assist in investigating the causes. The deck hand was not able to make any statements regarding the course of the damage since he had been working on deck at the time of the accident.
The inspection on board by the See-BG (German Safety Organisation) on 3 August 2004 revealed that relatively large quantities of oil were spread over the engine room. The engine room was less badly damaged, since the explosion extended to the companionway. All the connecting hoses and screw fittings were evidently intact and no influence of fire or burning was evident. The firm of safety experts Gesellschaft für Sicherheitstechnik/ Schiffssicherheit Ostsee mbH, Rostock, was commissioned to investigate the cause of the fire. A survey by two experts from the above company was held in the presence of the Federal Bureau of Maritime Casualty Investigation (BSU) on 13 August 2004 in Accumersiel.
The Institut für Werkstoffkunde und Schweisstechnik (Institute for Material Science and Welding Engineering), Hamburg, was charged with analysing the damage to an angle screw fitting.

6.1 Fire Damage

6.1.1 Bridge

The bridge showed signs of fire damage over the ceilings, walls and fittings from a height of approx. 90 cm above floor level upwards. The bridge equipment (monitor, communications facilities, operating facilities) was largely charred and had started to melt. The ceiling installation made of plastic (lampshades and housing) was completely destroyed. The artificial leather upholstery and the upholstery of the bridge seat were approx. 30 % burned. The equipment and furnishings below a height of 90 cm including the flooring were not affected. The bridge windows were covered in soot and had been rendered opaque.

Figure 8: Wheelhouse looking forward

6.1.2 Mess / Galley

The surfaces of the ceiling and wall covering, the furniture, the fittings and the PVC floor covering were completely destroyed by fire. The floor skirting boards had mostly melted and burned. The fibreboard panels on the floor remained intact. There were characteristic fire patterns on the wooden panelling, the wooden furniture, the wooden mouldings and the curtain rails. Stronger effects of the fire than in other areas were ascertained in the area of the engine room entrance. Plastic parts lying open had melted. The ceiling lamp had been destroyed completely and the bulb had melted. The chart compartment with the sea charts in it beneath the ceiling in the central aisle had been totally burned. The upholstery on the seats was almost completely burned. The aft windows were very opaque, covered with soot and had partly cracked.

Figure 9: Chart compartment

6.1.2 Engine Room

The engine room (ER) was found to be in a technically good condition with comparatively slight damage.
Large areas of the starboard side with the companionway, the workbench, the ceiling and aft edge starboard of the ER were covered with oil. The ER deck showed damage on the starboard aft part, such as burned layers of paint, blistering and peeling. The area of the ER entrance was coated with soot, but the paintwork beneath this coating of oil/soot was largely intact. The housing of the water circulating pump at the aft edge of the ER companionway and the housing of a measuring sensor on the starboard forward edge of the main engine were charred. Various cables in the ceiling area starboard were partly charred. The covers of sundry lamps and a cable duct at the front edge of the ER had melted. The layer of paint on the ventilation pipe on the starboard side was burned and peeling off. The companionway was largely intact, only the upper part and parts of the right-hand handrail showed signs of fire. The fire extinguisher in the ER entrance was no longer in its bracket and was lying in secured condition in the starboard bilge. The remaining areas of the ER were covered with a slight layer of soot. The further systems and facilities in the ER such as diesel generator and net winches showed no notable signs of damage.

Figure 10: Ventilation pipe

6.1.3 Main Engine

The oil film on the walls and ceiling on the starboard side of the ER was identified as lubricating oil from the main engine (ME). The ME of type CUMMINS NTA 855 M was thereupon examined in detail. During a visual inspection of the ME and its systems no signs of leaks in the fuel system or cable defects or evidently loose screw fittings were ascertained. The sounding of the oil sump using a sounding stick showed a filling level of 3 mm below maximum level. The only leak in the lubricating oil system was ascertained in the angle screw fitting of the lubricating oil line to the exhaust gas turbocharger on the filter housing of the oil cooler. The screw-in thread of this line was torn off at the housing and bent slightly downwards.

