THE MAGAZINE OF THE INSTITUTE OF MEASUREMENT AND CONTROL INSTMC.ORG

ANOTHER 50 YEARS OF INSTRUMENTATION

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A PERFECT PARTNERSHIP?

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STEVE GANDY

PRECISION

JUNE_2018_ISSUE SEVEN

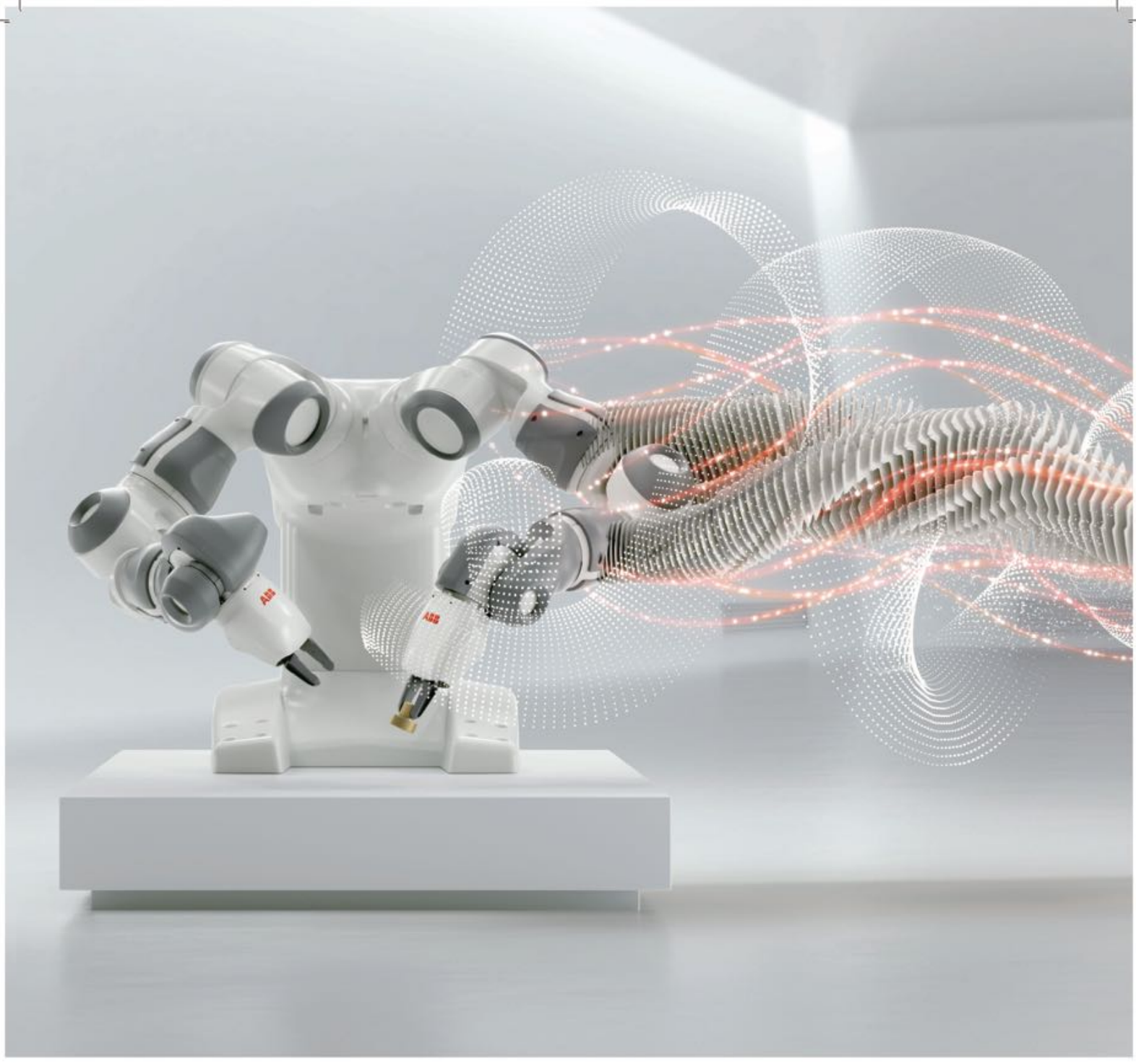
THE INSTITUTE OF MEASUREMENT AND CONTROL IS PROUD TO ANNOUNCE THAT IT WILL BE HOSTING THE NATIONAL FESTIVAL OF MEASUREMENT

The Festival will start in September 2018 at the IMEKO World Congress and run until World Metrology Day 2019.

On 20th of May 2019, all the SI units will finally be based on measurable physical constants and the last remaining measurement artefact (the kilogram) will no longer be needed.

To celebrate this change, InstMC wants to spend the time leading up to the SI redefinition highlighting the importance of measurement in all areas of life.

Festival of MEASUREMENT



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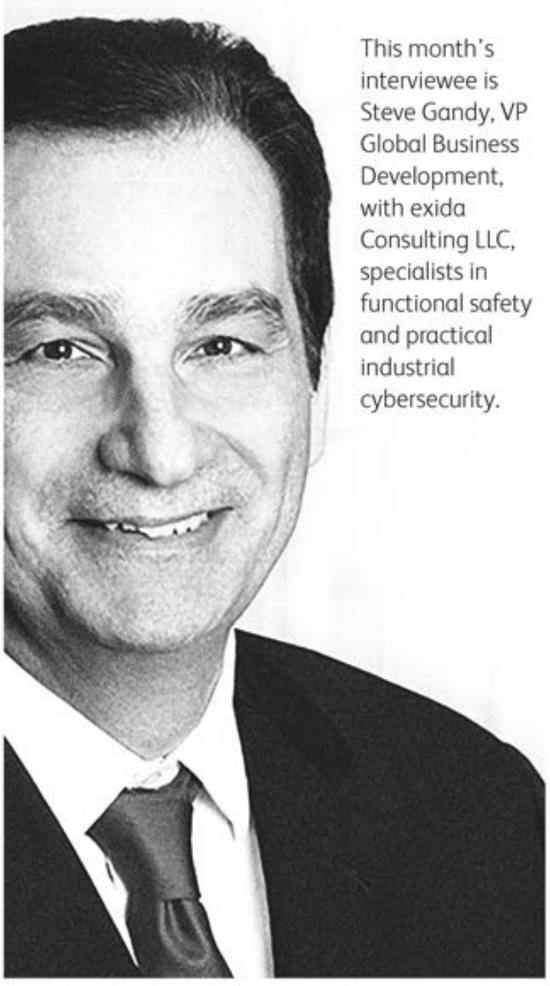

This month's interviewee is Steve Gandy, VP Global Business Development, with exida Consulting LLC, specialists in functional safety and practical industrial cybersecurity.

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M&A MARKET STABILITY CONTINUES WITH A STRONG START TO THE YEAR

Mergers and acquisitions (M&A) deal activity continued to hold firm in the first quarter of 2018, reflecting ongoing stability and unwavering confidence in the market, according to analysis from accountancy and business advisory firm BDO LLP.

