THE MAGAZINE OF THE INSTITUTE OF MEASUREMENT AND CONTROL
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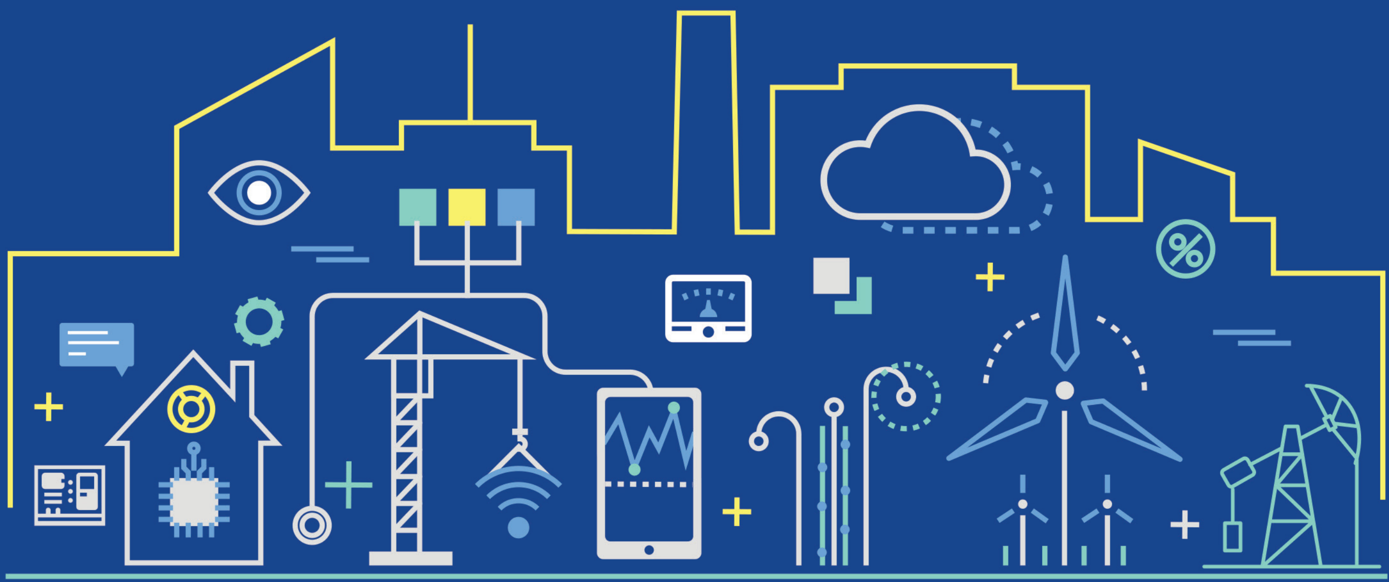
HOW DOES AIR TEMPERATURE AFFECT US?

FEATURES//
INDUSTRIAL CYBER PHYSICAL SECURITY ENHANCEMENT PART II

A NOSTALGIC LOOK AT THE SOCIETY OF INSTRUMENT TECHNOLOGY

ISSUE ELEVEN

PRECISION



GOODBYE TO 87 GOWER STREET

In the second half of 2018, the Trustees took the decision to sell the Institute's London headquarters, 87 Gower Street in order to raise money to fund a modernisation programme and to help pay off some historical debts.

The costs of maintaining an ageing grade 2 listed building in London were mounting and sadly, it was no longer able to provide the type of facilities that are required in a modern Professional Engineering Institution (PEI). The Institute is now housed alongside other PEIs in a more modern facility at 297 Euston Road not much more than a stone's throw away from Gower Street.

I want to look back on our time in 87 Gower Street and to pay our respects to the building that has been our home since 1984. First though, a bit of history.

The Institute of Measurement and Control was founded as the Society of Instrument Technology in 1944 (and is currently celebrating its 75th anniversary). In 1978, following a period of uncertainty about the intentions of the landlord of its Peel Street, London premises, the Trustees decided to buy the Peel Street building to secure the Institute's future. They were successful in doing this and paid approximately £400,000. As life became tougher for PEIs in the late 1970s and early 1980s, staff numbers reduced and Peel Street became too large for the Institute's needs and, in 1984, it was sold for circa £1 million and approximately £440,000 of this was invested in the purchase of 87 Gower Street.

From the estate agent's notes, "87 Gower Street is understood to have been built c1789 and is the end property in a terrace of five Georgian houses. It is located on the northwest corner of the junction of Gower Street and Torrington Place, London WC1E 6AF and consists of a basement, ground floor and three upper floors".

As a Grade 2 listed building, number 87 required planning approval for any significant changes, inside or out. The hallway and most internal walls could not be removed making it difficult to build a modern open plan office space. The fireplaces in the Council Room and other main rooms were thought to be original features although, in recent surveys, carried out to price-up a possible modernisation of the building, this turned out not to be the case. Instead, a much scruffier fireplace in the corner of the downstairs kitchen was highlighted as the important one. There was also an architecturally important outside privy that had to be retained and could not be not turned into a garden feature.

Two arches in the basement go out under the pavement and roadway, complete with signs of a coal hole at the apex, but these are hidden when looking in the street.