Figure 11: Companionway starboard side

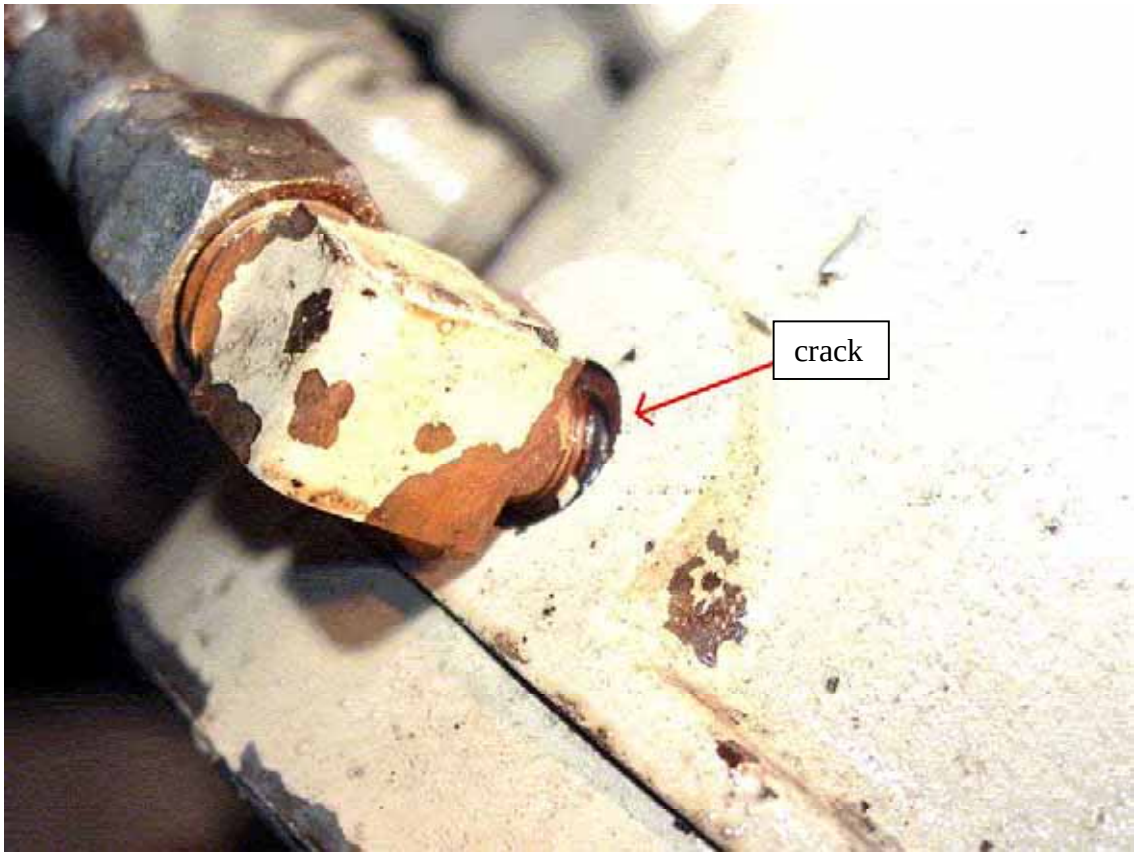

Figure 12: Screw fitting on oil cooler

The further examination was concentrated on the source of ignition.
The ME has an insulated, metal clad exhaust line on the starboard side. This line was also oily in the bottom area and showed clear traces of flames over its whole length. The exhaust gas turbocharger was insulated by a mat. No wiring was ascertained. This insulation and the housing of the exhaust gas turbocharger as well as the parts of the exhaust duct directly adjacent to it showed traces of fire, were covered with soot and contained residues of burned oil.

