MAIB SAFETY BULLETIN 4/2010

Catastrophic failure of a capacitor and explosion in an 11kV harmonic filter on board the passenger cruise vessel RMS *Queen Mary 2*

MAIB

Marine Accident Investigation Branch
Mountbatten House
Grosvenor Square
Southampton
SO15 2JU

MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

MAIB SAFETY BULLETIN 4/2010

This document, containing safety lessons, has been produced for marine safety purposes only, on the basis of information available to date.

The Merchant Shipping (Accident Reporting and Investigation) Regulations 2005 provide for the Chief Inspector of Marine Accidents to make recommendations at any time during the course of an investigation if, in his opinion, it is necessary or desirable to do so.

Steve Clinch
Chief Inspector of Marine Accidents

NOTE

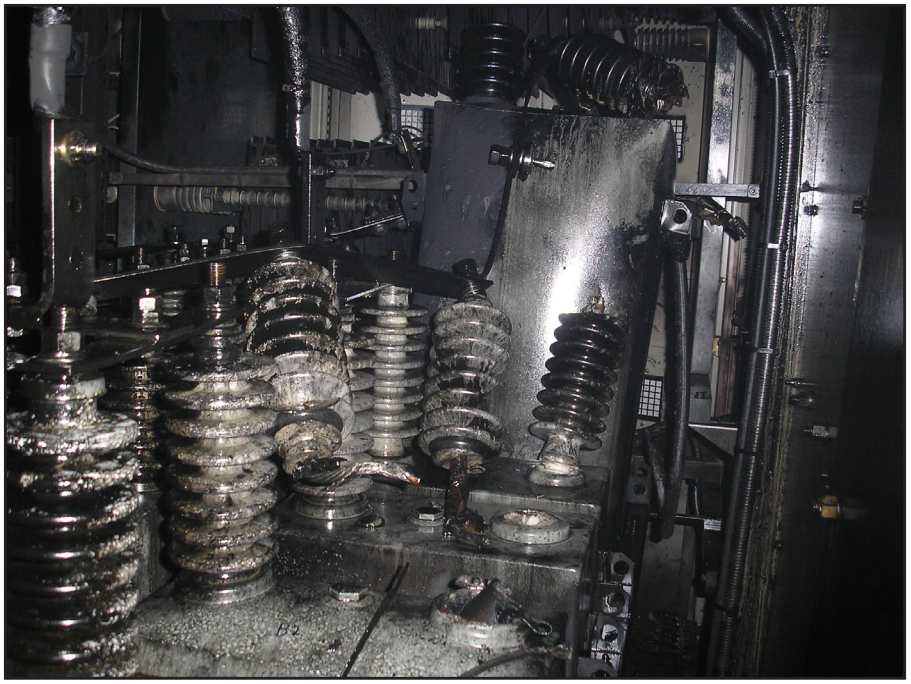
This bulletin is not written with litigation in mind and, pursuant to Regulation 13(9) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005, shall not be admissible in any judicial proceedings whose purpose, or one of whose purposes, is to apportion liability or blame.

This bulletin is also available on our website: www.maib.gov.uk
Press Enquiries: 020 7944 6433/3387; Out of hours: 020 7944 4292
Public Enquiries: 0300 330 3000

BACKGROUND

At 0426 (UTC+1) on 23 September 2010, the cruise liner RMS *Queen Mary 2* was approaching Barcelona when one of 12 capacitors in a harmonic filter[1] failed **(Figure 1)**, accompanied by a loud explosion. The explosion resulted in extensive damage to the surrounding electric panels and caused the vessel to black out. There were no navigational hazards nearby, main power was restored at 0455 and the ship was able to get back underway at 0523.

Figure 1



Capacitor which failed causing it to rip off the foundation bolts and rise approximately 60cm

The harmonic filter was connected directly to 11kV bus bars and was located in a compartment within the aft main switchboard room. The blast forced the steel door to the compartment out through its frame and also caused serious damage to an adjoining steel door into the main switchboard room **(Figure 2)**. The stiffeners on the bulkhead of the compartment were buckled and the steel cover plate on a cross-flooding duct was blown out into the main switchboard room. Fortunately there were no personnel in the vicinity. The steel casing of another capacitor in the same group was found to have bulged severely and was possibly on the verge of failure **(Figure 3)**.

There was evidence of smoke and heat in the compartment **(Figure 4)**, and any fire was probably extinguished by water from the hi-fog system. Two hi-fog outlets, one in the harmonic filter compartment and the other in the main switchboard room, were activated in the wake of the blast.

---

[1] Harmonic filter: Alternating current (AC) motors for electric propulsion operate on variable frequency and voltage. Thyristors used in the power converters result in voltage distortion. Passive harmonic filters, when applied correctly, are designed to attenuate the harmonic currents which result in excessive voltage distortion and which may otherwise damage or disrupt equipment connected to the electrical network.

Figure 2

Damaged steel door to the harmonic filter compartment

Figure 3

Top view of two capacitors indicating one which had developed a severe bulge due to internal pressurisation

Figure 4

Soot staining on the blown-out doors of the harmonic filter casing

ANALYSIS

Preliminary findings of the investigation carried out by the manufacturer of the capacitor indicate that the capacitor had deteriorated gradually. The monitoring device based on current unbalance detection did not give any indication of the fault developing. The dielectric oil appeared to have vaporised due to internal short circuiting, causing internal pressure to build up and resulting in the oil leaking out and being sprayed onto the high voltage bus bars. The oil vapour is likely to have provided a conducting path between the live phases of the 11kV terminals, resulting in a major arc flash event.

Catastrophic failure of large capacitors has been experienced in land-based high voltage installations. One or more of the following can cause such failures:

- Excessive harmonic currents and voltages produced by electronic power converters during the voltage rectification process in variable speed electric motor drives.
- Transient voltage spikes and 'line notching' produced in thyristor power converters.
- Radiated heat from resistors and electromagnetically induced heating from inductor coils within passive harmonic filters.
- High ambient temperatures or blocked ventilation.
- Degradation due to ageing.

The MAIB, in co-operation with the manufacturers of the harmonic filters, the ship owner and subject matter experts, is carrying out a detailed investigation to find the exact technical cause of the failure on board RMS *Queen Mary 2*.

RECOMMENDATION

S2010/139 Operators of vessels with electric propulsion which have large capacitors in harmonic filters, should urgently:

- Inspect the capacitors and check for any physical distortion, unusual smells (indicating dielectric fluid leakage) and signs of external overheating.
- Ensure that the cooling and ventilation systems are functioning correctly.
- Calibrate and function test any fault detection or condition monitoring system fitted.
- Ensure that if there is a history of capacitors in the equipment needing to be replaced, the underlying causes are understood.
- Carry out a thorough check for the cleanliness of all exposed conductors as well as for external signs of chaffing damage on high voltage cables.

Owners and operators of vessels or offshore platforms who have experienced catastrophic failures or bulging of capacitors in harmonic filters are requested to inform the MAIB by e-mail (maib@dft.gsi.gov.uk) using the title 'Capacitor failures' and include the name of the vessel or platform, the system manufacturer, and the date and place of installation.

This information is for internal use only and will be treated in the strictest confidence.

Issued December 2010