Fit for a Queen!

ABB climate control on board the Queen Mary 2

Örjan Götmalm, Odd Andsberg

The longest, widest, tallest, most expensive … superlatives abound for the Queen Mary 2, the latest and most luxurious of Cunard's ocean liners. Helping to make sure it lives up to its reputation is a state-of-the-art heating, ventilation and air-conditioning system from ABB.

The Queen Mary 2 left Southampton, England, on January 12th, for her maiden voyage to Fort Lauderdale in Florida. In her inaugural year, she will make 13 crossings between England and New York at up to 32 knots, taking over as Cunard's transatlantic liner from her sister ship, Queen Elisabeth 2.

ABB on board

ABB will be a constant companion of the luxury liner, although her passengers will hardly notice it. The ship's heating, ventilation and air-conditioning (HVAC) system, which ABB delivered, is unobtrusive, quiet, efficient and largely invisible. Yet, it is massive, in fact the largest ever designed for a passenger vessel. Versatile, too – it automatically maintains the ship's indoor climate within the required comfort range whether she's plowing through icy-cold waters in the North Atlantic or lies at anchor in the sunny Caribbean.

Besides supplying the HVAC plant, ABB was also responsible for other major deliveries to the QM2, including the generators and the main switchboard with LV panels and protection gear.

Sea breezes and fresh air

After a leisurely stroll on the promenade deck in the bracing sea air, QM2 passengers will expect a fresh and agreeable atmosphere when they enter a dining area or go to their cabins. And they will not be disappointed. The HVAC system supplied and installed by ABB will ensure their comfort under all circumstances.

The demands made on such a system are huge, to say the least. Air treatment plants on large contemporary cruise ships can handle some 30 million cubic meters or more of air every day. In tropical climes, this means not just cooling the air, but also ridding it daily of 100 to 500 tons of water.

The sheer volume involved almost defies imagination. Try to visualize a column of air, one meter in diameter and reaching all the way to the moon. That's how much air the air-conditioning plant on board the QM2 treats during a typical 10-day cruise.

Table 1: QM2 facts	
Length	350 meters / 1132 feet
Beam	40 meters / 135 feet
Draft	10 meters / 33 feet
Height (keel to funnel)	72 meters / 236 feet
Gross registered tonnage	150.000 gross tons
Passengers	2,620
Crew	1,253
Power	157,000 hp
Speed	30 knots / 34.5 mph / 55.2 kph
Propulsion	4 pods, each rated 20 MW

Table 2: HVAC data	
Summer conditions – outside	35 °C and 85 % rel. hum.
Winter conditions – outside	–5 °C and 95 % rel. hum.
Summer conditions – inside	24 °C and 60 % rel. hum.
Winter conditions – inside	22 °C and 30–60 % rel. hum.
Air flow rate	450 m^3/s
Heating power	9 MW
Cooling power	22 MW (gross)
Chilled water flow	2,700 m^3/h

Air-conditioning at sea – the challenge

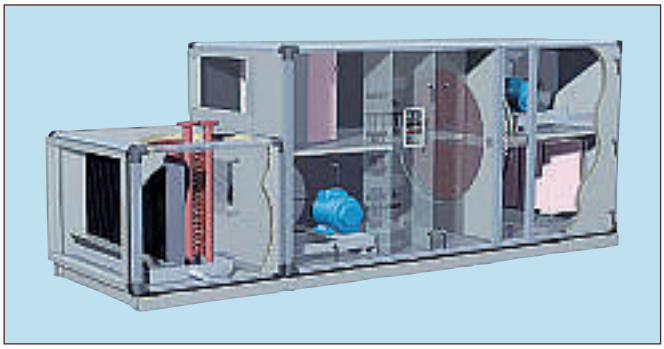
For ships plying the North Atlantic year-round, keeping cool is never a problem. However, in the tropics it is. Here, passenger ships have traditionally had to have awnings, shaded decks, air-circulating systems and high ceilings to provide relief from the heat.

Air-conditioning at sea poses a special challenge. Whereas ashore, insulation and wall thickness can be used to reduce heat transfer by conduction, on board a ship space is at a premium. Also, the very metal of which ships are made is an excellent heat conductor.

On the QM2, this problem is compounded by its sheer size. With hotels having more than 600 rooms already thought of as being 'large', it is worth considering that the QM2 has more than 1,500 passenger cabins and around 750 crew cabins, and that these are scattered over 10 decks.