Figure 13: Exhaust gas turbocharger insulation

Figure 14: Exhaust gas turbocharger insulation removed

6.2 Investigation into the Causes of the Fire

An evaluation of the documents available reveals the following circumstances:

The screw fitting of the lubricating oil line at the oil cooler showed signs of a leak. Lubricating oil escaped from this leak at a pressure of approx. 3 bar unimpeded in the form of spray mist. The size of the oily area and the fact that the volume of lubricating oil in the oil sump had evidently hardly been reduced indicate that no major quantities of lubricating oil can have escaped. The lubricating oil mist was spread over the starboard side of the ER, had wetted parts of the installation such as ceilings, walls, workbench etc., and formed an oily room atmosphere. At the same time the oil began to evaporate on the wetted, hot surface of the machine parts and formed ignitable mixtures. These products of evaporation and oil droplets gathered primarily in the starboard area beneath the ER ceiling.

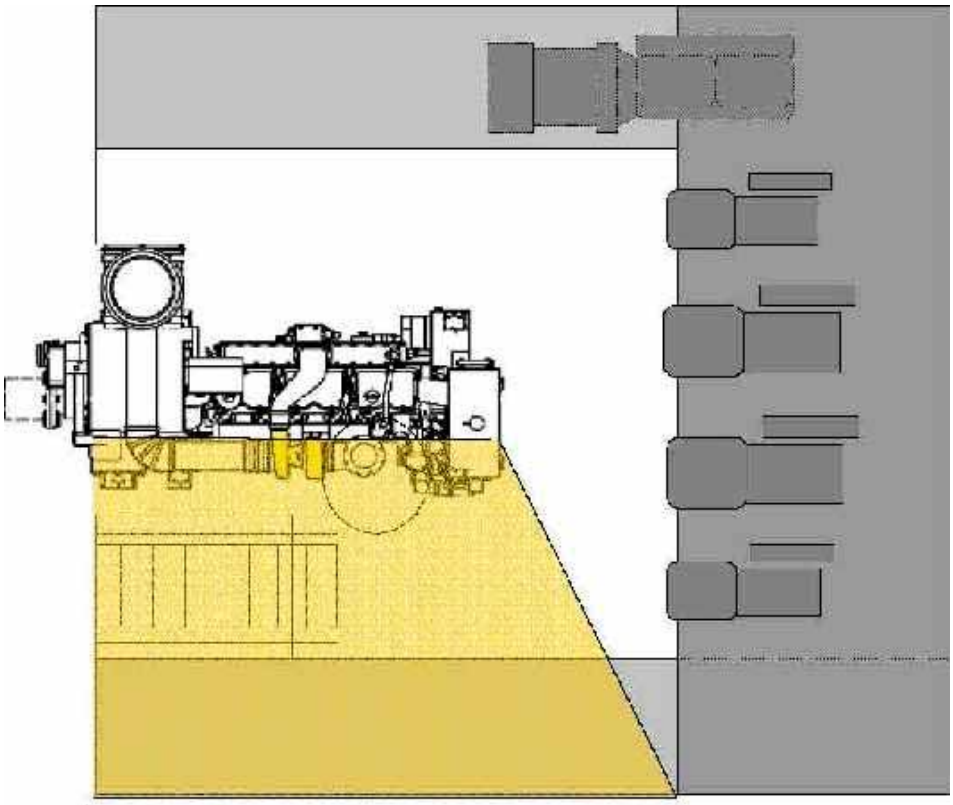

Figure 15: Oil mist propagation in ER

On the day of the accident the Master checked the engine operation and ascertained oil drops on the angle screw fitting between the oil cooler and the connection hose. He thereupon tried to tighten the nut on the connection hose using a spanner. In doing so he ripped off the angle screw fitting at the oil cooler. It can be assumed that the angle screw fitting was not ripped off completely, but instead that a fine crack first formed in the upper part through which oil was additionally atomised.

