Atomic kitten

Plant engineering around nuclear submarines is somewhat specialised. Brian Tinham talks to Rolls-Royce Nuclear Propulsion Systems about how they keep this plant purring

Pointers

- Inspection technologies include ultrasonics, digital radiography, eddy current testing, resonance testing, liquid dye penetrants and putty replication for microscopic and laboratory inspection
- Rolls-Royce uses all the non-invasive techniques on pipework, connections and vessels etc
- Bearings on the reactor plant's coolant pumps are checked using noise and vibration monitoring
- Beyond that, it's nothing more fancy than checking slow-down rates with power off, and examining the emf as they spin down to rest

Ever wondered about nuclear submarines and the issues for plant engineers in operational and supporting roles, either on-board or dockside? Andrew Law, specialist in the operational plant support department at Rolls-Royce Nuclear Propulsion Systems, is your man.

Part of the team responsible for managing nuclear steam-raising plant on the Royal Navy's fleet, and currently refitting Vanguard Class submarines in Devonport, he coyly describes the engineering as not dissimilar to civil installations. "Except that it's all compressed into a 30ft diameter tube, packed with high temperature, fast-rotating machinery designed to go anywhere in the world, mostly underwater," he quips.

And that has implications all the way from plant installation and commissioning, to operations, maintenance, the test and measurement technologies and engineering methods. It also requires much from the plant engineers on-board.

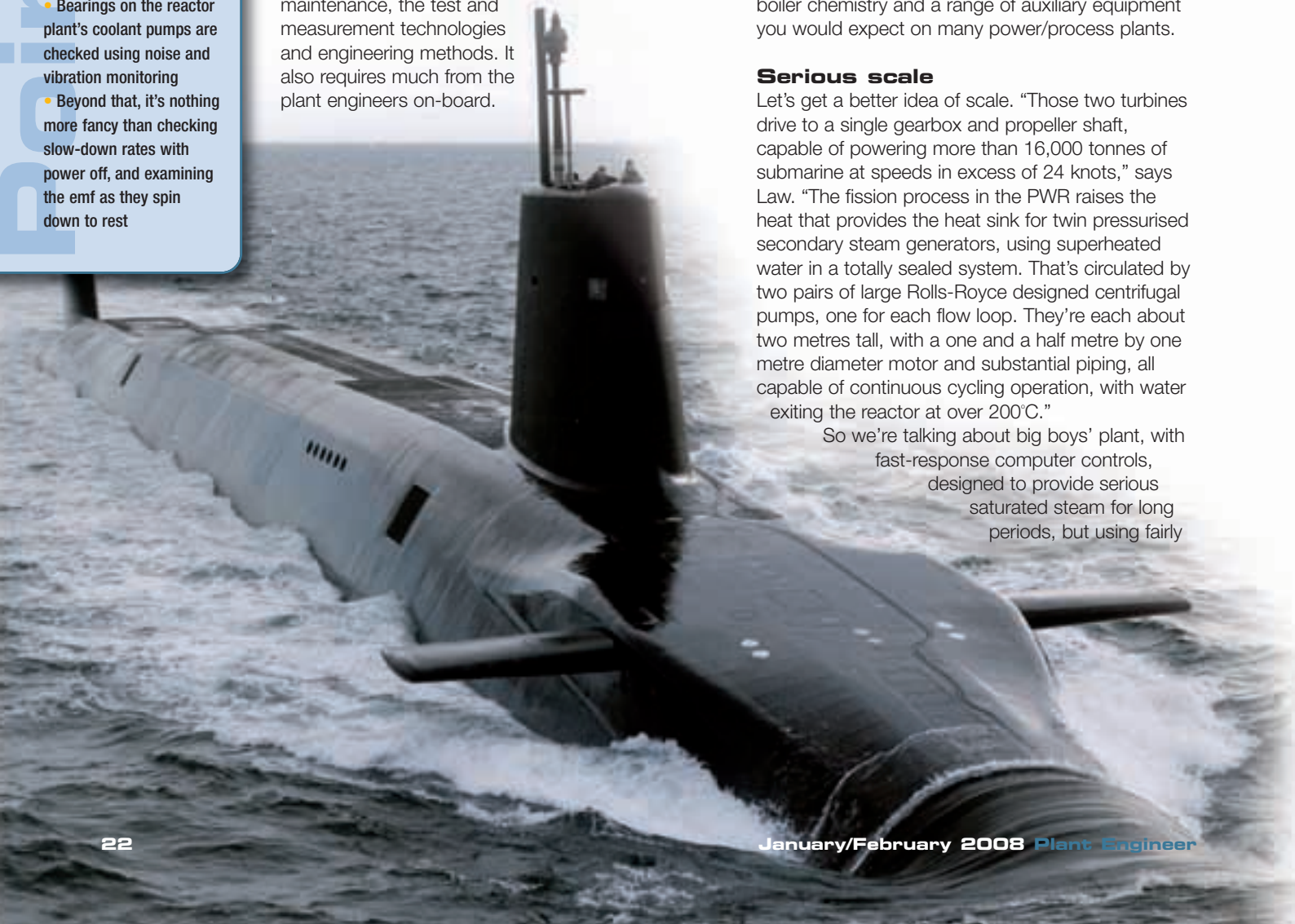
"There aren't many service agencies you can call on when you're on the other side of the planet, so the regime has to be engineers as operator-maintainers," says Law.