To cope with such a configuration, the QM2 has nine air-conditioning zones, coordinated with the ship's fire zones. These are served by five chillers with a total rating of 25 MW, located amidships along the keel within the machinery spaces. The total weight of the chilled water plant, including the piping and the water compressors, is 550 tons.

In all, the QM2 has 122 air-handling units for the accommodation areas and 43 for technical spaces. Weighing between 2 and 3 tons each and located along the ship's spine, they convey fresh air from the skin of the ship to its interior and stale air to the outside.



EMAA air-handling unit. 122 of these units are installed on the QM2.

With air quality dependent on eight to twelve air changes per hour, the right balance had to be found between the noise level, comfort level for passengers and crew, and space requirements for air supply and exhaust. Compact ABB air-handling units, combined with booster units, provide this balance, and have been used by ABB in similar configurations in a number of newbuildings.

The solution that was chosen has ABB MONOVENT® fresh-air control units installed for the QM2 suites and de luxe cabins, while the passenger cabins are equipped with an air-circulation unit located in the service locker just outside each cabin.

Multi-deck dining rooms are especially challenging to the HVAC engineer. To ensure an even temperature over the entire area, the air-conditioning system was integrated in the ceiling in a way that ensures the right airflow and mixing.

The ship's air-conditioning system also plays a major role in the water management. One of the air-conditioning system's main tasks is to maintain relative humidity levels of between 30 and 55%, depending on seasonal and climatic variations. The water that is removed from the air – up to 500 tons a day on the QM2 – is collected and used for cleaning purposes,

for example in the ship's laundry.

Passenger safety is all-important

The specification for the QM2 stipulated HVAC active smoke control for several large public spaces. Advanced CFD was used to verify the design of the fire smoke control system, especially its ability to clear smoke from the ship's large multi-storey theater. One of the parameters that received particular attention was the system's ability to remove smoke from the escape routes and the areas near them. The simulation verified that the space should be cleared of dense smoke within the statutory 10 minutes.

EMAA integrated power & automatic control unit

Air-handlers have a small footprint

The air-handling units on the QM2 supply 1,800 tons of fresh air, filtered, cooled and/or heated, per hour, to keep the ship's interior comfortable irrespective of the weather outside, the time of day, the ship's bearing and speed, and thermal load variations within the vessel.

New EMAA air-handling units with coolant pipes mounted topside are installed on the QM2. Besides making installation easier, their compact design saves a considerable amount of expensive deck space. Factory-tested, integrated electrics and control systems with forced cooled frequency converters ensure precise control of the variable air volume and air pressure.

An air-handler typically supplies the interior of the ship with 28 tons of conditioned air hour after hour to counteract thermal loading and replace stale air economically and safely. The EMAA units are packed with the latest air technology and come with smart integration of electrical and automation equipment ready for hook-up. Their fans and other components are highly efficient, with casings designed for compactness and high specific airflow capacity.

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High energy efficiency

The efficient utilization of energy is a cornerstone of ABB's HVAC system design philosophy. This is because the energy consumption of the HVAC system on board a cruise liner is second only to the energy consumption of its propulsion system.

ABB Variable Air Volume (VAV) systems constantly adjust their capacity to suit changing needs, while the fan-speed acts as an energy conservation device. In addition, the controller locks out fan speeds that could give rise to resonant frequencies – a common problem with conventional fan-speed control.

Sounds of silence

Only very low noise levels are allowed on the QM2 – 40 dB(A) for cabins and 50 dB(A) for public spaces. Special consideration therefore had to be given to the choice of fans, ducts, silencers, dampers and air distribution devices. This was especially important considering that some 60 km of pre-fabricated circular ducting were installed in addition to the non-circular ductwork.

ABB engineers analyzed the theoretical models and performed full-scale tests in close cooperation with ABB Corporate Research in Sweden to confirm that the noise levels would not be exceeded.

Control system

The HVAC control system for the QM2 was built around ABB Advant 31 programmable logic controllers. Over 400 of these super-fast PLCs automatically control some 40,000 hardware and software tags. Since it incorporates a very high level of redundancy, the system is

virtually impervious to global system faults.

The crew should have no difficulty learning to manage this robust and relatively simple system. Data from some

> A tropical test performed in spring 2004 confirmed the ABB control system's ability to maintain the temperature in public places to within ±0.1 °C of its setting.

6,500 individual points are automatically collected and packaged for communication with the integrated automation system, which allows limited remote monitoring of the HVAC.