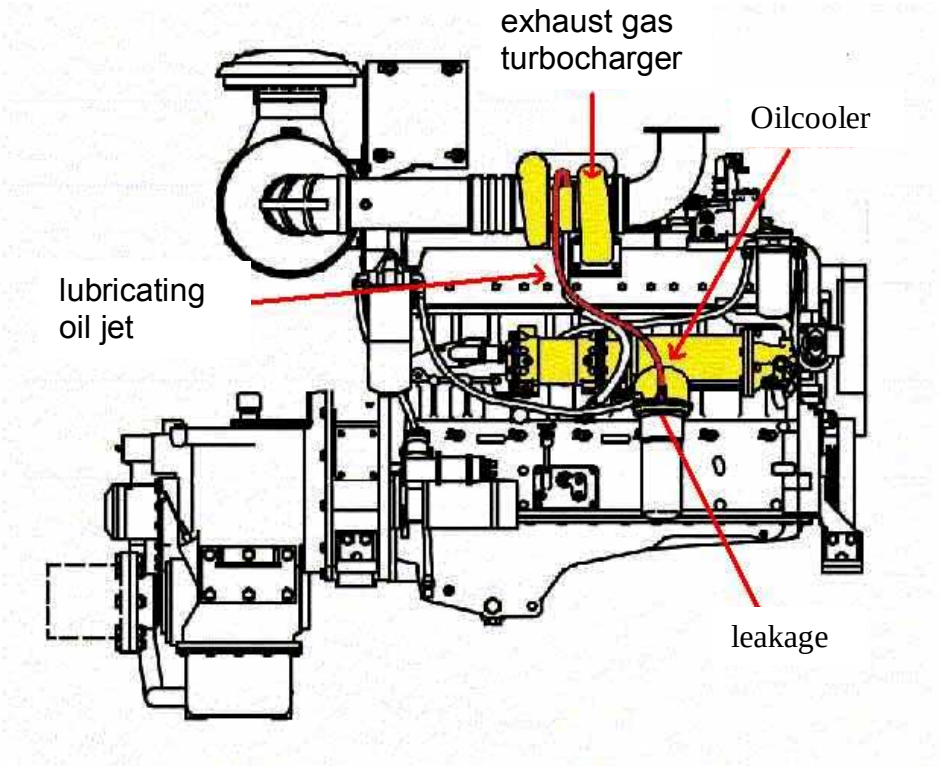

Figure 16: Leak and exhaust gas turbocharger at the ME

The exhaust gas turbocharger on this engine is located approx. 23 cm away horizontally and 38 cm away vertically from the position of the leak. As a result of the crack in the upper part of the angle screw fitting the exhaust system, especially the exhaust gas turbocharger, was necessarily in the direct area of the lubricating oil jet. The oil infiltrated beneath the insulation at the joint between the exhaust gas turbocharger and the exhaust gas line and was heated up to 600° C. As the damage configuration on the exhaust gas turbocharger and the insulation demonstrate, the lubricating oil ignited at this point.

Figure 17: Insulation exhaust gas turbocharger

Open flames developed on the upper side of the oil-saturated insulation and the fire was initially restricted to this area alone. The traces of flames on the exhaust gas insulation indicate that the open fire on the insulation of the exhaust gas turbocharger must be seen as the source of the ignition. The fire then progressed as follows:
During sea operation the entrance to the ER is only open for inspection and repair measures. At the time of the accident, however, this entrance cover had been opened for the inspection and was arrested in the device installed for this purpose. At the same time the port and aft door of the deckhouse were open. It can be assumed that as a result of this ventilation situation extra fresh air made its way into the ER and the oil mist-air mixture was at the same time able to spread out into the wheelhouse lying above it. The conditions now applying led to the oil mist-air mixture igniting right through, whereby with this sudden combustion a large quantity of heat was released within a very short space of time. This also involved an increase of temperature in the areas beneath the ER ceiling, the ER entrance and below the deckhouse of approx. 1100 °C and at the same time the hot gases expanded very quickly.
In the first phase of the now following fire propagation the oil mist-air mixture in the area of the ER ceiling burned off at the entrance and produced the damage configuration found here.

