AMEM Communication

031 – December 2010

Queen Mary 2 catastrophic explosion causes total power outage

General

The largest true transatlantic ocean liner in the world – *RMS Queen Mary 2* – features an IFEP Integrated Full Electric Propulsion system that uses both diesel engines (base load) and gas turbines (peak power) to generate electricity for electric motors, where there is no mechanical transmission from either to the propellers. Classed by Lloyd's Register and MCA Maritime and Coast Guard Agency, Cunard's flagship was intended primarily to cross the Atlantic Ocean several times per year, and was therefore designed differently from many other passenger ships, in particular cruise ships. The price tag was much higher compared to standard cruise ships of the same size, because of the high quality materials used and the consumption of 40 % more steel!

The world's largest passenger ship has a very high power demand, due to its large size and weight, and the high speed (26 knots). This puts emphasis on some unique characteristics.

Queen Mary 2's power plant comprises both (4) sixteen cylinder Wärtsilä 16V46CR Enviro Engine marine diesel engines generating a combined 67,200 kW (90,100 hp) at 514 rpm, as well as (2) General Electric LM2500+ gas turbines which together provide a further 50,000 kW (67,000 hp). Diesel engines and gas turbines drive electrical generators , which provide the power to drive (4) 21,500 kW (28,800 hp) Converteam (former Alstom) electrical motors located inside the Rolls Royce Mermaid podded propulsors and thus entirely outside the vessel's hull. The two gas turbines are not housed deep in the hull, but reside in a soundproof enclosure directly underneath the funnel. This arrangement allowed the vessel's designers to supply the oxygen hungry turbines with air intakes without having to run air ducts the entire height of the ship, which would have wasted valuable interior space.

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Integrated Automation, Control & Monitoring Systems

The bridge of the *QM2* is located on deck 12, and is the navigation and safety centre of the vessel. Consisting of a central navigation area, chart room, safety centre, and two totally enclosed bridge wings, the bridge is manned 24 hours a day by two navigation officers.

The Integrated Automation System ensures the control of the following installations and functions:

- Power management
- Alarms & monitoring
- Propulsion supervision
- Bilge / ballast system
- Cargo management and handling
- Ship auxiliaries
- Process control

The system is totally compatible with the propulsion control and the dynamic positioning system. It covers four functional levels, with possible redundancy features:

- Multi-station centralized control &monitoring
- Local control & monitoring
- Process control
- Input/output functions

Partial view switchboard

A Computer Safety System (CCS) enables the officer to monitor all safety systems throughout the ship.

Nevertheless, the propulsion system is designed to be operable even without the automation, control and monitoring system working. In the case of an engine room incident, the ship remains at minimum with 50 % of propulsion power even in a degraded mode with auxiliaries and/or part of the propulsion system not in operation.

Passenger ships, as well as cruise ships and ferries have to satisfy very stringent rules and requirements concerning the redundancy of the entire propulsion system. It is designed in such a way that any disturbance in the machinery will cause the least possible effect on ship's speed and passenger comfort.

So far so good.
It all works perfectly well in theory.
But reality is quite different!

Total power outage due to catastrophic engine room explosion on *QM2*

Early in the morning on 23 September 2010 at 0426 hours, the passenger ship *RMS Queen Mary 2* was approaching Barcelona when one out of 12 capacitors in a harmonic filter failed. Leaking oil was sprayed onto high voltage bars, causing a major arc flash event, in other words – a heavy explosion near one of *QM2*'s main electric switchboard rooms. The harmonic filter* was located in a compartment within the aft main switchboard room. The explosion resulted in extensive damage to the surrounding electric panels and caused the

* Alternating current (AC) motors for electric propulsion operate on variable frequency and voltage. Thyristors used in 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.

vessel to black out. The *Queen Mary 2* was drifting off the coast of Barcelona with no power! After approximately one hour the ship slowly started to move and limping towards port.

If things were designed properly, all the power shouldn't have gone out!

