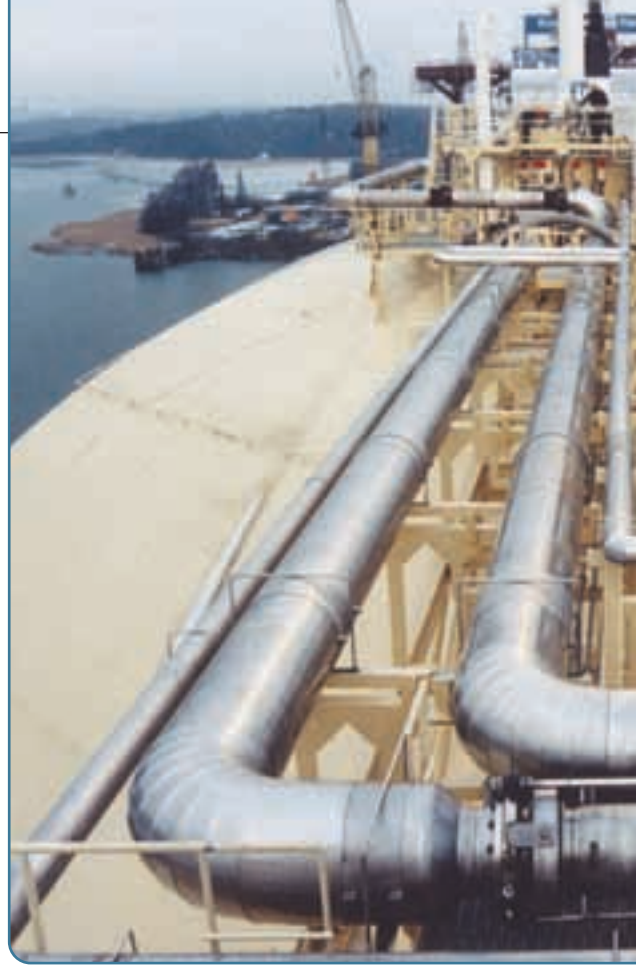
Bellows baloney

Flixborough did no favours for bellows manufacturers, particularly Teddington. Brian Tinham talks to its technical team about the real world

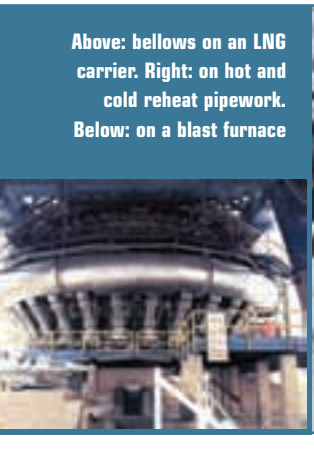


Contrary to popular misconception, metal bellows expansion joints are as useful as any other of the tools in the plant engineer's armoury – provided good mechanical engineering practice is followed. So says bellows manufacturer Teddington Engineered Solutions, the firm whose predecessor's equipment was linked to the Flixborough disaster 34 years ago.

Its defensiveness is entirely understandable. The company makes the very valid point that it was flawed plant modifications at Flixborough that led to the catastrophic chain of events (Plant Engineer, May/June 2007, page 8), not the bellows themselves. Yet, ever since, bellows have been tarred with the brush of suspicion. At the London 'Flixborough Revisited' conference last April, HAZOP/HAZAN guru and celebrated author Trevor Kletz declared: "You should avoid bellows on flammable and dangerous services. Use them only on steam and low pressure systems."

"That's plain nonsense," says Peter Evans, chief design engineer at Teddington. "You've got to remember that, on Flixborough, prior to Reactor Five being removed, the bellows were perfectly well installed and operating within engineering guidelines. The cause of the problem was the dogleg connection, installed using the original bellows, but inadequately supported on scaffolding – meaning the system became inherently unstable. That situation was unacceptable then and is unacceptable today for any bellows installation."

He refers to a designers' guide to bellows, recognised by engineers at the time and cited in the court inquiry – and, in fact, produced back in the 1970s as Teddington's own catalogue for plant engineers. "Bellows, in their nature, are a critical element in a piping system – they are designed to allow a certain flexibility, depending on how they're restrained. That bellows installation was fundamentally changed, with just an ONC engineer on-site who paid no regard to the impact of what he was doing on the bellows and pipework. It became an accident waiting to happen."



Above: bellows on an LNG carrier. Right: on hot and cold reheat pipework. Below: on a blast furnace

Engineering common sense

This should be the lesson of Flixborough: plant modifications of any kind – and bellows are no exception – must be referred to competent engineers for validation and acceptance. Yes, some care is required in handling bellows – they're flexible elements, so in lifting, stacking and so on, it's important not to damage or stress the convolutions. But that's little more than engineering common sense, and there are similar precautions for everything from control valves and actuators to instrumentation, bearings, gaskets and seals – you name it. And we don't just use them on steam or low pressure service.

