Under Pressure

Writer Jennie Clarke

With over 40 years' experience in boiler design and manufacture between them, what mechanical engineers Doug Cockerell and Peter Judd don't know about boilers, as the saying goes, "ain't worth knowing".

Both men cut their engineering teeth in the hydro industry: Mr Cockerell in Tongariro, then Clyde; Mr Judd in the Waikato. Then came the ANZAC frigate project in Palmerston North for Mr Cockerell, while after the mandatory OE Mr Judd found himself rebuilding a dairy factory following the 1987 Edgecumbe earthquake.

These days, Mr Cockerell is the General Manager and Mr Judd the Engineering Manager for Lyttelton Engineering, a company that's been building boilers and repairing ships alongside Lyttelton Harbour since 1953. Boilers account for up to 45 per cent of the company's turnover, year on year.

Mr Cockerell says boilermaking complements the ship repair side of the business: "Our guys are craftsmen and specialists at shaping plates. I mean, there's nothing straight on a ship, every plate is curved and just about everything we make, including boilers and pressure vessels, are cylindrical shells made from sheets of steel that started life with straight edges and sharp corners." The similarities don't end there, however; the high-level inspections that accompany boiler building are similar to the inspection requirements for ships: but more of this later.

There's no doubting boilers are important. "Pretty much the entire process industry runs on steam," Mr Judd says. "Steam's the energy transmission medium, so you'll find virtually every processing plant or institution – be it a dairy or wood pulp processing plant, a hospital or a school – has a boiler."

Opposite: The 7.5-Megawatt standby liquified petroleum gas/diesel boiler being craned into position at Christchurch Hospital. Photo: Christchurch District Healthboard.

Above: Engineering Manager, Peter Judd, in front of two fire tube boilers under construction in the workshop. Photo: Murray Irwin.

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It's clear that boiler failure is something to be avoided if institutions and plants are to keep operating. There are other reasons to avoid failure too: due to their high temperature and high pressure operation, boiler failure is often synonymous with catastrophe, including loss of life.

So what hazards contribute to boiler failure and how are they mitigated?

Low water level within the boiler is the biggest hazard. The already heated surfaces and hot gases overheat and shortly after, following failure of the steel which softens when it's overheated, the boiler explodes. Preventing such dramatic failure requires a raft of safety measures built into boiler control systems, which remove the heat source. With a gas-fired boiler, a valve shuts, the flame stops and it's all over. With a solid-fuel fired boiler it's a bit more interesting as the bed of coal or wood waste and associated refractory has an immense residual heat and keeps burning. Mr Judd: "Providing there's still power, cooling water will be circulating because the pumps are running. But if there's a power cut, it's a different story. We test the boilers when they are commissioned by simulating a power cut. If it's not safe, then an alternative form of energy supply has to be installed – backup generators that come on automatically, for example."

Then there's the potential for fire-side explosions – at ignition and during operation. Take gas-fired boilers: gas build-up in the ignition chamber equates to a huge potential for things to go wrong. So, before each ignition, the space is automatically purged with fresh air – at least five times – to ensure it's clear of gas. Then, during operation, it's about maintaining a safe and efficient fuel to air ratio in the combustion chamber: if the air ratio gets too low, carbon monoxide is produced at a rate of knots, and again there's potential for explosion.

What about burn hazards? "Hot surfaces are either protected or there's plenty of warning signage. Actually, as well as keeping people safe, you're trying to stop the heat loss regardless, trying to use it in process to maximise efficiency," Mr Judd says.

Safe access is another big issue for boiler designers and manufacturers. Code requirements have tightened up significantly over the last 10 years. "Requirements to provide safe access – to ensure that people can actually work on the plant and not risk falling and injury – are stringent. Some of our biggest boilers are almost seven metres high. That's a long way to fall."

Of course, boiler safety is not just about operational issues. The New Zealand code of practice for design and manufacture of boilers, including third party independent inspection and certification provision, is focused on safety. Manufacture can only begin once design has been certified by an approved design verifier. Then, during the build, equipment inspectors – and here's that high-level inspection regime – make between 10 and 20 visits to the workshop, inspecting weld preparations, auditing material certifications, checking completed welds, until finally, the hydraulic test – the ultimate test to prove the vessel is sound and secure.