We sold 87 Gower Street in late February this year for £2.85 million, quite a return on the original investment, and money which will be invested and used to build a stronger Institute for the 21st century

What will emerge when Gower St is modified by its new owners? Will we eventually solve the mystery of the location of the Secretary's wine cellar of legend, tales of which some older members may remember?

With grateful thanks to our Honorary Treasurer, Colin Howard, for providing some of the important historical facts. Finally, I wish the Institute, its staff and members, well in our new home in Euston Road.

Dr Graeme Philp
Honorary Secretary

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Our experts wade through our 'post bag' to find interesting questions to answer. The query this issue is:

I see there has been a rapid increase in the use of multiphase flow meters over recent years. What has driven this trend and how have the meters advanced?

Lynn Hunter, Business Development Manager, TÜV SÜD National Engineering Laboratory explains.

20-21

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INDUSTRIAL CYBER PHYSICAL SECURITY ENHANCEMENT PART II

In Part 2 of his article, Cevn Vibert, Industrial Cyber Physical Security Consultant and Co-Chair of the InstMC Cyber SIG looks at some of the ways in which organisations can improve their cyber security.

Security Operation Centres (SOC)

Cyber security management systems for industrial operator interfaces are still in their infancy. These typically sit in a Network Operations Centre (NOC) or a Security Operations Centre (SOC). Operations security management is essentially about the people, their procedures, methods and capabilities. The Concept of Operations (ConOps) of a security team should be made up of the manuals and documents and the process which has been worked out to achieve the highest and most robust levels of security, and of course honed over time. In reality the ConOps are defined once, read once, then left on the shelf or even 'stored safely' in a box!

Recently there has been a welcome increase in knowledge management systems deployed to support security operations, with rules engines, flexible database driven operator assistance and mandatory guides being used to good effect. When a site alert occurs, the security staff can be taken through an approved procedure step-by-step, with each action being recorded for future alarm analysis, and for operational improvements in the database steps. The concept of an industrial SOC is being discussed more frequently and the challenge of integration is being reviewed against the risk of implementations.

Safety

Safety is becoming a strong component of the security mix. Systems cannot be stated as "safe" if they are not secure, and systems cannot be stated as "secure" if they are not safe. There are no truly international definitions of safety and security which can be used as a standard by all experts in safety or security. Building Management Systems, HVAC, water management, environmental monitoring and similar ancillary systems are also subject to attacks which can have serious consequential impacts, and should not be left out of a risk analysis.

Outside the Box

Supply chain risks are only now being reviewed, with defence suppliers being most strictly audited, although industrial and commercial organisations are also waking up to supply chain security. An organisation can be excellent in its own defence but if its supply chain is compromised then either components or data can be compromised, exfiltrated or aggregated to increase the threats from their suppliers. The adage that a chain is only as strong as its weakest link applies.

Data promulgation and corruption is also a threat to Industrial systems. CAD drawings, netlists, build diagrams, material make-ups, cavity and void plans, electrical schematics, 3D drawings of physical security systems, 3D object definition files for 3D printing and modelling all could pose significant risks if compromised or exfiltrated and then re-used by attackers or unaware suppliers in the supply chain.

Integrated Security

Integrated Security means bringing at least two or more security disciplines together to create a tangible benefit to the operations of a Control Room or Security Room. Holistic Integrated Security (HIS) means bringing multiple systems together to create a Command, Control, Communications and Computer solution. The drawbacks of Integrated systems are the cost of developing and maintaining the integration, the potential security risks of inter-connectivity, and the cost of managing the complexity and rule-sets. The benefits are often seen to easily outweigh the potential drawbacks. Integrated systems are evolving as the norm. Security of interconnection is not such a challenge with newer technologies being adopted. Scenario 1 illustrates a disconnected system and Scenario 2 a HIS system.

Technology plays a key role in improving security, but human interactions and softer skills are also needed in equal measures. Much more work is being done on social engineering and operator interactions, and the scientific findings are being increasingly understood and practically applied. Security designers need to understand the technologies, but motives and compromises also need a foundation in psychology, social engineering, MITM, least privileged operations, politics, espionage and so on.

Enterprises need to be aware of the significant advantages of HIS systems for de-risking potential threats, improving current business operations through efficiencies, reducing mistakes across disparate systems, and finally improving morale through greater staff security. Integrated Holistic Situational Awareness is not a silver bullet to threats posed but can yield enormous improvement if carefully engineered, and integrated into the normal operations of security teams and seen as a clearly perceived benefit.

Analysis

Many industry exponents are now trying to include safety under the security umbrella to ensure that safety systems are secure and security systems are safe. The UK Health and Safety Executive (HSE) has recently released guidance relating IEC 62443 to Safety Integrated Systems (SIS). Again, this seems an obvious inclusion in business planning and in system architectures but has been lacking due to many factors. Hazard analysis (HAZOPS/HAZANS/etc) has often excluded intentional attacks in any form as this exclusion approach reduces the complexity of the analysis task, and ensures a sensible consideration of hazards and effects within normal boundaries. Unfortunately, this likelihood appreciation is now no longer the case. Hackers can intentionally disrupt both operational and safety systems and use man-in-the-middle (MITM) insiders to override basic safety systems and hence cause catastrophes. Multiple safety compromise actions can cause events assumed to be highly unlikely but these must now be re-assessed. The cost of reassessment will be considerable, adding further to the cost of the new Security Mitigations also needed.