According to the MAIB Marine Accident Investigation Branch report, the situation was more serious than passengers knew. The report goes on to say that the explosion was forceful enough to damage steel doors and casings and buckle stiffeners on the bulkhead of a compartment within the aft main switchboard room. He steel cover plate on a cross-flooding duct was blown out into the main switchboard room. The MAIB's investigation revealed that the capacitor had "deteriorated gradually", yet monitoring devices did not detect the problem. Therefore the MAIB issued strong recommendations to cruise lines and other ship owners to prevent similar events from taking place. The recommendations include inspecting the capacitors for signs of physical distortion, ensuring that cooling and ventilation systems are operating normally, testing monitoring devices and checking for cleanliness of exposed conductors and chaffing damage on high voltage cables.

The MAIB reporting of this incident raises the issues of safety, predictive, preventive and planned maintenance as well as the use of original equipment manufacturers' components, reduction of operating costs and the liability of classification societies.

Resumee

To be fully dead in the water takes many, many system failures! Floating cities like the *QM2* or *Carnival Splendor* must not suffer from a total breakdown of power! Their propulsion concept will have to be completely rearranged. IFEP Integrated Full Electric Propulsion will have to be abandoned and there will be a strict physical separation between main and auxiliary (emergency) power supply. Proactive retrograde steps toward minimum one direct drive for emergency operation controlled via a

Queen Mary 2

conventional (simple) switchboard will have to be taken.

Due to the size of today's modern cruise ships, the distance they travel from ports, and the enormous number of passengers they carry, an onboard explosion / fire in the engine room could have devastating consequences. What happens next time in a distant location midAtlantic, midPacific, in Arctic waters or the North Sea?

Cruise line operators will have to learn their lesson that even the Mediterranean Sea is not a year round covered swimming pool illuminated by an artificial sun and half an hour power outage in European waters can end up in a catastrophe.

The number of reported as well as the estimated number of unreported engine room accidents is far too high! Safer operation of passenger and cruise vessels should have priority over green shipping!

It should be mentioned in this context that this was not the first *QM2* power outage incident. During a westbound transatlantic passage, *QM2* lost power and propulsion in the early hours of August 15, 2008. It took more than an hour until emergency power was restored. QM2 could continue her voyage at reduced speed for 18 hours. When the liner was catching the tail of a hurricane with force 11 winds, heavy swells and huge waves, sufficient power was available to weather the storm.

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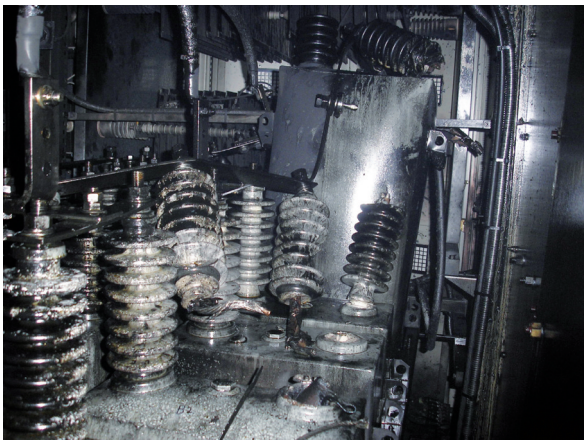
The Marine Accident Investigation Branch (MAIB) examines and investigates all types of marine accidents to or on board UK ships worldwide, and other ships in UK territorial waters. Located in Southampton, the MAIB is a separate branch within the Department for Transport (DfT). It is not a part of the Maritime and Coastguard Agency (MCA).

The powers of MAIB inspectors, and the framework for reporting and investigating accidents, are set out in the Merchant Shipping Act 1995.

Mangled steel door from the aft main switchboard room
Source: *MAIB SAFETY BULLETIN 4/2010, www.maib.gov.uk*



Harmonic filter compartment – source of explosion
Source: MAIB SAFETY BULLETIN 4/2010, www.maib.gov.uk