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PRECISION

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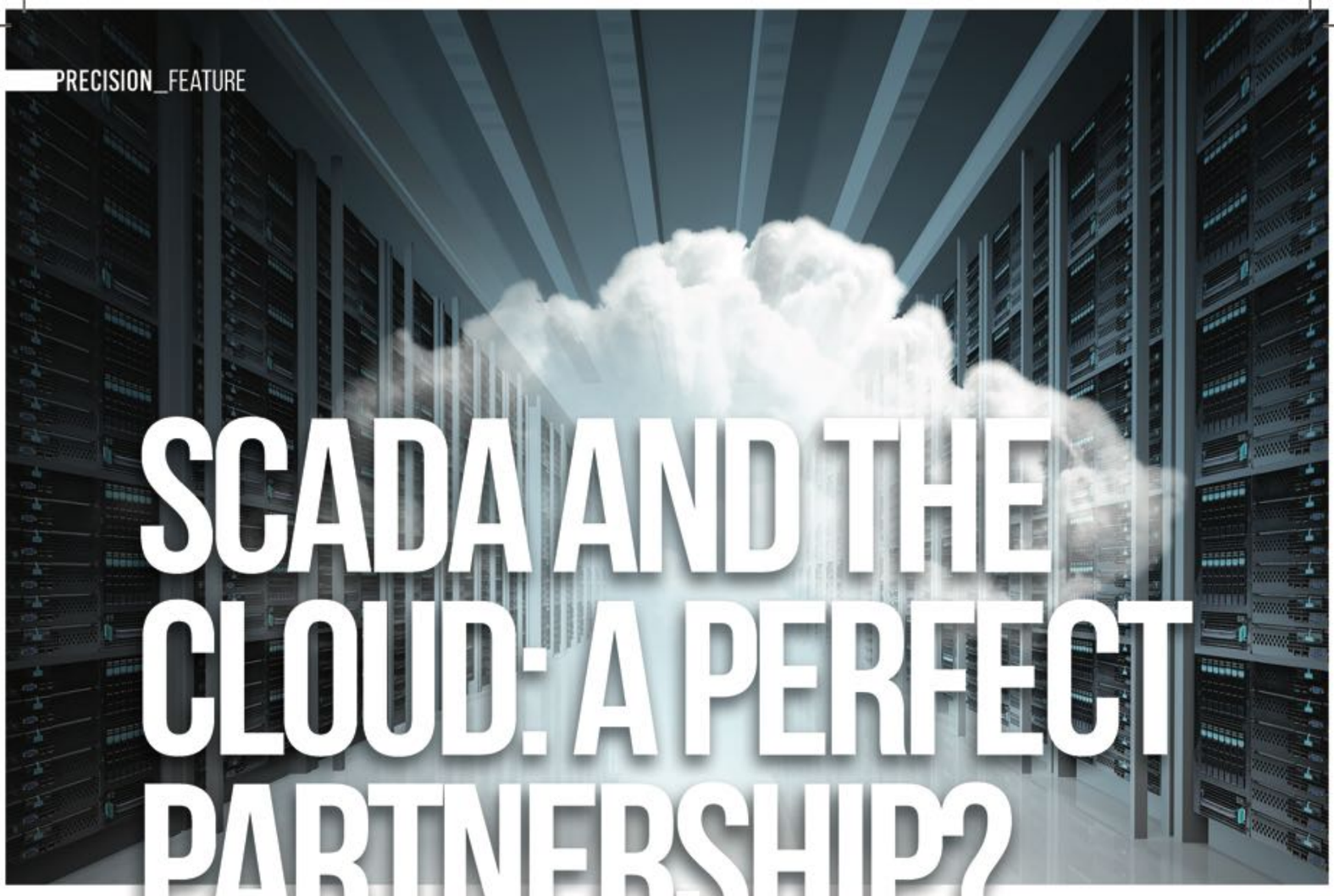

SCADA AND THE CLOUD: A PERFECT PARTNERSHIP?

Suzanne Gill reports on the changing role of SCADA systems as we enter the era of smart manufacturing and IIoT.

In the last decade the most usual solution to an operational bottleneck has involved the introduction of yet another isolated information system. This has resulted in mind boggling quantities of process data being available today. However, according to figures supplied by Yokogawa, only 5% of this raw data is converted into workable information; only 10% of data is relational structured; and more than 50% of data is considered poor.

The emergence of a combined SCADA/MES (Modern Enterprise Solutions) layer was a big step forward for the process industry, helping simplify data management. However, just connecting databases is not sufficient to turn data into knowledge. "To really capitalise on the massive amounts of data, in other words, to become analytically competitive, companies need to be thinking about their overall information strategy," said Frank Horden, global business development and marketing manager for Yokogawa Electric Corporation.

Of course, SCADA users are accustomed to collecting enormous amounts of data from machines and processes and due to an increasing need for transparency and to meet increasing regulatory compliance, they also understand the need to store this data. "What is new are the tools that can extract and capture actionable information and meaningful insights from the data. The explosion of data results in the need for modern enterprise SCADA solutions – which have already evolved from mere PLC and device integration – to become an environment where a more holistic information-model approach is applied," continued Horden.

The greatest benefits of data for engineers in technically complex environments is for the early and precise detection of defects and to help increase product quality and consistency. In addition, by obtaining information from the data it is possible for planning to be improved throughout the production chain.

"Taking full advantage of the data in the hybrid data ecosystem has the potential to transform the operational and industrial landscape in the same way that the media, communication and technology industries has changed the consumer landscape over the past decade," said Horden.

Horden believes that SCADA/MES will continue to play an important role in real-time operational management of smart factories and processes of the future by collecting, storing and managing the data utilising the latest IT-technologies. However, many companies are facing a difficult time.

"Edge computing will also grow as organisations attempt to collect, analyse and process data from assets more efficiently than traditional cloud architectures," said Holden. "This will lead to a reduction in the amount of data being sent to the cloud, decreasing network latency which, ultimately, will improve system response times in mission critical applications." Horden predicts that the adoption of Edge computing will also lead to the use of newer technologies such as LTE and LoRA which makes data available everywhere, quickly.

Another strategic driver is the growing need for collaboration between IT and OT. As the systems merge and integrate within SCADA/MES it is important to define and segregate responsibilities to avoid tension between IT and process engineers to ensure efficient operation. "Users of SCADA/MES will need to create a shared understanding of the 'real-time' and 'near-real-time' requirements of each system so that the need of the production process for real-time information is not compromised by using shared public infrastructure which is critical to the IIoT philosophy," concludes Horden.

A bright future

Martyn Williams, managing director of COPA-DATA UK believes that the future for SCADA is bright, quoting the findings of a report from global market research firm Technavio, which says that the manufacturing industry is set to experience a significant growth in the adoption of analytical software through SCADA.

"The integration of predictive analytics into modern SCADA software has made it easy for manufacturers to collect and archive production data and make future predictions based on this intelligence," he said. However, Williams believes that SCADA systems can provide much more than an insight into the lifespan of machinery. "The integration of cloud computing with SCADA systems has enabled operators to control production from any location, further improving the flexibility of the plant," he said. "As with any cloud migration, there are security concerns. However, as cloud security features become more sophisticated and SCADA providers increasingly adopt a security by design approach to their software, this concern is unlikely to deter manufacturers from embracing – and benefitting from – cloud-based SCADA"

These industrial automation trends are just a taste of the intelligent applications still to make waves in the industry. The coming year will be all about the great influx of supervisory control technologies that are designed to improve the flexibility, accuracy and security of production.