Changing Times

Many serious account hacks that happened in the past were disclosed in 2016. Overall, a billion account credentials fuelled the black market. [1]

- 2012 LinkedIn breach affected around 117 million.
- MySpace breach exposed 427 million users.
- Tumblr data breach exposed 65 million accounts.
- VK security breach exposed 93 million accounts.
- DropBox security breach exposed 69 million accounts.

These accounts hacks are then used to compromise the identity and authorised capabilities of staff. Ideal information for MITM attacks.

Industrial Cyber Security is now deeply into a form of arms race. Defenders are needing more defence tools and monitoring wizardry to detect and prevent attacks, but only if they can afford the resource time and expertise costs. They are usually seriously hampered by lack of budget and resources. Automation and Security Vendors are building more and more complex systems to help the defenders, but only if the defenders can afford the prices. Automation Systems Integrators are skilling up their resources to provide the expertise in security, not previously provided or required. Government and Academia are trying to find expertise, solutions, projects and understanding of the unfamiliar Automation Industry. The Attackers are often either state or organised international criminal gang funded and have neither the resource, cash or time limitations of the defenders. Attackers are becoming more formidable adversaries than was previously known or expected.

Methodologies

There are numerous approaches to enhancing Industrial Cyber Security. The best approaches consider the many factors in and around the environment to be secured, often called the Focus of Interest or the systems Boundary, depending on the scale of the scope. The scope could be a full enterprise including all the IT and Operational Technology (OT) Automation or it could be a single factory/plant or a manufacturing line or a single system of interest. The important points to ensure that are addressed are the holistic nature of the systems, and the solutions, both for the enhancement event and the very necessary long-term programmes. No enhancement solution is a project, and they should be both viewed and promoted as an ongoing programme. Every solution to include the formulate-review-install-monitor-review-formulate cycles since there is no such thing as 100% secure and the attacks change constantly.

Many industry exponents are now trying to include safety under the security umbrella to ensure that safety systems are secure and security systems are safe.

There are international methodologies for analysing and assessing the Informational and Operational security under scrutiny. No single method is "The Best" as has been found by many practitioners, since no single system and environment are the same as others. For IT Information Assurance, standards such as ISO 2700x may be suitable, and for Industrial systems the use of ISO 62443 or ANSSI or NIST methods may be suitable. Many programmes involve a form of hybrid of several methods together with customised measures designed for each system under scrutiny.

Stairway to Security

There is a well-planned, but adaptable, "stairway to security" (Fig 1). Each step is an achievable security improvement, either in understanding, awareness, readiness, or defences. Each step can be small or large but is always an improvement.

The Security A-Team

To achieve the successful Security Enhancement Project requires a wide range of disciplines and roles. Selection and the coming together of an effective Security 'A-Team' of people who are tasked, and keen, to carry through the enhancements both from a project basis, a technical and assurance basis, and a social and marketing basis is essential (Fig 2). All aspects must be considered in the team selection and the formation is critical to both the practical and political success of the programmes.

Figure 1: The Stairway to Security

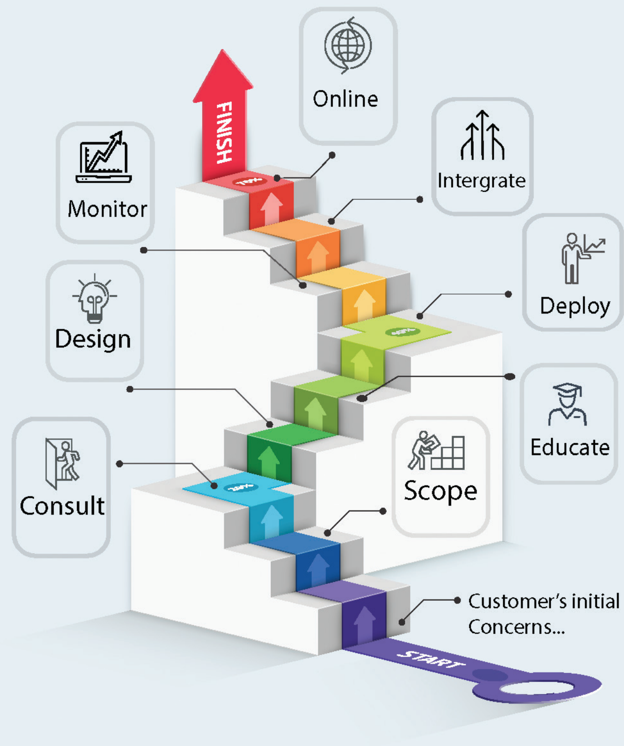
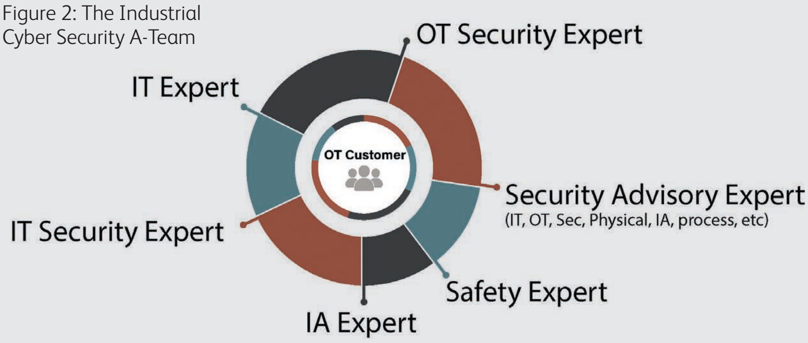