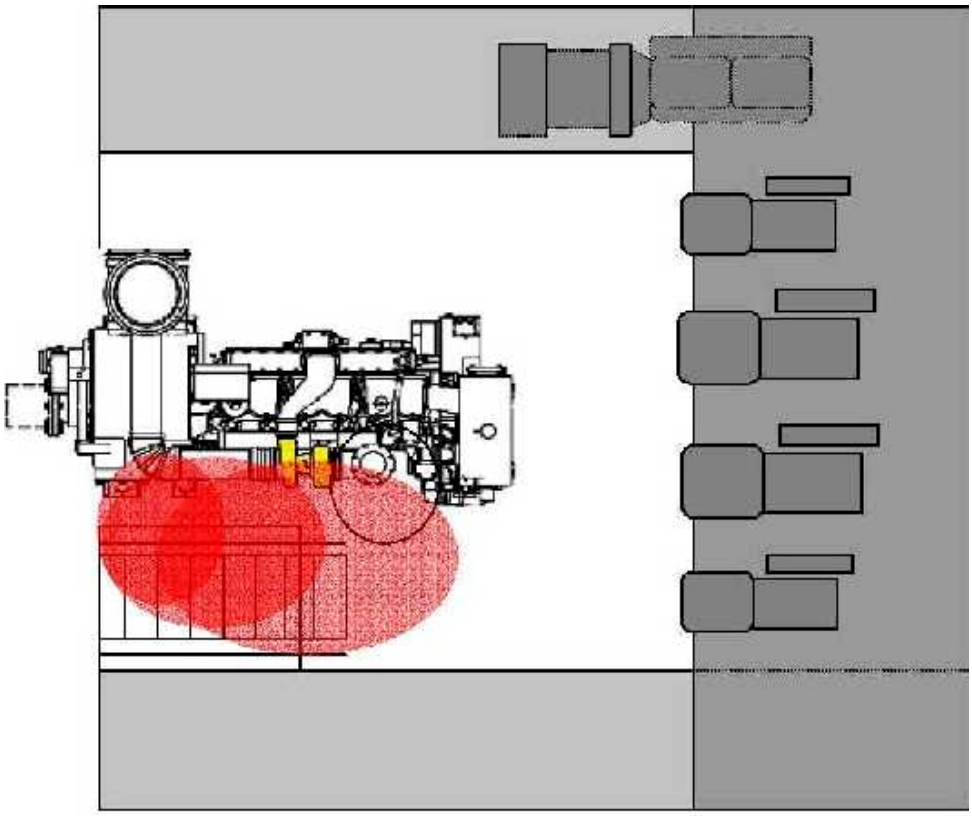

Figure 18: Fire propagation below deck in the ER

In the second phase the hot and partly burning gases spread throughout the entire mess/galley within a few seconds. The energy potential was sufficient to produce large quantities of combustible gases and to ignite the combustible surfaces of the furniture, the walls and ceilings suddenly. Clear evidence of the high temperatures was provided by the melted bulb of the ceiling lamp in the mess room. Ultimately the mess caught fire completely throughout its entire extension.
The propagation of the fire on the bridge followed a few seconds later, with the transfer of hot gases evidently being inhibited by the constriction in the cross section at the transfer from the mess to the bridge. On the basis of the damage noted it was evident that not all the combustible surfaces had been ignited completely.

The Master later stated in a discussion that he had run out of the engine room through the flames into the open and tried to save himself by jumping into the water.

6.3 Fire Test to Determine the Source of Ignition

A fire test was conducted in the laboratory with a sample of the lubricating oil taken from the vessel. This experiment revealed that the experimental sample ignited automatically without the presence of an ignition flame at a temperature of 580 °C.
It is to be assumed that at the time of the accident, due to the drag operation, the engine was running in a high load range. The exhaust gas temperature, approx. 1.0 m after the exhaust gas turbocharger, is usually 430 °C according to the information supplied by the manufacturer. Thus the exhaust temperature in front of the exhaust gas turbocharger at the time of the accident was about 580 °C to 600 °C. Consequently self ignition of the lubricating oil hitting the exhaust gas turbocharger appears certain.