Also, there's an interesting counterpoint: right up to the design life specified, bellows need no maintenance. The only reasons to change them are if they get damaged accidentally, or the service changes. Evans explains: "We design bellows for a fatigue life, whether that's 1,000, 5,000 or 500,000 cycles. On process plant, for example, they know

updated 40-year-old American EJMA (Expansion Joint Manufacturers Association) code, around which the new standard is written, provides comprehensive guidance.

That said, the list of bellows types, materials, sizes etc, is considerable and often bespoke to the application – much like process transmitters and automatic valves. Hence 'Engineered Solutions' in Teddington's company name. Unrestrained bellows can, for example, allow axial and lateral movement and, depending on mechanical construction, they're going to shut down, say, every six months – and that's when the major movement is going to occur, along with smaller transients every week or whatever. So we select materials to suit, also taking into account the fluid service, corrosion resistance and so on, to ensure that the bellows will outlast the plant."

Says Glen Graydon, business development manager: "Whenever we see a premature bellows failure, it's because of incorrect installation – for example, bellows not restrained as per design specification, or some change causing the same thing. Last summer, a major oil refinery in the UK shut down while a pressure vessel was taken off-line. After completing the work, they wanted to do a pressure test. But, rather than putting the pipework back on the bellows as per the design, they supported the bellows with a jack and fixed a plate over the end. It was an engineering change on a restrained bellows. The first we knew was a cry for help, with the plant wanting replacement bellows before they could go back into production."

Fair point, and it comes down to nothing more than knowing the tools of your trade – or, in mechanical engineering terms, understanding the loads on your piping and the bellows' contribution to those, and then facilitating the movement required. An international standard (EN 14917, Metal Bellows Expansion Joints for Pressure Applications) is due for publication this year, following BS 04/30118252, 2004 (which was for design, not application). But in the meantime, the

tolerate 40bar, as long as the support structure of the pipework is man enough. "These tend to be used on pipes at a low level so there are no problems with installing anchors," explains Evans. "But our catalogue gives the figures for calculating the loads used to design these."

Beyond these, however, if the loads prove too great, there's a world of restraint mechanisms allowing single- or multi-plane movements. Evans lists: double bellows with tie-bars that allow lateral movement only; hinged types that allow angulations in one plane; gimbal-based devices that take movement in two planes; and combinations allowing movement in any plane required.

"If a customer is not happy designing a bellows system, they can send the pipework isometric to us and we will recommend the type of unit, or design the whole system," says Graydon "Similarly, if anybody has an issue of where to put a bellows or what to do with it if it's in service, we're here to help." And he also suggests that, where possible, the company will police good practice: "If it becomes apparent that a customer's choice doesn't make sense, we will gently intervene." PE

Bellows applications

Teddington Engineered Solutions boasts bellows for a huge range of applications – everything from seagoing LNG carriers to blast furnaces, process plant, and oil and gas installations.

"We were involved with the first ever LNG carriers back in 1968, for example," says Jason Thomas, commercial manager. No mean feat, given the cryogenic service and rolling motion of the sea, plus inevitable movement during loading and offloading. "We designed those using our own design codes, alongside oceanographic information showing the forces such a ship's superstructure could expect over its lifespan," he explains. "There have been zero failures."

Apart from that, the company recently completed a jetty project, for which it was initially asked only to supply costs for axial bellows. "Two weeks later, the engineer came back with calculations showing huge pressure loads – so big that they would require pipe anchors set in concrete 120 metres deep! We suggested restrained units, harnessing the natural change of direction in the pipework to allow them to work in a lateral plane. Problem solved."

That's impressive, but so are its hazardous service applications, such as bellows at the bottom of blast furnaces. Again, Teddington claims success, only making the point that, while it can design out most problems, it can't rule out post-installation mechanical damage. Says Thomas: "In some cases, we put protective covers on our bellows, but accidents can happen – and that's mostly due to people, for example, driving over them with forklift trucks."

Technical pointers

- For maintenance, Teddington Bellows recommends nothing more than regular post-installation inspection, depending on the environment. But even that is the exception, rather than the rule
- In nuclear reactors, bellows don't see the light of day for 20 or 30 years – and that's in an extremely challenging environment. Mechanically, there's nothing to harm them
- Bellows usage is little more than engineering common sense, and there are similar precautions for everything from control valves and actuators to gaskets