Figure 2: The Industrial Cyber Security A-Team



The products, partners and solution integrators are also key parts of the enhancement programmes and should also be thought out, researched and integrated closely in the success measures. Often, security enhancement projects are disruptive and require significant changes to technical, social, operational, procedural and political well-worn grooves. Building the Jigsaw of

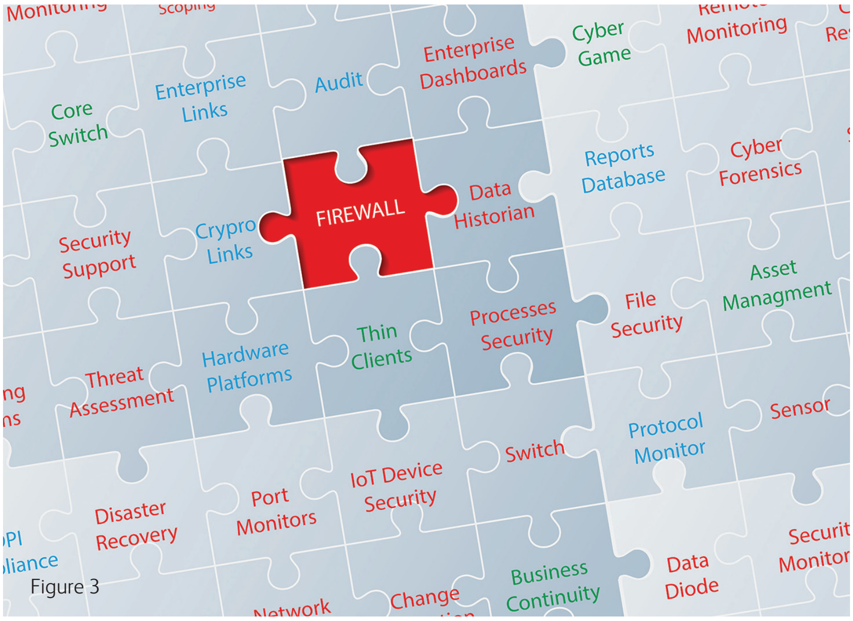


Figure 3

Security products, operations, procedures and activities into the Security solution can reveal strengths and weaknesses. Creation of an overall security jigsaw map (Fig 3) of each system under consideration is useful for communication and for a missing-pieces check.

The team should walk through the reasons for selection of each Jigsaw part and record the reasoning. System Design records can really help review decisions made in both current and future mitigations. Systems having firewalls with particular ports being blocked for no currently known reason is an example of decisions made but not recorded. US software firm Microsoft will continue to invest over $1 billion annually in cyber security research and development in the future.

Conclusions

Having the right 'A-Team', the right political and financial backing, the right partners and choosing some suitable methodologies and standards is essential to effective enhancements. Consider both the technical aspects, the inter-departmental aspects, the financial aspects and the political change aspects, and keep refining these considerations throughout the programme. The industry must remember that the bad guys are getting better; they have unlimited everything and our industries have limited resources, so the resources must be used wisely and continuously. When building the A-Team take on both members and advice from 3rd parties to both give an alternate perspective, and to utilise other people's experience and expertise.

A security improvement checklist might follow some typical points such as: -

- Agree internally that action, or investigation, is needed, will be funded and supported.
- Identify the internal leader of this improvement initiative
- Engage trusted external assistance in building the programme
- Create an "A-Team"
- Plan the Stairway to Security programme ahead
- Start the cycle of Plan-Monitor-Decide-Act-Review within the programme
- Engage with supplier of The Security Jigsaw components
- Train staff, consult, partner, communicate, promote, collaborate, etc.

The industrial cyber war continues.

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1. http://resources.infosecinstitute.com/the-biggest-cyber-security-incidents-of-2016/#gref Accessed Sept 2018

If you are a Student

...and are working towards a degree level qualification in engineering, why not sign up as a Student Member! The Institute of Measurement and Control is here to help you make confident decisions about your future.

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AIR TEMPERATURE

Dr Michael de Podesta MBE, Principal Research Scientist at NPL, discusses one of the most common measurements on Earth, and explains why it is not as easy as it seems.

Air temperature affects almost everything people do. If it's cold outside we put on our coats and turn up the heating, and in industry, air temperature affects product quality in thousands of processes, particularly those involving humidity control.

When it comes to precision measurements, accurate knowledge of air temperature is critical in three quite distinct ways.

- Firstly, equipment of all kinds generally has some sensitivity to air temperature, and maintaining a constant known temperature is critical to making the best measurements.
- Secondly, air temperature is often used as a parameter in test measurements. For example it is commonly assumed that objects left on the bed of a measuring machine will eventually acquire the same temperature as the air flowing past the machine.
- And finally, small errors in the determination of the air temperature can lead to significant errors in the inference of relative humidity.

No easy task. Some three years ago I was asked to measure the air temperature in one of NPL's laboratories that has a closely-controlled and very stable temperature. Using small platinum resistance thermometers, I found that the temperature was indeed very stable – it varied by less than ±0.01 °C over several hours! However, I found that every object in the laboratory appeared to be at a different temperature, and no object in the laboratory was at the temperature of the air! I was puzzled. How could I have failed to do something as apparently trivial as measuring the air temperature? It took several months of puzzlement before I finally understood what was happening.