6.4 Examination of the Angle Screw Fitting

The angle screw fitting that had sheered off was thoroughly examined at the Institute for Material Science and Welding Engineering, Hamburg.
The angle piece is a so-called 90° fitting made of free cutting brass. These fittings are normally used in oil lines, but also in water lines. The angle screw fitting has two external threads with an external thread diameter of 16 mm and an almost square body 17 mm thick. Thanks to the form the fitting body is suitable for use with a spanner width of 17 mm. The 17 mm spanner can on the one hand be used to mount the fitting in the oil cooler housing, and on the other hand to hold it in place when tightening the cap nut of the connecting hose.

The hardness test resulting from three measurements produced an average hardness of 105 HBW (Brinell hardness value). This corresponds to a customary hardness for this material.

Figure 19: Angle screw fitting / 90° fitting

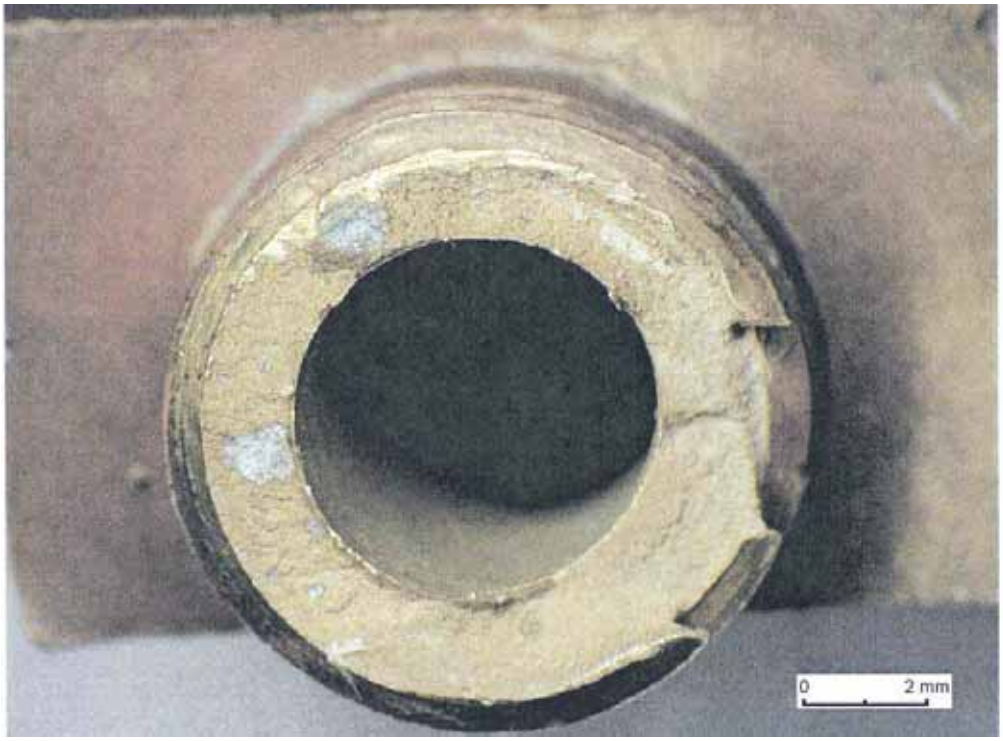

Figure 20: Fractured surface

The photo of the fractured face only shows that the crack occurred at the top in the installed condition and spread from the top to the bottom.
The fractured face was thereupon examined with a scanning electron microscope.