Coming together

In an era of Industry 4.0 and the IIoT, we are starting to see IT and OT environments fusing together more and more, according to Katrin Kunz, head of marketing for Industrial PCs and SCADA, Siemens Division Digital Factory. She believes that cloud infrastructures and SCADA systems have the ability to enrich each other in modern industrial environments. SCADA systems have, for many years, been an essential tool in production-critical processes, wherever it is important to display data in real-time and log it with a time stamp in order to make and document strategic business decisions quickly. It can also be used for teleservice and remote maintenance.

Cloud systems thrive on having access to the largest and most comprehensive data pool possible as the basis for analysis apps and services. Assured data availability and data display in real-time play a subordinate role here.

"The question that needs to be considered is which analysis and deductions are reasonable in the cloud and which ones are better done in the SCADA system? And how can they complement one another?

"The SCADA system of the future could transfer non production-critical data to the cloud in order to enrich its data pool for higher-level apps and services. In the other direction, SCADA systems could have the potential to utilise domain knowledge from the cloud, such as weather data, in order to facilitate further conclusions which would not be possible without this synergism," concludes Kunz.

Practical developments

"Putting aside the obvious and inevitable strides forward in functionality and networking communication, I think the major factor driving the development of SCADA for the factories of the future is a practical one – the user demand for increased versatility," said Paul Hurst, director at Products4Automation, which is the UK distributor for Progea products which include Movicon SCADA and NExT.

Hurst believes that SCADA monitoring systems should offer ease of integration for existing and new technologies; and should also display the scalability and transparency required to allow plant managers to create a truly custom monitoring system with ease.

Hurst goes on to explain that such characteristics can be achieved by actively designing a SCADA system for the latest software platform technologies – future-proofing – which can be achieved by utilising the latest network protocols, modular process structures, graphical capabilities and communication technologies as part of SCADA software architecture.

"A next generation SCADA platform should use specific hardware and OPC UA protocols for ease of integration across the plant; Windows Presentation Foundation (WPF) graphics for modular process modelling would be a good idea and connectivity to the Cloud via a range of options is pretty much essential," he said. "All of these technologies are likely to form the basis of the Internet of Things (IoT) and compatibility with future expansion towards Industry 4.0 compatible monitoring systems. It makes sense that SCADA platforms evolve and adapt seamlessly with these trends."

Breaking free

Traditionally, SCADA has been confined within the plant. Smart phone SCADA apps for iOS and Android operating systems mean that plant managers can now monitor and analyse data from anywhere, 24-hours a day on a personal wireless device. This results in improved responsiveness to alarms, helping to increase production uptime.

Hurst believes that monitoring will be further revolutionised by breakthroughs in Augmented Reality (AR) and Virtual Reality (VR) technologies. "In the not too distant future, I believe we will see engineers utilising virtual headsets to navigate a 3D plant which offers real-time data and models representing the physical plant off-site. Increases in graphical capabilities will achieve accurate environments which will enable engineers to gain even more insight into processes, and maybe even amend applicable parameters virtually via the AR or VR environment."

Alternative views

Taking an alternative view about the future role of SCADA, Nicholas Temple, marketing manager at B&R Industrial Automation, questions whether there will actually be a need for SCADA solutions in many applications in the future, as HMI solutions grow in capability and MES and ERP solutions become more cost competitive with Business Intelligence Solutions. He said: "SCADA systems usually carry an additional engineer resource so the integrity of an automation platform for a plant can be at risk. If a PLC programmer can use a single engineering environment to completely cover the needs of both SCADA and PLC, why complicate matters further with another engineering environment?"

He argues that typical SCADA systems come out with a new solution annually with support offered for a limited period after launch. This means that hardware and software lifecycles can also come unhinged, creating unnecessary costs for the user with software updates that may not be compatible with the potentially legacy hardware installed base.

B&R offers a simple, modular way of programming with its mapp solution and a visualisation solution called mapp View. mapp View integrates web technology right into the software development environment. While it is built on HTML5, CSS3 and JavaScript, automation programmers never need to deal with these languages and can continue to focus on their own areas of expertise.

Benny Magrafta, head of software research & development at Unitronics, also questions the need for SCADA software in many applications. "Why go to the trouble of setting up a SCADA system, when the front of your PLC can easily become an elegant HMI touch screen, and all of the data in the control system is immediately accessible?" he said, referring to the integrated PLC and HMI offerings available from his company.

Unitronics Industrial Automation Solution targets the smart factory of the future. "This is one of the reasons our all-in-one PLC/HMI controllers include a built-in webserver. We enable our users to click-to-convert HMI screens to webpages. The application can then be viewed and edited –depending on the security levels assigned — by users on any browser, whether that be a on PC or mobile device," said Magrafta.

Support for protocols such as Microsoft SQL, FTP, email, SNMP is also important, and according to Magrafta, this results in the PLC side communicating machine/application data and the HMI/wWebserver side enabling direct communication with the application and the facilities backend systems, while protocols such as SQL, FTP, email, SNMP communicate data to/from the management layer. "The all-in-one controller becomes the nexus of the system," he concludes.

Final comment There can be no doubt the SCADA system has changed over the years, evolving from the role of providing a plant-wide monitoring and control solution for often geographically wide spread systems, and delivering data to the control room. Today there is ever more data to collect and its data management capabilities have been extended and its role as an HMI has reduced. It looks likely that the concept of a SCADA system, in some form, will continue to dominate as a tool for harvesting information and insight from the plant, albeit the system might be unrecognisable when compared to SCADA systems of the past.

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THE BENEFITS OF MULTI-FUNCTION CALIBRATORS

Alistair Norwood discusses the changes in calibration techniques taking Sellafield into the next phase of its lifecycle.

Sellafield (nee Windscale) has been operational since 1939, built as a Royal Ordnance ammunition factory, supporting the UK's war effort. Today the site is home to a wide range of operations including Magnox and Oxide fuel reprocessing, with a growing emphasis on the decommissioning of redundant buildings and high hazard clean up missions; spent fuel management; and the safe storage of nuclear fuel and the arising wastes. Sellafield is the largest and most complex site in the UK nuclear estate, indeed; it's the largest nuclear site in Europe. Its annual budget is over £2bn. Sellafield's mission is to deliver safe, sustainable and publicly acceptable solutions to the challenge of nuclear clean-up and waste management. This means never compromising on safety, or security, taking full account of the social and environmental responsibilities, always seeking value for money for the tax-payer, and actively engaging with our stakeholders.

Modern technology in instrument calibration

Look in many instrument manufacturing and maintenance workshops across industry and you will see there has been a revolution in new, multifunction calibrators used in the set-up and calibration of instruments.