“Air temperature affects almost everything people do. If it's cold outside we put on our coats and turn up the heating, and in industry, air temperature affects product quality in thousands of processes, particularly those involving humidity control.”

What's the problem?

When a thermometer is placed in an environment, the temperature at which it equilibrates – the temperature a user will read – depends on the balance of heat flows into and out of the thermometer. The reading will be stable when these heat flows are equal.

There are two basic difficulties with this. The first arises because heat transfer between air and thermometers is surprisingly poor. The second arises because radiative heating of thermometers – particularly from room lighting – is much stronger than is generally considered. When these effects are combined, they can result in temperature sensors stably indicating an air temperature which is quite different from the true value.

The ineffectiveness of heat exchange with the air can be appreciated if you imagine air flowing perpendicular to the axis of a cylindrical temperature sensor. The air which initially strikes the sensor exchanges heat with the sensor and – because of the low heat capacity of the air – it quickly reaches the temperature of the sensor. This 'equilibrated' air then flows in a 'boundary layer' around the sensor deflecting 'fresh' air away from its surface. Because of the low thermal conductivity of air, this effectively insulates the sensor from the 'fresh' air. The effectiveness of heat exchange with the air thus depends on the size and shape of the object, as well as the air speed.

"When a thermometer is placed in an environment, the temperature at which it equilibrates – the temperature a user will read – depends on the balance of heat flows into and out of the thermometer. The reading will be stable when these heat flows are equal."

Additionally, sensors in a typical laboratory are subject to both optical radiation from the lights – most labs don't operate in the dark – and thermal radiation from warm objects – including humans. For thermometers immersed in liquids or solids, the effect of this radiative load is generally small – at the level of a few thousandths of a degree. But for thermometers in air, the poor heat exchange can lead to errors of several tenths of a degree.

When these two effects combine, you find that the temperature reported by a thermometer depends on its size, with smaller thermometers reporting a temperature closer to the true air temperature, but not actually equal to the air temperature. Additionally, these combined effects explain the observation I described earlier where every object in the laboratory was at a different temperature and none the same as the temperature of the air. So simply leaving an object in a room will not, in general, mean that it acquires the temperature of the surrounding air no matter how long it is left to equilibrate!

If this seems unlikely to you, or even impossible, then I sympathise – because that's exactly what I thought until I measured it!

Recommendations

If you are measuring in normal offices or laboratories, and only need to know the temperature to within ±1 °C, then unless there is something very warm near your thermometer, you probably don't need to worry. Just use a calibrated thermometer with a probe that is as narrow as possible – 3 mm diameter probes are readily available.

...simply leaving an object in a room will not, in general, mean that it acquires the temperature of the surrounding air no matter how long it is left to equilibrate!

However, if you want to know the temperature with an uncertainty of 0.1 ˚C – an uncertainty which is a common aspiration for precision measurement laboratories – then you have a very significant challenge. The problem can affect users in one of three ways.

- Air temperature: Using 6 mm diameter, stainless steel probes in a room lit to 1000 lumens per square metre can easily result in an overestimate of temperature of more than 0.1 ˚C, with the effect becoming larger at low air flows.

- Artefact temperature: In laboratories used for dimensional measurements, it is important to realise that artefacts left in a room will acquire different steady-state temperatures depending on their size. In one of our laboratories, an un-heated object 150 mm in diameter was found to be 0.5 ˚C warmer than the air temperature.

So the temperature of objects in a lab will, in general, neither be that of the air, nor that of thermometers placed in the air!

- Relative Humidity: Around room temperature, an error of 0.1 ˚C in air temperature can affect the relative humidity estimate by 0.7 % of value. So depending on the radiative load and air flow, it may be necessary to consider this effect.

These difficulties are compounded by the fact that there is still no definitive standard procedure for measuring the true air temperature. If all this sounds alarming, then the first step is to become aware of the magnitude of the problem in your measuring environment.

Perhaps the simplest test is to leave an object – perhaps a tube – roughly 40 mm (say) across, in a location close to where the air temperature is required to be measured. Now measure the temperature with a sensor first inside the object, and then outside. If you see a difference in reading, then your measurements may be affected and you may need to carry out further investigations, the most obvious experiment being to repeat the measurement with the lights off.

In Summary

We generally measure air temperature because of its effect on something we care about. So if air temperature affects something you care about, then make sure to take care of the measurement of air temperature.

Q&A

David Tipton

This month's interviewee is, Eur Ing David Tipton CEng FMInstMC. Managing Director Omega Engineering Ltd. Vice President

What was the root of your interest in Engineering?

My Grandad was a mechanical engineer. After he retired, he dabbled in repairing mechanical clocks and pocket watches. I used to sit with him while he did this and I was fascinated by the fault finding skills applied to the extent that I retained an interest in watches ever since. Unfortunately, I didn't have his patience or his gift of explaining the intricacy of what he did so that's why I'm a collector rather than a repairer!

What is your vision of Engineering in Britain in 2020?

Wow, that's only next year! I don't see too much changing from where we are at present, in that we need to continue to build on the STEM initiatives and involve schools and further education in science pretty much like the InstMC did at the recent IMEKO conference in Belfast.