Mr Judd says that while New Zealand's code of practice and certification process is robust, there's concern within the industry about the quality of some imported boiler plant and the effect that might eventually have on safety. "There's pretty good evidence of some smaller boiler plant coming into the country that's missed the certification process altogether – people buying off the 'net, not realising they have to meet these requirements. And it's getting installed and commissioned, completely side-stepping the regulatory environment, which is a worry, because the concern is that one day there might be an incident that could have been avoided."

While Lyttelton Engineering manufactures most of its plant, its import focus is on sourcing materials from Australia, Europe and certain Asia countries. "We've found the quality is actually pretty variable from some parts of Asia. In fact, we've had some pretty scary events with some pipe fittings that have turned up here with cracks in them. You can't always trust the certification; it sometimes appears to be fabricated, and that's quite scary because if those materials are being used in New Zealand – and they are available, you can buy them from many of the steel suppliers – there will be some failures sooner or later. So we go to some effort to actually avoid using that stuff because it's just not worth the risk," Mr Cockerell says.

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According to Mr Cockerell, as the level of boiler automation and instrumentation has increased, so too has their inherent safety. "They're a bit like aircraft; they have to have backup systems to be 100 per cent failsafe: there can't be anything on it that could go wrong and cause a hazardous situation. The idea is for the controls to shut the plant down immediately a critical fault is detected, so there is some control duplication: two low-level alarms so that if one doesn't work there's another. It's backup, backup, backup."

It's no surprise then, that automated boilers – and most boilers constructed in New Zealand since the mid-80s are fully automated – require additional design and manufacture approvals, including control system verification pre- and post-commissioning. Mr Cockerell: "Once up and running, automated boilers look after themselves: the control system adjusts fuel levels to match the load, regulates the pressure in the system, that sort of thing, and they have to be tested by an ISO 9001 boiler servicing company or manufacturer's representative every three months. [ISO 9001 deals with the quality management system requirements that organisations wishing to meet the Standard have to fulfill.] In fact, it's no longer possible to manually operate a fully automated boiler – it's physically impossible to override the controls, and, actually, it's not permitted."

Below: A two-Megawatt gas fired boiler for New Zealand Pharmaceuticals in Palmerston North, nearing completion in the steel fabrication shop. Photo: Murray Irwin.

Satisfying New Zealand's seismic requirements is another key safety element in boiler design. Events of the past three years have shown why. The company won the contract for Christchurch Hospital's replacement boiler plant. It's a highly complex plant, designed, unusually, for several fuel-type changes throughout its life. Plus, with its two-stage heat recovery and two-stage emission control equipment – what comes out of the stack is basically a clean heat haze – it's absolutely state-of-the-art. Mr Judd explains: "By mid-February 2011, the first of the hospital's two new boilers, 45 tonnes of it, had been jacked up on site, ahead of installation on its 4.5-metre-high support frame. Barely was the weld cool before the big quake of 22 February rocked on through. Welding was completed on 21 February, and the plant absolutely didn't move! In fact, none of our boiler plant installed in Canterbury was affected by that quake. There was some foundation movement but virtually all the plant was running the next day. That's pretty damn good. It says a lot about the codes and standards we work to."

That Christchurch Hospital project stands out as the most challenging of Mr Judd's 25 years of boiler projects with the company. "Maintaining the service and getting new plant commissioned while working around ongoing earthquake issues – including a collapsing service tunnel from the plant to the hospital and a significantly damaged chimney stack – plus keeping everyone focused going in the right direction when we were all dealing with our own personal earthquake situations was outstandingly difficult."

That's no understatement. Considering the years of experience and numerous, highly complex challenges this duo, and the company they work for, have faced, the unjust demands of the Christchurch quakes might have weakened even the strongest nerves of steel. But the boilers appear to have survived the seismic onslaught and are powering full steam ahead into the future – safety first, of course.