That said, primary plant on board a Vanguard nuclear submarine includes the new generation pressurised water reactor (PWR) itself, designed by Rolls-Royce to last 25 years without refuelling, along with associated steam-raising plant. This drives two steam turbines and two turbo-generators – the former for propulsion and the latter delivering electrical power for weapons systems, domestic equipment and life support. Beyond all that are the systems for emergency shutdown, automatic monitoring and control, remote major valve controls, performance monitoring, sampling equipment, boiler water replenishment plant, treatment systems for boiler chemistry and a range of auxiliary equipment you would expect on many power/process plants.

Serious scale

Let's get a better idea of scale. "Those two turbines drive to a single gearbox and propeller shaft, capable of powering more than 16,000 tonnes of submarine at speeds in excess of 24 knots," says Law. "The fission process in the PWR raises the heat that provides the heat sink for twin pressurised secondary steam generators, using superheated water in a totally sealed system. That's circulated by two pairs of large Rolls-Royce designed centrifugal pumps, one for each flow loop. They're each about two metres tall, with a one and a half metre by one metre diameter motor and substantial piping, all capable of continuous cycling operation, with water exiting the reactor at over 200°C."

So we're talking about big boys' plant, with fast-response computer controls, designed to provide serious saturated steam for long periods, but using fairly



conventional pressure vessel technology and controls, albeit rather shoehorned in. “The pressuriser that maintains the entire reactor coolant pressure, for example, is a large pressure vessel, and that’s the only place in the reactor plant where the water is allowed to boil, with continuous automatic controls on the vessel heaters as part of the reactor instrumentation,” explains Law.

“Also, water on the primary side is demineralised, deoxygenated and ultra pure, so it has to be regularly tested, using a sampling system and lab testing, checking for zero oxygen and optimum pH, and for any radio nuclides that may give an indication of reactor fuel damage.” Treatment on the secondary side is also tightly controlled to protect the thousands of stainless steel heat exchanger tubes carrying reactor water, but now you’re into fairly standard boiler chemistry.

Sealed system

As for the major control valves he refers to, since it’s not possible to get onto the main plant while the reactor is operating, everything has to be remotely managed, with hydraulics providing isolation, again much as per the process industries, except that the control and actuation medium is water. Also, the pressure relief systems discharge into a catch tank within the reactor plant, so that lost pure water can be regained – although there is water replenishment plant. When Law says it’s sealed, he means it. The entire pressurised plant is fully welded and provided with secondary containment.

What about managing all that? “We think of it as a compact mobile power station with some additional redundancy and systems,” says Law. “For example, the operating regime is similar to that on a civil reactor plant, with the usual protection systems, but you have to bear in mind that, no matter how sophisticated those are, if the PWR tries to shut down, it could put the submarine in a difficult position. So we use the fact that the plant is dispersed around the reactor compartment, with duplicated loops, to provide some redundancy and there are emergency procedures. That’s something you’ll never see on a civil PWR.”

There’s also continuous back-up, provided by the Rolls-Royce team, which receives plant data from the submarines, once they return to port, for analysis of transients, thermal shock, component design life and overall plant behaviour.

“All this data is logged hourly by the crew, so there’ s a lot of data to analyse,” adds Law. “We keep very close to the operating submarines, and we’re also always involved in inspection and validation. We have people on the bases and we provide an emergency response organisation, which is exercised on a regular basis with different incident scenarios.”

What about those inspection technologies? “Ultrasonics, radiography – including now digital radiography – eddy current testing, resonance testing, liquid dye penetrants and putty replication for microscopic and laboratory inspection: we use all the non-intrusive techniques on the pipework, connections, vessels and so on, and some of those have now been deployed on civil installations,” he says. But the rest is less exotic. Bearings, for example, on the reactor plant main coolant pumps are checked using noise and vibration monitoring, and, beyond that, it’s nothing more fancy than checking slow-down rates with power off, examining emf as they spin down to rest. PE

Vanguard class submarines present some testing challenges for marine plant engineers