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

Having a challenging and achievable manufacturing strategy would help. I travel across Europe and Asia Pacific in my role at Omega and it's apparent that there has been Governmental involvement in developing a culture that recognises the importance of engineering to science and the economy. In my view, successive governments have failed to recognise and inspire the engineering profession. As in all organisations, if the leaders don't believe in the mission, neither will the majority of us.

What do you do in your free time to relax?

Family, friends, sea fishing and repeated failed attempts to revive my golfing activities.

Given one wish what would that be?

Manchester City to win the Champions league in my lifetime.

"In my view, successive governments have failed to recognise and inspire the engineering profession. As in all organisations, if the leaders don't believe in the mission, neither will the majority of us."

A nostalgic look at the Society of Instrument technology - Part 1

In 1994, as the Institute celebrated its Golden Jubilee, Stuart Bennett Department of Automatic Control and Systems Engineering took a look at the early years.

Introduction

The first official meeting of the Council of the Society of Instrument Technology, the forerunner of the Institute of Measurement and Control, was held on 10 May 1944 at Imperial College. It was at this meeting that the Society became a legal entity and it is the 50th anniversary of this event that we are celebrating this year. The meeting was chaired by the President Sir George Paget Thomson and the Council members present were:

Representing users
- Dr W.J. Clark
- G.H. Farrington
- Dr W .F. Higgins
- W.B. Wright

Representing manufacturers
- R. E. Iggleden
- F.C. Knowles
- E.B. Moss
- C.R. Sams

Representing research and education
- Prof F. Debenham
- Prof H. Spencer Gregory
- Dr Exer Griffiths, FRS
- D.A. Oliver

Hon. Treasurer
- Dr H.B. Cronshaw

Hon. Secretary
- L.B. Lambert.

The purpose of the Society, as reported by Engineering and Nature, was

> *the advancement of instrument technology by the dissemination and coordination of information relating to the design, application and maintenance of instruments. It will also provide opportunities for discussion, particularly between the designers and manufacturers on one side, and the users on the other.*
>
> *Among other objects of the Society are the technical education of those who wish to enter, or are already in, the industry and dealing with instrument research, design, manufacture or use: encouragement of research into problems relating to instrument technology: standardization of instruments and accessories by collaboration between manufacturers and users: and the status and prestige of those employed in the industry.*

This formal, official beginning had been preceded by months of discussion, arguments and negotiations but above all by enthusiasm coupled with detailed and careful planning by a number of dedicated people. The lead was taken by L.B. Lambert, Sales Director for Negretti and Zambra, and H. B Cronshaw, a consultant, who had discussed together, before the beginning of the Second World War, the possibility of forming a new society dedicated to instrumentation. The advent of war delayed their plans and it was not until 1943, prompted by the news that the Australian Society for Instrument Technology had been formed, that they took the idea further. They organized a meeting of interested parties for the 21 October 1943, at the Waldorf Hotel in London. The meeting, chaired by Dr Cronshaw, was attended by over 100 people, mainly senior technical staff from industry, universities and research associations. Those present agreed on the need for an organization to deal with technical and educational matters relating to instruments but were divided as to whether this should be a new society or part of an existing body.

A small committee, comprising Cronshaw, Lambert, Dr W.J. Clark, Professor H. Spencer Gregory, D.A. Oliver and R.E. Iggleden was elected and asked to investigate the matter further. Oliver, who became the second President of the Society (1948-1951) recalled in 1969, 'the curious difficulty that instrumentation ran into as a subject. The Institution of Mechanical Engineers was willing

LB.Lambert, President 1962-64, in the robes of Master of the Worshipful Company of Scientific Instrument Makers (1965- 66)

to encourage mechanical, pneumatic and hydraulic instruments but could not hope to cover electrical ones. The reverse was almost true of the Institution of Electrical Engineers, while the Institute of Physics could go so far, but its specialized Group structure and its publications had certain limitations, especially regarding engineering topics. The committee conducted a postal survey of research and technical directors covering a wide range of industries and found that of those consulted 139 were in favour of forming a new society and 14 supported other courses of action. With this overwhelming support in favour of a new society another meeting was called on 25 November 1943 at which a formal motion to set up such a society was passed.

A third meeting of the committee was held on 10 March 1944 at which Professor Spencer Gregory introduced Sir George Paget Thomson, who despite his other commitments agreed to accept the Presidency of the Society. Thomson, who had been awarded the 1937 Nobel Prize for Physics (shared with C.J. Davisson of the Bell Research Laboratories) for his discovery of the diffraction of electrons, was nominally the Head of the Physics Department at Imperial College but was also working full-time as Deputy Chairman of the Radio Board and Scientific Aviser to the Air Ministry. This was his second wartime role; previously he had alerted the authorities to the military possibilities of the fission of the uranium nucleus and, in 1939, persuaded the government to purchase for him a ton of uranium oxide with which he was able to demonstrate that starting a chain reaction would not be easy. He subsequently formed and steered the 'Maud' Committee which provided a link among scientists working on nuclear weapons and between scientists and the British Government.