The main driver is their multi-functionality. What used to be twelve or thirteen stand-alone individual calibrators have been incorporated into a single

multifunction device, which means only one calibrator to carry instead of a dozen or more.Typically, a single new multicalibrator would replace mA and mV sources and the ability to read both of these; reading and writing of Ohmic resistance with conversion to temperature; reading and writing of thermocouple signals, frequency, pulses and three or four pressure ranges; reading Platinum Resistance Thermometer (PRT) temperature probes; communication via HART and fieldbus; and documenting and recording functions.

The decision of which type to buy involved actual usage and a number of other factors such as the ability to meet regulatory requirements on removing items from the radioactive areas. Sellafield has standardised on the Beamex range. These multifunction calibrators are used to calibrate instrument loops and check on the reliability and performance of the individual instruments in these loops.

Sellafield reviewed a range of calibration products from various manufacturers some 10 years ago, with a view to reducing the number of different products used and standardising where possible. Following technical evaluation, the Beamex MC5 was chosen with an initial order placed for 25 units, with an expectation of more to follow. However, there was work to be done to make Sellafield fit Beamex and Beamex fit Sellafield. Subsequent later orders were for the later MC5's direct replacement, the MC6. We now have 250 multicalibrators (a mixture of MC5, MC6 with a small number of MC2 and some external plug-in transducers). However both our Druck DPI 620 series and Fluke 700 series are still in use and won't be replaced until they either fail or become obsolete. That is quite a tough job for one single calibrator.

Of course, the most important performance requirement from a calibrator is accuracy. A look at the specifications of these calibrators will show how far these have come over the years. A typical reading of mA with a handheld DMM from the early 2000`s gave a typical accuracy of at 20mA of 0.15% reading ±10 counts; compare that with a Beamex where the accuracy in the same range is 0.01% reading and 1micro amp. If the same comparison is done in resistance at the 400 ohm reading, the 2000s model reads 0.05% of reading ±10 counts; the Beamex for the same reading is 0.009%. A very similar comparison is true for DC volts. When you compare the Beamex multi-functional calibrator accuracy to that of discreet calibrators, a similar differential in accuracy exists.

"We are not comparing apples with apples" I hear you cry! All multifunction calibrators have limitations on the ranges they measure; a typical early 2000`s DMM can go up to 1000V and measure AC. The MC6 will only read DC up to 60V. The same is true for current and resistance ranges. There is also the elephant in the room, an MC6 is 14 times the cost of a typical early 2000`s DMM, although as we said earlier you only need a single calibrator to do the work of many discreet ones. When Sellafield introduced these calibrators, an MC5 or MC6 replaced: a DMM, mA

"We are not comparing apples with apples" I hear you cry! All multifunction calibrators have limitations on the ranges they measure; a typical early 2000`s DMM can go up to 1000V and measure AC. The MC6 will only read DC up to 60V. The same is true for current and resistance ranges.

source, mV source and resistance box. The MC6 has three inbuilt pressure ranges and thus took the place of all three. In Sellafield's case, these were the Druck DPI 615 or 603, pulse/function generator, thermocouple simulator, HART and Fieldbus communicator and a chart recorder. So while it may have reduced ranges and have a higher purchase price, the Beamex has the lower life-time costs. To some extent the choice comes down to the user: will you actually have a use for all these multi-functions?

You also have to consider recalibration cost of thirteen individual calibrators compared with that of a single multicalibrator. We have our own calibration laboratory on Sellafield site but, if you were to send all of the discreet calibrators for calibration and compare the cost with that of a MC6, the saving would be around £300 or £400 per year in favour of the MC6. There is also the overhead of remembering and then sending all the individual calibrators for recalibration.

The role of the Sellafield CERP

To get the best from a multifunction device you'll probably need to change your company practices and procedures too.

At Sellafield we have a system of CERPS (Calibration Equipment Responsible Persons) who control the issue and recalibration of individual items of test equipment. There are currently some fifty CERPS on site. The CERP is also responsible in their area or building for communication with our internal calibration laboratory on matters such as repair cost and queries with end calibration certificates. Currently we have over 5000 active items of test equipment on our Met-Team inventory control system. The CERPs are building based and they cover over 70 buildings. The role is a bolt-on for their normal day-job, so a CERP is either an instrument technician or possibly a mechanical fitter. Each CERP has 1 day training in control of test equipment and 1 day in understanding calibration certificates. Most of the changes in how calibration works needs to come from, in Sellafield's case the CERPS or in other users case their principle user's. By the time our CERPS understand the cost savings and the process benefits they become evangelists for the multi-function calibrators.

Our CERPs play an important role in change management. When the MC6s were introduced it became important the now obsolete calibrators should not be maintained in-service: if they had remained operational it would have removed a great deal of the incentive to change to MC6. One problem was that sometimes less technical savvy members of the teams found the new MC6 touch app driven technology to be daunting and wanted to keep using the older calibrator. This is where at Sellafield the CERPS came in. They have members within their teams working and helping users to understand the benefits of MC6 and how to use them. We had people who said "I will never use one" who are now more than proficient. The rise of the iPhone (other phones are available!) has helped in this. As touch technology and the use of apps have been taken up by the less technical, the resistance to using MC6 with its app interface and its touch technology faded away. Much of the acceptance has been driven by our CERP community. However some companies may need to take a firm line with users on using the new multicalibrators.

> There was work to be done to make Sellafield fit Beamex and Beamex fit Sellafield.

While we were still evaluating the Beamex calibrator we examined what it could do and how it could change our work instructions. The changing of work instructions is important. There is nothing so disheartening as having a multicalibrator capable of reducing the time taken to perform calibrations, or making them safer, or easier to manage, and yet somehow not realising the cost, time and quality benefits. If you go down the multifunctional calibrator route, there needs to be a buy-in at all levels that you will change how and when instruments are calibrated. Some examples of this are:

The common practice with pressure switches was to use a pressure calibrator to measure the switch pressure and a DMM to monitor the switch contact (open/closed). With the MC6 we are able to connect to the pressure switch and measure both simultaneously. MC6 also allows us to see much better, the switch latency (hysteresis) which may signify future problems. A single MC6 multicalibrator made for safer calibrations, as it was just one multicalibrator at the top of ladders, scaffolding or gantries. Using MC6 we are also able to use the same multicalibrator to look at mA or switching contact resistance.

The MC6 converts the output of a PRT100 directly into Celsius, Fahrenheit or other specified unit which may be process specific, which is a lot easier than measuring the resistance of the PRT in ohms and then converting it into temperature using look-up tables.

If you have any input in, say, frequency, pressure, mA or mV and any output in another, for example a 4-20 mA, you can programme the MC6 to show you the deviances at any point, with no need to work it out.

Just because a multicalibrator can measure a particular pressure range does not mean we should use it. Using for example the 20barg range to measure 100mbarg would give incorrect readings. MC6 has 3 pressure ranges all of which are 0.01 % FS + 0.025 % RDG. Technicians need to be taught about using multicalibrators in the correct part of their range.

The list does not stop there. Using multicalibrators for HART, fieldbus and as chart recorders also makes changes possible resulting in procedural and cost savings. If you are going to buy a multicalibrator, spend time getting to know it, understanding how you can put the parts together, then look at your plant calibration procedures.