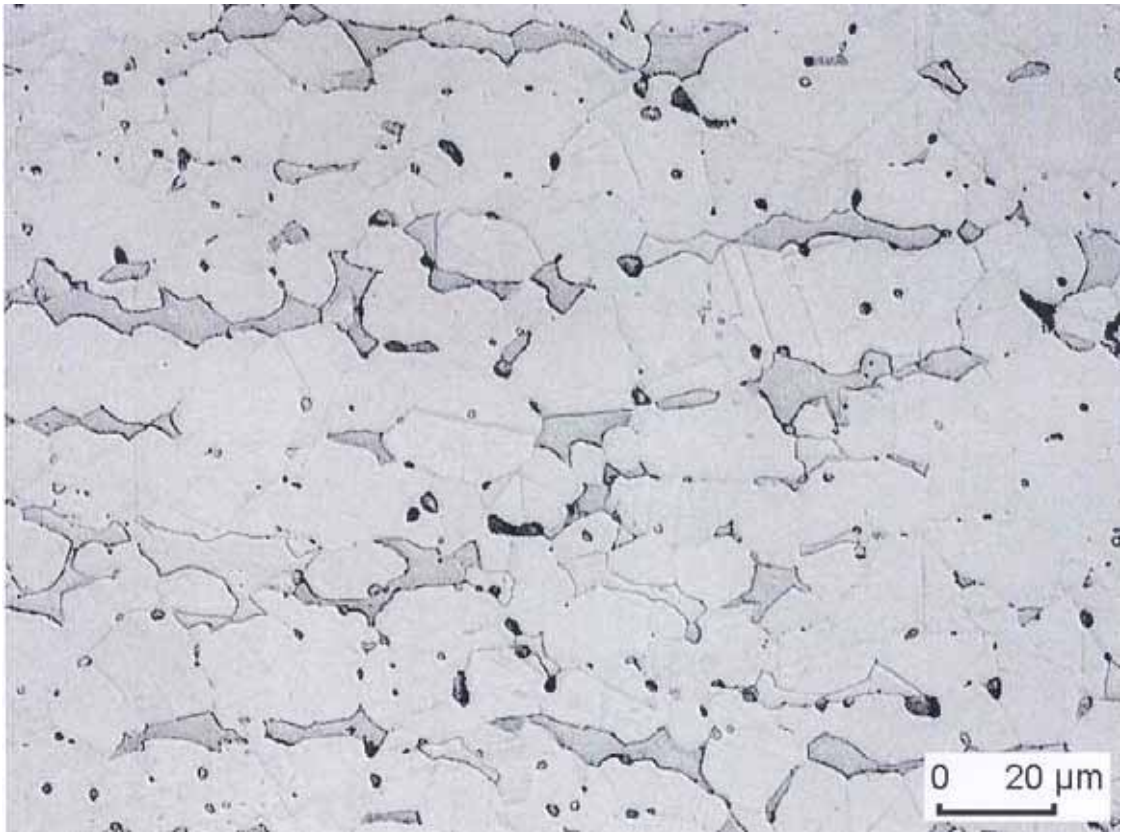

Figure 21: View under the scanning electron microscope

Viewed under the scanning electron microscope, a uniform picture was found almost all over the entire fractured face. This picture is characterised by a honeycomb structure as is shown in Figure 21. These structures indicate a forced fracture and are interrupted by lead eliminations and stains with corrosion products. The eliminations and corrosion evidently occurred subsequently when the area came into contact with firewater during extinguishing of the fire.
In view of the microscopic fracture structure, prior damage of the fitting can be ruled out.

A sample was taken from the fractured area and a micro-section prepared to assess the material further.