The son of Sir Joseph (J.J.) Thomson and Rose Paget, 'G.P.' as he was known to fellow physicists, was an 'establishment' figure. He grew up in Cambridge where his father held the Cavendish Chair of Experimental Physics and his mother, who had worked as a physicist in the Cavendish Laboratory, had strong family connections in medicine and the Church. His work on electron diffraction was done at the University of Aberdeen where he held the Chair of Natural Philosophy from 1922 until 1930 when he was appointed to succeed H.L. Callendar as Professor of Physics at Imperial College. As P.B. Moon in a biographical memoir for the Royal Society observed, 'G.P.' had an extensive network of contacts and was adept at using them in order to get things done. It is reasonable to suppose the committee thought that Thomson's Presidency of the fledgling Society would bring respectability and prestige, and that his contacts would open many doors. However, Thomson was unable to devote much time to the affairs of the Society and he was unable to garner as much government support and encouragement as might have been expected (there is no mention of his Presidency of the Society in the list of activities given in Moon's memoir).

A meeting of the putative Council was held on 27 April 1944, with the intention of officially forming the Society; members of the Council and the officers were duly elected; however, during discussion of the constitution and laws it was realized that members would have unlimited liability for the debts of the Society. The only solution was to register the Society as a limited liability company and this was confirmed at a second meeting held 13 days later. The consequence of this necessary decision was that the Society did not begin functioning effectively for another eight months during which time the officers were occupied with the legal procedures of registering the company and agreeing a Memorandum and Articles of Association. The time was not entirely wasted as the Secretary sent out 1750 application forms and, by the end of January 1945, he was able to report that about a quarter had been returned, and that the completed forms had been reviewed by a membership committee which recommended 192 persons for membership, 144 for Associate Membership and 5 as student members. However, until there was formal acceptance of the Memorandum and Articles of Association it was difficult to enrol members. The difficulty was resolved at a committee meeting held on 31 January 1945, when it was agreed to send a letter to all successful applicants which informed them that they had been elected on 31 January 1945 but that in the absence of the Memorandum and Articles of Association they had the right to withdraw should subsequently they find anything in these documents that they found unacceptable.

It was not until 12 December 1946 that the Memorandum and Articles of Association were finally approved and a Certificate of Incorporation issued, the change of name to the Society of Instrument Technology Limited being formally approved at the annual general meeting held on 25 March 1947.

Prior to this meeting an application was made to the Board of Trade for the granting of a licence to the Society to enable it to be incorporated as an association operating without profit and therefore able to omit the word 'limited' from its title. This was turned down on the grounds that being newly formed the Society could not claim to represent all the instrument technologists in the country! Members of the committee must have been sorely tempted to challenge the Board of Trade to produce a definition of an instrument technologist. In retrospect this was but an initial skirmish: 'the really classic example, in the history of the Society, of delay and frustrating waste of effort', wrote A.J. (Christopher) Young 'must forever remain the struggle to produce Articles and Memoranda of Association acceptable to the Board of Trade; a struggle which seemed destined to continue indefinitely.' The struggle began in 1949 and was pursued for eight years, continued Young, 'with infinite patience and unremitting determination first by L. B. Lambert and then by R.H. Tizard. This was a vital step in establishing the Society and hence a prerequisite towards obtaining ultimately a Charter. I cannot believe that anyone in the Society has worked harder on a more uncongenial task than these two men: a kind of legal obstacle race run in a nightmare with a new hazard introduced every time the winning post came into view. It was a shocking waste of effort which could have been avoided if the hands we could have expected to help had been extended to us.'

D. A. Oliver, President 1948-51

The inaugural technical meeting of the Society was held on 21 April 1945 and over 200 people attended. Three papers were presented:

- 'Electrical non-destructive testing of materials' by Pogreen and Tomlin
- 'The determination of steam wetness' by J. H. Burkitt
- 'Electrical tachometry' by E.B. Moss (President, 1951-1954).

One of the objectives of the Society was the publication of technical papers; however, in the immediate postwar years there were two difficulties: one was financial and the other was the rationing of paper. The allocation of paper was based on consumption in 1939; as there was no Society in 1939 there was no paper ration. As a temporary solution the cooperation of other technical publishers was sought and, for example, the first of the above papers appeared in Electronic Engineering, and the second in Engineering and Boiler House Review. (The paper by Moss was eventually published in issue number 2 of the Transactions of the Society, December 1947.) The commencement of publication, in November 1946, of a new journal, Instrument Practice, edited by Cronshaw, provided the Society with editorial coverage and an outlet for the publication of papers presented at meetings. However, the Committee decided this was insufficient and that the Society must publish its own proceedings, and in January 1947 issue number I of volume I of the Transactions appeared.

By this time two of the objectives of the Society had been achieved: provision of a forum for personal contact, and the publication of technical papers. The Committee was also working hard to achieve the other objectives and in particular 'the encouragement of technical education for persons engaged in the manufacture and use of instruments'. The issue of education was a complex matter and there was some disagreement among Council members as to how best to proceed; some members favoured working through existing ONC and HNC courses sponsored by existing bodies; others wished to develop a new course in instrument technology. The matter was closely linked to the question of whether the Society should seek to become an 'examining and qualifying association'. The story of the transition from a study association to a professional, qualifying body and the gaining of a charter is told in the article by David Nutting who led the Institute in its efforts towards achieving this goal.

"Why form a society of Instruments?" will feature in the next Issue of PRECISION.