Conclusions

The world has moved on from single function calibrators. The benefits of savings in both cost and time, portability and accuracy are there to be claimed. However the benefits only come if there are changes to the mind-set of the calibration technicians and if you change your process instrument calibration procedures.

Alistair Norwood has been in the control and instrument business for over 35 years. For the last 22 years he's been in the nuclear industry. He is a member of the InstMC Standards Policy Special Interest Group and is currently the link between Sellafield and NPL (National Physics Laboratory) on measurement issues at Sellafield Ltd. He also represents Sellafield of BSI SS06 which is responsible for the British view of the GUM guide BSI 17025 and BSI QS01 which controls the uses and interpretation of the 9000 and 10000 series of quality standards.

…the world has moved on from single function calibrators.

ANOTHER 50 YEARS OF INSTRUMENTATION

Martin Belshaw looks into his crystal ball at the future of instrumentation and control in feeding the world.

Last year at the 50th anniversary dinner I spoke about 50 years of instrumentation and I want to do the same now. Not looking back over the last 50 but ahead to the next 50, because we are on the cusp of a revolution and connectivity is about to become all encompassing. In that address I mentioned ABBs universal instrument, not a panacea, but certainly a game changer in retro-re-instrumentation. Glasgow's Smart Street, capable of back feeding the national grid as well as charging cars, and how cell phone companies use AI to reduce the power demands of operating networks at night. But I did not mention the Internet of Agricultural Things- the internet of sheep and cows - and it's this last point I want to expand on here.

Earlier this year I was invited to parliamentary briefing, along with lots of IT savvy farmers and some boffins, to discuss applying controls

& automation technology directly to both livestock & arable farming so as to realise efficiencies previously only a fantasy. It is called precision agriculture, a largely hidden and unknown facet of the instrumentation, controls & automation industry.

The main challenge is feeding the world in next 20 years, against a backdrop of the relative decline in production efficiency over the past 30 years. We need to see yield increases of 70-80% globally to redress this. There has been a break in the link between production and fundamental science, or rather too great a focus on biology rather than on-farm measurement, which is where automation and control might step in.

Both agriculture and engineering sectors must respond to the challenges of feeding a rapidly growing population sustainably. Research & development is vital to addressing this challenge but agri-tech is likely to play a vital role too.The challenges include understanding variations in crop and livestock production; optimising input (fertiliser/feed) to maximise profits and reduce environmental impact; improving product quality with technology capable of understanding key production characteristics (when fruit is ready to be picked); and combating pests and diseases using new technology to detect them. Crop production methods require advances in measurement and control including the development of sensor-smart crops and instrument guided crop modelling (big data). In fact just like any process plant operating right now.

Among the solutions are robotics and autonomous systems to reduce labour in milking and harvesting; satellites and drones to monitor crops; new instrumentation to monitor operations and infield performance of cropping and grassland systems and new sensing and imaging technology to monitor crop and livestock production, quality and health.

In short, networks of sensors connected via the internet making SCADA on the farm a reality. An

The main challenge is feeding the world in next 20 years, against a backdrop of relative decline in production efficiency over the past 30 years we need to see yield increases of 70-80% globally to redress.

Internet of Agricultural Things (IoAT), seamlessly linking producers, vets and advisors into an integrated feed-growth-environment. Its monitoring system would be essentially the same as that MIS systems that big O&G/ Pharma operators are using already.

Robots can already do the milking, monitoring food in/milk out (per cow), checking on welfare and administering treatments at the same time. They can also do the feeding and 3D precision imaging in both production and processing, record patterns of growth, capture variance (weight gain and/or an indication of disease) and calculate the all-important dead-weight on the hoof, which itself becomes a control variable.

An Integrated On-Farm Data Platform would provide services such as the optimisation of feed mix for target performance goals (milk yield/quality), reduction of waste, management of greenhouse gas emissions, fertility, weight gain, fat content, feed analysis, energy/eating periods, and collating milking robot outputs …

Innovative sensors, robotics, data analytics and systems integration projects will become key players in the future of agriculture. The 'Internet of Farming', a systems approach to agricultural efficiency, will re-establish the link between science and progressive agriculture.

The Internet of Cows, is not wishful thinking it's a reality. A collar, a pedometer, a tail tag, compromising ultra-low power sensors, processors and transmitters akin to wireless meshing systems we use today in the other process industries, provide real-time data for decision support in precision farming. Using the latest sensor technologies to understand whole-chain efficiency will radically change the efficiency of food production. It is not what we see but rather what is in the gaps of what we see where real efficiency opportunities will lie.

Put briefly, the weather is process noise which you can filter out, historical data provides models for advanced predictive controls, the rest no more complicated than everyday process plant where livestock and crops are the process.

Food for thought, surely?

This was part of a speech given at the 51st Annual London Section Dinner on 3rd May 2018.

by Martin Belshaw,
Vice President of the InstMC

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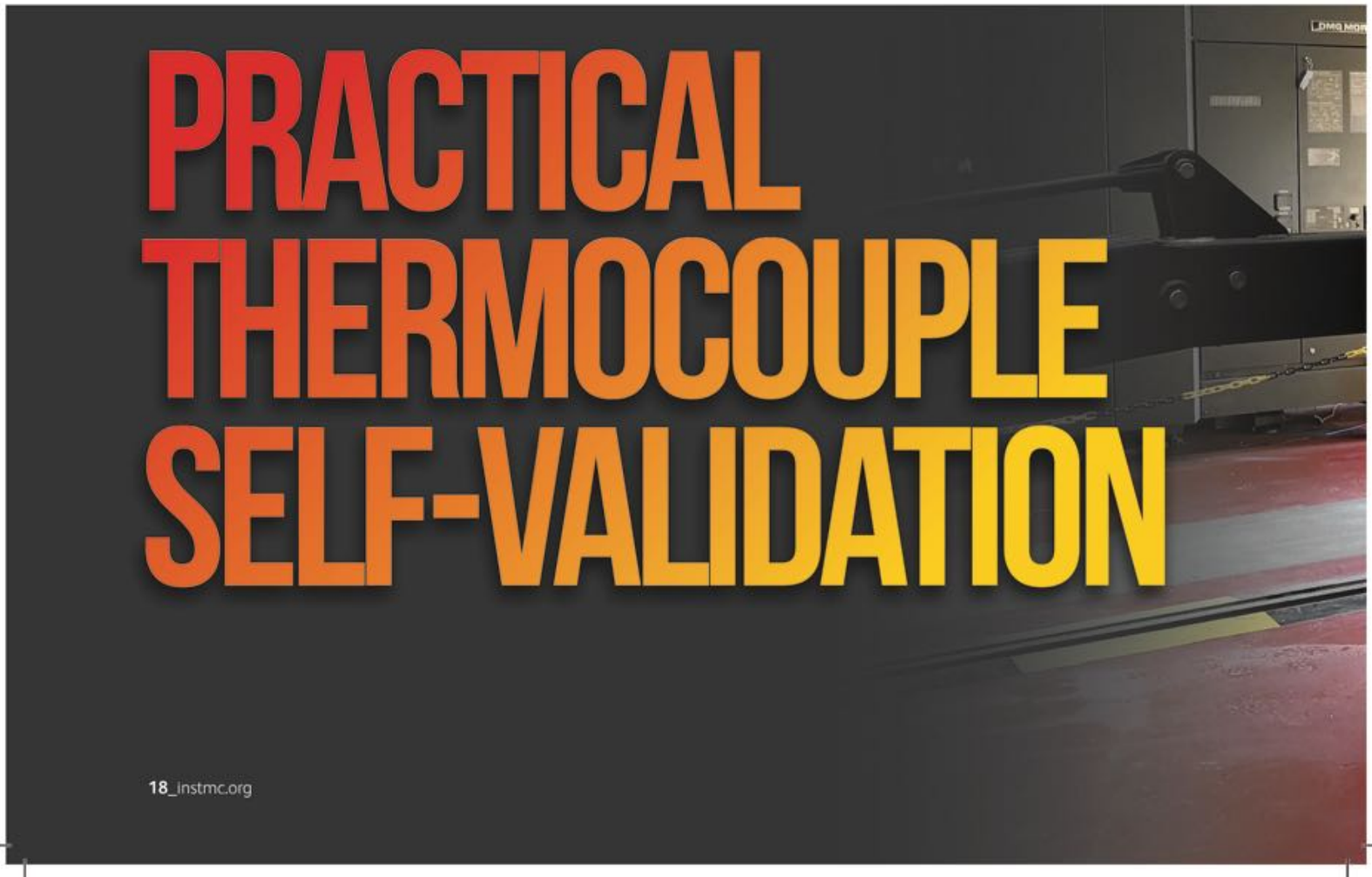
PRACTICAL THERMOCOUPLE SELF-VALIDATION



