Instrumentation and control engineering is a specialist field. But, as plant engineers don the weighty mantle of responsibility, we need to upskill, says Brian Tinham

Virtuoso

Pointers

- HART and full fieldbus communications enable remote diagnostics
- Sizing, mechanical type and construction materials depend on the application
- Read specifications carefully: quoted turndown is often not what it seems
- Knowledge of flowmeter technologies is key to good specification and choice
- Coriolis mass flow devices are falling in price and offer mutli-parameters
- Technology changes fast here, so ask the vendors

It won't have escaped your attention that instrumentation and control is encroaching inexorably into our bailiwicks. It started in condition-based maintenance, with plant engineers using, for example, portable ultrasonic flowmeters, vibration monitors and infrared thermal cameras. Now, like it or not, we're increasingly responsible – and not just for equipment installation, commissioning and test, but increasingly also troubleshooting and, in some cases, specification.

Why? Quite simply because, over the years, as the chemicals sector, oil and gas companies and others have cut costs, by making skilled technicians redundant, and outsourcing instrument and control maintenance, the industry has lost a whole generation of specialists. Now – although apprenticeships are returning – there simply aren't enough to go around.

So plant engineers must skill up: get a handle on the technologies involved, what to use where, sizing issues, best practice, common problems and pitfalls. Importantly, we also need to do that in light of recent developments, bearing in mind three cardinal points: that technology in this area moves faster than many, that almost every application is different and that this is a very big subject.

Hence this first in a series of features on control and instrumentation engineering. Starting from the premise that you can't control what you can't measure, this first piece aims to provide an update on the instrument end of the business, beginning with key parameters such as pressure, flow, level and temperature, and covering advice and guidance on the broad issues and best practices.

Taking pressure first, you're looking at fairly mature instruments, mostly using capacitance, piezoelectric, inductance and vibrating wire sensor technologies, as well as the old Wheatstone bridge resistance kit. Choice of sensor technology here is not normally the issue: it's dictated by pressure range. For example, high pressures tend to be best handled by piezo-based devices, while the construction of inductance sensing units lends itself to severe over-range handling requirements.

Trevor Dunger, pressure specialist with ABB, comments that the last decade has been about "an arms race on accuracy and stability", that's gone about as far as it can, with most of the majors long since able to claim high-spec instruments. For him, what matters today is ease of set-up and operation. "It's about reducing instrument commissioning time through common programming, simple HMIs and easy set-up menus so that, when an engineer is on an oil rig, on his own, in the dark, it's all intuitive."

That much is a recurring theme throughout instrumentation – certainly not just pressure. Most of the big instrument manufacturers build intelligent transmitters (incorporating sensor housing, mounting assembly, electronics and process connections) and, even if signalling and power are via the dated analogue 4–20mA, setup is digital.

Size matters

For those that use the superimposed HART digital communications technology, there are the added benefits of remote set-up and instrument health diagnostics, while moving up to any of the flavours of full digital fieldbus plant communications means multiplexed loop signalling to the control room, so a massive reduction in wiring. Wireless HART and fieldbus clearly promise even greater savings. (HART and fieldbus will be covered in a forthcoming issue of Plant Engineer.)

Returning to pressure instruments, key selection issues concern sizing, mechanical type and materials of construction – and there are potentially tens of thousands of permutations. Thankfully, ABB, Emerson and others provide very useful wall charts and online selection guides, designed to take engineers through a logical sequence of decision points to reach the right choice.

Beyond that, from a mechanical engineering perspective, it's relatively simple stuff. "For example, lowest cost pressure devices just use screw connections, typically half inch NPT," explains Dunger. The only real concern (apart from safe installation, access for maintenance and issues

performance

around abrasive or aggressive media or plant environments) is ensuring that your impulse lines aren't going to block, due to process fluid viscosity or entrained particles.

However, Dunger also advises: "You also need to consider temperature and whether you should protect the transmitter with a stand-off assembly. On applications up to 180 C, for example, the instrument's diaphragms and impulse line fill fluid may be fine, but heat transfer to the electronics might be a problem." Although, that said, such devices routinely work on steam applications, using water-filled impulse lines, and in cryogenics, with low freezing point fluid fills.

However, if screw connections are not man enough, you're into transmitters with flush diaphragms and remote seals to the process. These units eliminate any blocking problems and can also be specified with large flange connections for difficult, highly viscous media. Standing off from the remote seals, using liquid-filled capillaries, again solves any temperature problems.

Turning to pitfalls, Dunger warns engineers to tread carefully when it comes to quoted turndown – reduced ranges over which instruments can theoretically be used. "It's all lies, damned lies and specifications," he quips. "No one can design a single sensor to cope with everything from half a mbar to 600bar and maintain the same accuracy, so we all offer a series of instruments, claiming turndowns of, say, 100 to 1. That implies, for example, that a 600bar unit can also be used for measuring from 0 to 6bar. And it can, but doing so accentuates the errors, including temperature errors and static pressure errors on differential pressure devices, both of which are quoted as a percentage of the upper range limit. So an instrument rated at 0.025% accuracy might deliver just 2.5% at the extreme of its turndown in a practical application."

Much the same is true across most mechanical instruments that involve micro sensing and the plain fact is, you need to read the fine print. However, there are also significant differences that matter when you're selecting devices for other parameters.

Technology for flow

Take flow, for example, and you'll find that choice of technology is key, best arrived at by first establishing the process fluid, and only then the range, accuracy and cost limits. Main flowmeter types include electromagnetic, Coriolis (mass flow), vortex, swirl (also mass flow on dry or saturated steam), clamp-on ultrasonic, differential pressure, variable area meters and positive displacement mechanical units.