ASK THE EXPERTS

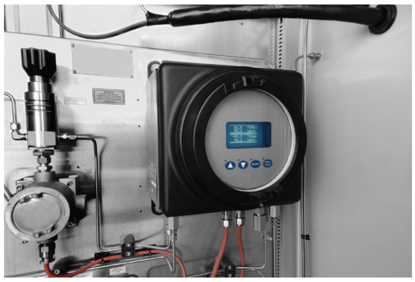
I see there has been a rapid increase in the use of multiphase flow meters over recent years. What has driven this trend and how have the meters advanced?

**Yours sincerely,
Curious of Stevenage**

Lynn Hunter, Business Development Manager, TÜV SÜD National Engineering Laboratory replies:

Background

The growth in multiphase metering has been driven by the large worldwide shift to subsea oil and gas production. Although multiphase flow meters were first introduced around the mid 80's, the last decade has seen substantial innovation to support the challenging needs of the oil and gas sector. They are very much considered an enabler to subsea engineering and can single-handedly make the difference between a field being commercially viable, or not. Their ability to measure unprocessed streams removes the need for installing costly processing equipment on

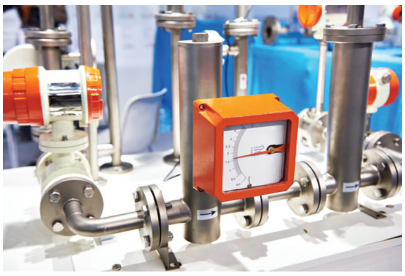


the seabed to separate out and measure the different oil, gas and water streams. In the first instance, it is often impossible to deploy such large-scale equipment on the seabed, particularly when remote and deep-water fields are involved. For this reason, multiphase meters have become more favoured over conventional separation methods.

Do you have a question for the our experts? Please send them to publications@instmc.org

In addition to becoming more accurate, there is also a push to have meters fitted with on-board diagnostic tools which can perform a "health-check" when in operation. This is extremely important due to the difficulty in removing the meters from service for periodic calibration and maintenance. This alone has driven the need for the development of in-situ validation methods.

Multiphase meters serve a multitude of measurement applications. These range from production monitoring through to fiscal allocation measurement when shared pipelines and infrastructure are in use. Unlike the separation method, the meters also measure continuously in real-time across wide operating conditions. This essentially allows greater optimisation of production when they are installed at the wellhead. The meters also play a critical role in mitigating flow assurance issues which can make or break a field development. This includes, amongst other things, the detection of early water production for chemical inhibiters. They can also detect oil slugs in the pipeline which can cause large pressure spikes, leading to the irreparable damage of plant and equipment.



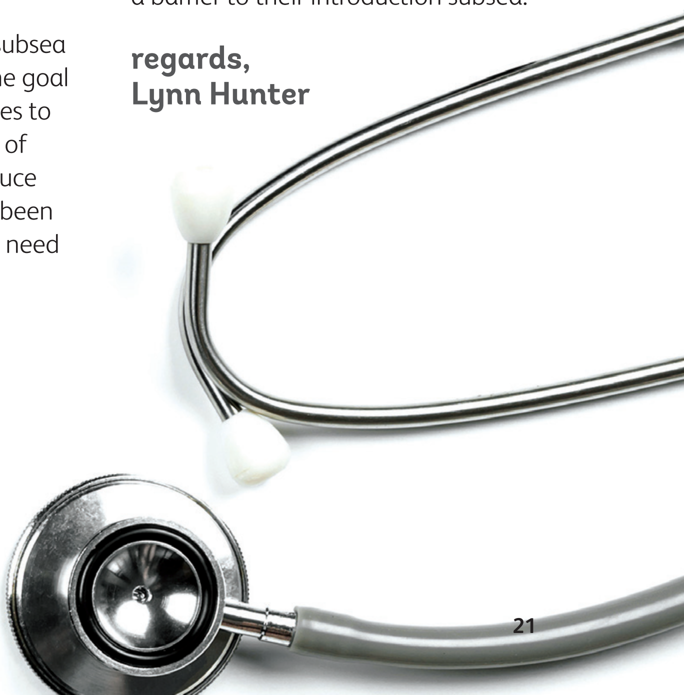
To install multiphase meters subsea on every wellhead, which is the goal of many oil and gas companies to optimise production, the cost of the meters would have to reduce significantly. To date this has been difficult to achieve due to the need for robust materials to deal with the hostile conditions and environments associated with subsea installations.

Recent years have seen new technologies enter the fold, along with the introduction of lighter and more compact meters, which makes them ideal for well testing. They have also become more accurate, thus allowing operators to meet their measurement obligations including Joint Operating Agreements (JOA) and Production Sharing Contracts (PSC).

In addition to becoming more accurate, there is also a push to have meters fitted with on-board diagnostic tools which can perform a "health-check" when in operation. This is extremely important due to the difficulty in removing the meters from service for periodic calibration and maintenance. This alone has driven the need for the development of in-situ validation methods.

To date, due to the absence of suitable test facilities, it has been impossible to assess multiphase meters under realistic field conditions. However, the development of TÜV SÜD NEL's Advanced Multiphase Facility will, for the first time, allow industry to evaluate the different metering technologies under elevated pressures, temperatures and flow rates. Ultimately this should help increase industry's confidence in their use, which has historically been a barrier to their introduction subsea.

regards,
Lynn Hunter



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