Research Scientists Claire Elliott, Declan Tucker and Jonathan Pearce from NPL introduce thermocouple in-situ validation – a viable means of mitigating sensing and control errors in high temperature industrial processes.

Thermocouples are commonly used for controlling a wide range of processes from sterilisation to manufacturing safety-critical aircraft components. There are many different types to choose from, including parameters such as operational temperature range, sheath material, flexibility and accuracy. Each type has its own pros and cons for a given process. Often, they are used at the limits of their operational capability and their behaviour can become significantly different from what is expected.

Over time, the thermocouple voltage signal can drift away from the calibration values, and the extent is unpredictable – this is especially true for thermocouples used above 1,000 °C or in harsh conditions (e.g. where there are contaminants, reactive gases or even ionising radiation). The resulting errors in reading the temperature can lead to errors as bad as tens of degrees Celsius, over hundreds of hours. Fortunately, this extreme case is not widespread but where precise conditions are needed, for example in the metal and ceramic manufacturing industries where heat treatment and the forging of components takes place, it is crucial to monitor the thermocouple drift in order to be confident that the control is within 0.5 °C over tens of hours continuously.

Alternative temperature measurement techniques may be available – but where the environmental conditions are particularly harsh, or there is no line-of-sight to the subject to permit non-contact thermometry, a robust thermocouple can be the only practical option.

When the problem of calibration drift becomes apparent to the user, often, one initial reaction is to increase the thermocouple replacement rate, which mitigates the immediate problem, but creates extra disruption and increases the frequency of maintenance shut-downs. This can be very costly, in terms of sensor cost and lost productivity, hence, the user is often looking for a practical solution which will prevent additional interruption of the process.

Working across Europe to develop a practical approach

NPL has been working with partners CCPI Europe Ltd, Advanced Forming Research Centre (AFRC) and the

Romanian National Institute of Metrology BRML-INM, to overcome this problem.

Together, we developed and demonstrated a practical new technology in a Europe-wide project known as 'EMPRESS', which ran from 2015 to 2018. It was clear that this technology would need to be useable in-situ, without affecting the conventional control process and access ports, and demonstrated to be reliable over a considerable period of time. For uptake, this also meant using, wherever possible, simple manufacturing techniques and the same thermocouple parameters (materials and dimensions) as currently in use.

Typical thermocouples in the aerospace, metal manufacturing and energy sectors include those made of noble metal thermocouple wires in a 7 mm outer diameter ceramic sheath. The newly developed technology , fits within both of these parameters. Additionally, as part of the project, Type S thermocouples with self-validation have now been demonstrated and proven to work up to 1 100 °C and for over 9 500 h, in industrial conditions.

Thermocouple self-validation - how does it work?

The general principle is to miniaturise the same concept used in calibration laboratories – where the reliable and well known melting and freezing temperature of metal ingots is used to calibrate thermocouple readings.

In calibration laboratories, the metal ingots are encapsulated to keep them pure, and carefully designed to include a deep well into which the thermocouple is inserted. As the ingot is warmed or cooled in a furnace, the deep well ensures that the tip of the thermocouple is fully immersed and therefore experiences the same temperature as the ingot. This ensures that when the ingot melts (or freezes) the thermocouple voltage corresponds reliably to the ingot melting (or freezing) temperature. This corresponding reading is a calibration point (voltage vs. a known temperature).

Self-validation is the concept of integrating this 'calibration' into the thermocouple so that a check on the reading can be made in-situ when required. There are, of course, many technical challenges with taking a technology from the 10 cm scale down to less than 10 mm.

Through thermal modelling and iteration, we developed a design which is sensitive enough to detect the melting and freezing of an ingot less than 0.3 g in weight, whilst undergoing the typical industrial process conditions of ceramic manufacture and metal forming. Furthermore, the design has an outer diameter of 4 mm, such that it comfortably fits inside an industrial thermocouple with a 7 mm outer diameter sheath.

Whilst the integrated self-validating ('inseva') thermocouple is in use at temperatures below the ingot melting/freezing temperature, it behaves just like a conventional thermocouple. But, as its environment passes through the ingot melting/freezing temperature,

the thermocouple voltage reading 'hesitates' at the value corresponding to the ingot melting/freezing temperature for up to 10 min (depending on the process conditions). This reading can be checked, as the temperature at that point is known, and therefore used to perform a correction to account for the calibration drift.

Such self-validating thermocouples have been demonstrated in processes including ceramic manufacturing at ICPE-CA in Romania, with assistance from BRML-INM, where the inseva thermocouple operated reliably for 9 500 h, over the 11 month test duration. Similar tests were performed at the Advanced Forming Research Centre (AFRC) in Scotland, where the inseva thermocouple was used for 6 200 h over the 8 month test duration.

Flexibility of the design

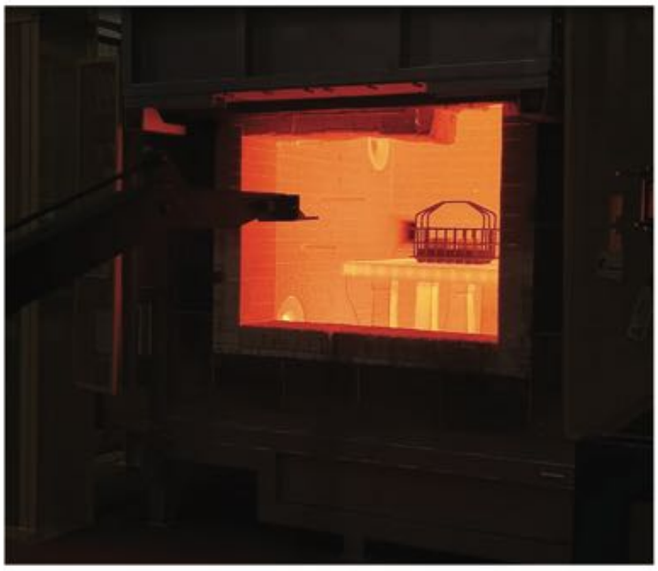
The design can be used with all noble metal thermocouples (e.g. Type B, R and S), and since it works with the same 7 mm outer diameter alumina outer sheath as typical thermocouples in present use in some industries, it can be swapped seamlessly for a conventional thermocouple.