Outside domestic water, magnetic flowmeters, with their sensing electronics built into the pipe assembly lining, are by far the most common, with sizes typically ranging from 3mm to 2.4 meters diameter. Tony Hoyle, UK flow product manager with ABB, advises that, if the fluid to be measured is conductive and the pipe diameter 25mm or greater, this is your first choice. "The biggest application is water – and not just in the utilities, but for pipeline flows throughout industry – but they're also ideal for fluids such as milk, juices and beer," he explains.

Again, there are choices of fitting – in this case,

Above: Emerson's smart wireless transmitter at a BP tank farm Below left: installing Micro Motion Coriolis meters requires no flow conditioning or extra mounting

flange, wafer style (for hygienic applications) and insertion devices, the latter usually provided with a welded boss and valve for hot tapping into the pipework. There are also variants with, for example, octagonal profile sensors, said to improve accuracy and stability, as well as others that are battery powered for remote work, and versions designed for measuring partly full pipes, as in sewer channels. Highest accuracy comes from the full pipe, flanged or wafer devices (0.2%), falling to around 2% for insertion units (which are half the price).

Which brings us to installation issues. Almost all flowmeters require straight lengths of pipe up and downstream of the transmitter, the object being to deliver fully deveoped turbulent flow to achieve the quoted accuracy and repeatability. For magnetic meters, it's typically five pipe diameters upstream and two or three down. Clearly, the practice of installing isolation valves or similar within that envelope may seriously compromise measurement.

Moving on, Coriolis meters, which rely on detecting the effects of so-called pseudo forces exerted by media on vibrating pipes, are rapidly gaining in popularity as prices fall – certainly in the smaller sizes. There are all sorts of shapes, from straight-through dual tubes to 'S' and 'U' shaped pipe arrangements, but all offer the ultimate in flow accuracy and stability, as well as universal operation that's independent of media conductivity. There is also, uniquely, no requirement for straight pipe lengths before and aft.

Emerson is widely acknowledged as the pioneer of Coriolis mass flowmeters, having acquired Micro Motion and Brooks through Rosemount many moons ago – although ABB, Krohne, Bronkhorst, FCI, Heinrichs, Siemens and others all now make versions with claims and counterclaims for robustness, ease of cleaning and maintenance.

Liz Broddley, Emerson's flow solutions product manager, makes the point that Coriolis units today cover huge ranges. "We manufacture instruments all the way from 0.8mm up to 12 inches, capable of measuring from one droplet per hour to 2,040,000 litres per hour." She also warns that geometry is critical in defining the accuracy and the kinds of fluids that can be measured: for example, straight pipe devices are not ideal for gases. And, most importantly, she explains that many offer multi-parameter outputs – not just mass flow, but also volumetric flow, density and often also temperature – saving on additional sensor/transmitters and associated installation costs and pipe disturbances.

Mass flow-plus

Price and bulk are very dependent on size. Above 150mm pipe diameter, for example, units run out at double or triple the price of electromagnetic or vortex equivalents and are way bigger. However, at 30mm or below, price differential is low, they are compact and uptake is growing, particularly from the food industry. Beyond that, there's nothing special about installation or commissioning – other than handling them with care.

Moving on, if your application involves non-conductive fluids, gases or steam, and you don't need the accuracy (or cost) of Coriolis instruments, vortex and swirl meters provide ideal options. Vortex meters use piezo technology to measure the frequency of vortices induced in the flow by a bluff body in the pipe. They're very useful, except that they need 15 straight pipe diameters upstream and five downstream. Swirl meters are similar in appearance, but only need three upstream and two downstream – but, of course, they're not cheap.

Beyond these, you're into the differential pressure devices, with a wide range of orifice plate designs, Venturi tubes, Pitot tubes or pressure and temperature transmitters (some ready built-in). Ten diameters upstream and four downstream is a general rule, but best turndowns are typically 10:1, compared with magnetic meters' 1,000:1, and you need to be aware of wear and blocking risks.

So much for flow, and we're out of space, with the other big ones – level and temperature – still to consider next time. For now, a final worthwhile thought. Emerson's Broddley speaks for many when she says: "If you've not sure what to use, just ring any of the vendors and they will always assist you. Don't feel you can't keep up: this industry is moving at an incredible pace and all applications are different, so there is often a need for some system engineering. C&I isn't about catalogue selling." PE

Swirl saves steam spirit at Glenfiddich

Accurate steam flow data, delivered by 11 swirl meters, is enabling whisky distiller William Grant to identify areas for energy savings at its Glenfiddich distillery in Dufftown, Scotland – and indirectly improving spirit quality.

Project engineer Tony Allen explains that the plant uses steam in its distillation process, heating fermented liquid to boiling, and that the company wanted to improve energy efficiency, but also understand steam usage before buying a replacement boiler for its central boiler house.

Since the distribution system allows steam to move in both directions from the boilers and back from the site, the application called for a very accurate, multi-directional flowmeter, also capable of being retrofitted into the pipe network. ABB Instrumentation alliance partner JWF Process Solutions suggested ABB swirl meters back-to-back for several reasons: 0.5% accuracy, mass steam flow measurement, minimal straight pipe length requirements (three diameters upstream and one down) and turndown, which is 10 times better than orifice plates.

Allen reports that energy consumption is now being precisely monitored, enabling William Grant to focus on the most fruitful departments and processes for driving down waste. He also says that data from the meters is being used to better manage steam production around the site.

"Without steam meters, you don't know what's being used, when or where. Previously, the system just ran and you used steam when it was required. Sometimes the steam would run out, delaying the process. Now, ABB's swirl meters accurately measure demand and reveal how much steam is being used by each piece of equipment. By analysing this data, we can balance steam use and optimise energy usage. The meters have already proved their value around the site."