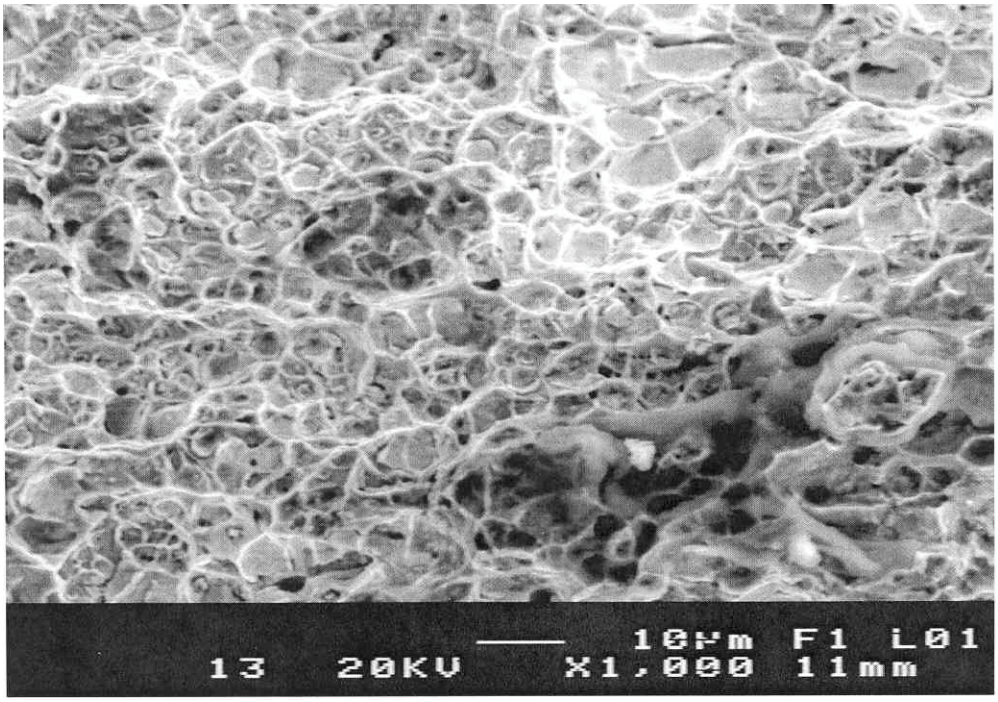

Figure 22: Photo of the structure

The micro-section (Figure 22) shows the structure of the material consisting of Alfa and Beta brass with finely distributed lead eliminations. The structure appears fine-grained and uniform. No abnormalities have been ascertained. The structure is typical for free-cutting brass.

No prior damage or material faults that could have promoted the damage were ascertained.

6.5 Summary

It is to be assumed that the unfortunate coincidence of the following circumstances was responsible for the outbreak of fire on FC HARMONIE:

- Leak of the angle screw fitting at the oil cooler
- Partial crack of the angle screw fitting at the oil cooler
- Form and quantity of the lubricating oil that escaped
- Direct vicinity of the exhaust gas turbocharger to the leakage point
- Temperature of the exhaust gas turbocharger in the range of the ignition temperature of the lubricating oil.

The leak of the screw fitting on the oil cooler was not easily visible for the Master, since it was located behind a cooling pipeline. His attempt to eliminate the leak by tightening the cap nut without the help of any suitable fixing of the fitting body failed. This design in itself very quickly leads to excessive stress and unless the fitting is secured using a 17-mm spanner also to cracking of the fitting at the thread to the filter housing.

7 Safety Recommendations

The elimination of minor damage, for instance at the pipes, is part of work at sea. Investigation into the cause of pressure loss and oil loss in pressurised systems can generally only be carried out when the engine is running. The actual work on these systems is often also carried out during operation of the main engine. The German Marine Safety Organisation (See-BG) issues very clear implementing instructions for such work in its Accident Prevention Regulations (UVV See). In particular according to UVV See, § 151 - maintenance of engine facilities - the following is to be noted:

§ 151 Maintenance of engine facilities

.....

(6) Before undertaking maintenance work at pressurized systems, the respective plant parts shall be safely separated safely from systems remaining under pressure.

(7) Pressure vessels and units operating under pressure may be carefully opened only after it has been ensured by two independent measures that no pressure exists or can built up.

.....

This Regulation must be observed during all work on pressurised systems by engine fitters and masters. During work on main or auxiliary engines these are to be stopped so that in particular the lubricating oil and fuel lines are not under pressure.

8 Sources

The investigation report relates to the investigations by the BSU, the Waterway Police Norddeich, the Marine Insurance and Safety Association (See-BG) and to

- written and oral statements by the Master and the deck hand
- expert opinion by Gesellschaft für Sicherheitstechnik/Schiffssicherheit Ostsee mbH
- test report by the Institute for Material Science and Welding Engineering, Hamburg
- Sea charts of the BSH.