Furthermore, the ingot metal can be chosen to match the process. The thermocouple which was used at ICPE-CA (Romania) was made with a copper ingot which has a freezing temperature of 1 085 °C. Similarly, other pure-metals, as designated in the International Temperature Scale of 1990 (ITS-90) can be used. High-temperature ingots have also been investigated e.g. Ni-C which has a melting temperature of 1 329 °C.

Conclusion

Self validating thermocouples show great promise, not just in the ceramics and metal forming sectors but across a wide spectrum of industries. They eliminate costly and disruptive thermocouple replacement in critical applications, saving both production time and money.

> ...it is crucial to monitor the thermocouple drift in order to be confident that the control is within 0.5 °C over tens of hours continuously.



Footnote

We thank Aurik Andreu (AFRC), Trevor Ford (CCPI Europe), Marius Neagu (BRML), Adam Greenen (formerly NPL) for their contribution and assistance.

This project (14IND04 "EMPRESS"), has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

For more information on this project see: www.strath.ac.uk/research/advancedformingresearchcentre/whatwedo/collaborativeprojects/empressproject/ or to receive updates on this and the follow-on project "EMPRESS-2" please contact jonathan.pearce@npl.co.uk

For further information on the work of NPL's temperature measurement team see: www.npl.co.uk/temperature-humidity/

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M&A MARKET STABILITY CONTINUES WITH A STRONG START TO THE YEAR

Mergers and acquisitions (M&A) deal activity continued to hold firm in the first quarter of 2018, reflecting ongoing stability and unwavering confidence in the market, according to analysis from accountancy and business advisory firm BDO LLP.

BDO's latest PCPI/PEPI report, which tracks trade and private equity transactions, found that 560 deals were completed in the first quarter of 2018 - maintaining the volume profile seen through 2017.

International buyers, particularly from the US and Europe, continued to invest in the UK market, completing a number of the largest deals seen in the quarter. The PCPI/PEPI index, which also tracks the multiples paid by trade and private equity buyers for private companies, found that the stability in M&A activity has not been at the expense of deal values. The trade (10.3x) and private equity (11.9x) multiples have both remained at high levels throughout the first quarter of 2018.

Roger Buckley, M&A Partner at BDO, commented: "Valuations rose slightly in Q1, demonstrating ongoing resilience in the M&A market. The UK remains a highly sought after market. International players continue to look to the UK for attractive acquisition opportunities, and competition is rife for quality businesses. We anticipate another prosperous year ahead for buyers and sellers alike".

Test & Measurement Q1 deals: investing for growth

The beginning of the year saw a healthy flow of deals in the test & measurement sector, including large fundraisings that that will position certain key players to make strategic acquisitions going forwards.

Sensirion, a leading global manufacturer of environmental and flow sensors based in Switzerland launched an IPO on the Swiss stock exchange in March, with shares over-subscribed several times due to strong demand from Swiss and international institutional shareholders as well as domestic private investors. Six weeks later, the Company, which generated CHF 148m turnover in 2017 and an EBITDA margin of 18%, is trading with a market capitalisation of CHF 638m. Sensirion produces around 350,000 environmental and flow sensors every day for the automotive, medical, industrial and consumer end markets.

Sensirion is well-positioned to capture the growth in environmental and flow sensors, driven by structural megatrends and the Internet of Things. The net proceeds from the primary offering will provide Sensirion with enhanced flexibility for its future financing and corporate strategy and will enable Sensirion to exploit additional growth opportunities.

Private equity investor Agilitas' buyout of Hydro International Ltd is a further example of financial investment to provide fuel for growth. Hydro International is a global provider of advanced products, services and technology for the treatment of wastewater and the control of stormwater for municipal, industrial and construction customers. Water management is an area of increasing government focus, as water scarcity grows in importance as a global issue, linked to increased population size, growing urbanisation and climate change. Agilitas plan to take Hydro to the next level through further geographical expansion and through the extension of its services and products, which if successful, should increase the future returns.

The strong regulatory drivers and high growth potential underpinning much of the test & measurement market mean that it is highly attractive to investors. Private equity have large quantities of cash they need to invest, and competition for quality investments is high. Unsurprisingly, these dynamics are pushing up valuations. Company owners should be watching and assessing these features carefully, ensuring they are making the most of potential opportunities for the future growth of their business.

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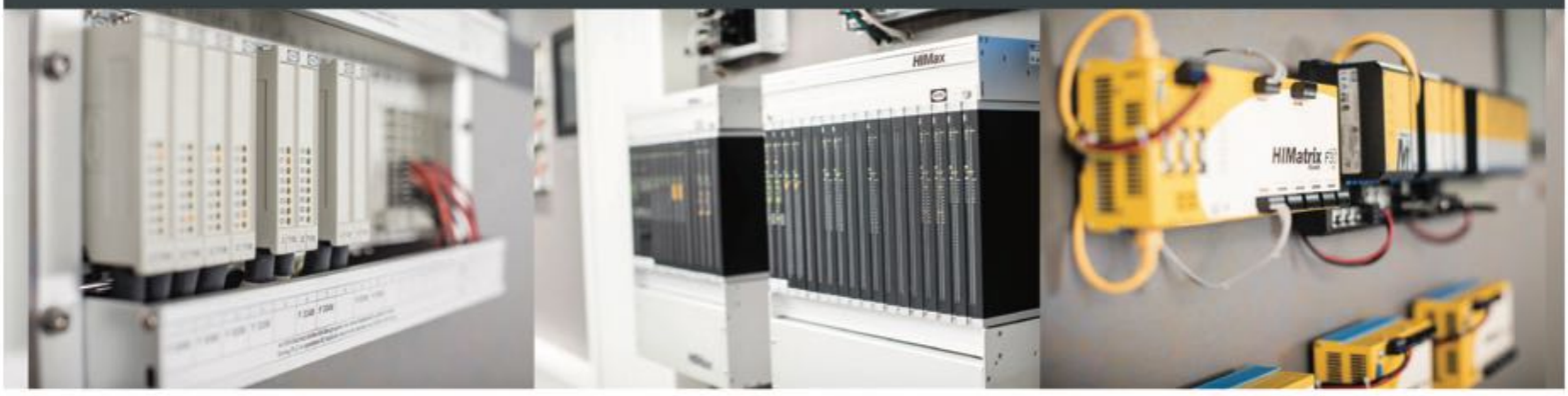