Cunard and Queen Mary 2

Cunard's latest ocean liner, the Queen Mary 2, is the largest, longest, tallest and widest passenger ship ever built (www.cunard.com). Standing beside her at the quayside, visitors behold a structure as tall as a 21-story building. Stood on her end, she would be a hundred feet taller than the Eiffel Tower. If she were afloat in the pool at the foot of Niagara Falls, her stack would rise more than twenty feet above the rim.

Stepping aboard the QM2, guests will enter a realm of sweeping spaces and grand designs the likes of which have not been seen for decades. They will stroll a broad, 1/3 mile-long teak promenade deck that encircles the entire ship. A lobby that towers over three decks high, graced with a sweeping grand staircase and monumental works of art, will entrance them. They will travel in accommodation that varies from the commodious to the shamelessly extravagant.

Passengers on Queen Mary 2 have ten dining venues to choose from, as well as the only Canyon Ranch SpaClub® at sea, the world's first planetarium at sea, the largest library at sea, and the largest wine collection afloat. It also features a Veuve Clicquot champagne bar, a two-story theater, a casino, five indoor and outdoor swimming pools, hot tubs, boutiques and children's facilities complete with British nannies.

Seven multi-purpose classroom facilities comprise a College At Sea, with expert instruction in a wide variety of subjects. Like her sister, the QE2, QM2 boasts a ballroom, with an orchestra. She has a health, fitness and relaxation area of over 25,000 square feet.

Queen Mary 2 was built in the Alstom, Chantiers de l'Atlantique shipyard at Saint Nazaire, France (www.alstom.com).

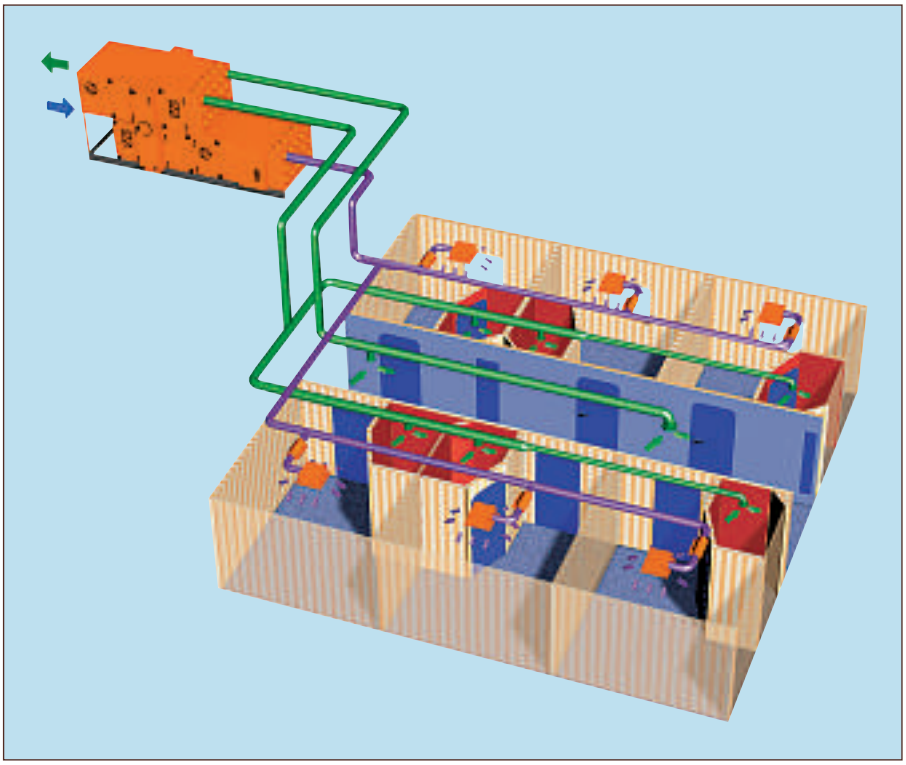

ABB MONOVENT® units are installed for suites and de luxe cabins on the QM2.

Fans of modern air-conditioning

Shipboard ventilation has come a long way from louvers and punkahs to the automatically controlled air-conditioning we enjoy today. Modern cruise ships offer passengers a level of comfort and an ambience comparable with that of the most luxurious hotels on land. Working silently and efficiently, advanced air-handling units maintain the temperature and humidity on board the Queen Mary 2 at the same agreeable level, come winter gale or tropical heat wave.

Örjan Götmalm
Odd Andsberg
ABB Automation Technologies
Marine Ventilation
Gothenburg
Sweden
orjan.gotmalm@se.abb.com
odd.andsberg@se.abb.com