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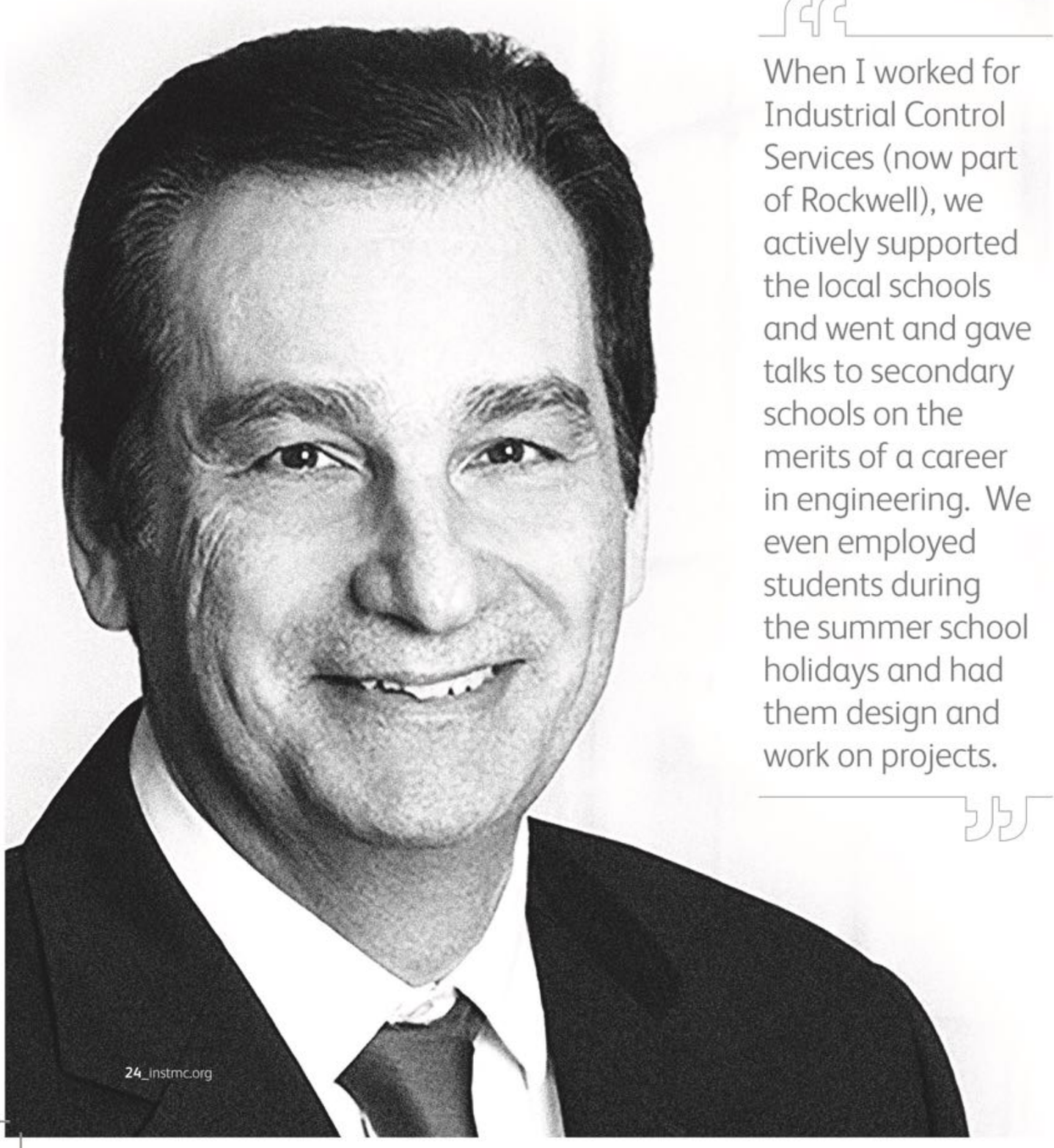
Q&A

Steve Gandy

This month's interviewee is Steve Gandy, VP Global Business Development, with exida Consulting LLC, specialists in functional safety and practical industrial cybersecurity.



When I worked for Industrial Control Services (now part of Rockwell), we actively supported the local schools and went and gave talks to secondary schools on the merits of a career in engineering. We even employed students during the summer school holidays and had them design and work on projects.

What was the root of your interest in Engineering?

It all started when I was 16 years old and my science master asked me if I'd like to do a demonstration of Ohm's Law for a parents' open evening. Not knowing what Ohm's Law was, he outlined what I'd need to do and the basic principles. That was it. I was hooked! The ironic part about this was that my father was a college lecturer in electrical and electronic engineering and had been trying to get me interested in engineering for years. When I went home and asked where the jar of resistors was in the garage, you could have knocked him over with a feather!

What is your vision of Engineering in Britain in 2020?

I think the UK needs to develop more on the biosciences side, as well as automation. The reality is that more automation is the future with autonomous driving vehicles, manufacturing robots, mobile technology, online applications and surgical automation. I see engineering becoming more "sexy" than the traditional notion of the engineer and what this means. Advancement in technology will enable more radical and innovative applications to be developed in these areas. Technology is definitely the future and for the UK this will be very important as it transitions out of the EU.

What should the UK government do to address the shortage of UK engineers?

This is a very interesting question since we are experiencing a shortage of engineers, which doesn't seem to be improving. Countries like India and China are turning out a lot of engineers and with Brexit and tighter immigration I see this as a continuing problem. I believe more encouragement should be given to school children to consider engineering. In the past I was involved in the David Sainsbury sponsored engineering programme for schools, that was looking to do just that. However, I believe there should be more government sponsored programmes to promote and support technology and engineering development in schools, not just from the private sector. Also, when I started my career it was as a student apprentice with Marconi-Elliott. I don't see too much evidence of this type of sponsorship being easily available nowadays and a lot of the old technology companies, such as Marconi, are now gone. Providing tax benefits and/or subsidies to engineering and technology companies who can provide apprenticeships and/or student sponsorship would be a good way to go. When I worked for Industrial Control Services (now part of Rockwell), we actively supported the local schools and went and gave talks to secondary schools on the merits of a career in engineering. We even employed students during the summer school holidays and had them design and work on projects. We even used some of the designs in our systems.

I think the UK needs to develop more on the biosciences side, as well as automation. The reality is that more automation is the future with autonomous driving vehicles, manufacturing robots, mobile technology, online applications and surgical automation. I see engineering becoming more "sexy" than the traditional notion of the engineer and what this means. Advancement in technology will enable more radical and innovative applications to be developed in these areas.

What do you do in your free time to relax?

All my life I've been active in sports, although these days it's using the gym and playing golf. I also have a passion for music and compose and record my own instrumental compositions and have an in-home studio and website. I also trained as an artist and used to sketch pets of friends and family on planes when flying around the world in my previous job. These too are on my website (www.theflyingartist.com). I also enjoy spending time with my family and our holidays abroad.

Given one wish what would that be?

Again, another good question. I guess if I were in a beauty pageant I'd be saying world-peace. However, winning the lottery and being able to retire on a tropical island with a fancy yacht to sail around in. Now there's a dream. And, of course, for world-peace.

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