

TOO MUCH INFORMATION



FEATURES//

SIG SET TO DRIVE
INNOVATION AND
COLLABORATION

FUNCTIONAL SAFETY FOR MANAGERS

VALIDATING GAS
MONITORING EQUIPMENT

SPECIAL INTERVIEW//

DR CLAIRE ELLIOTT MINSTMC

APRIL_2018_ISSUE SIX

PRECISION

MAGAZINE

FS Engineer & Technician (TÜV Rheinland) ***Courses 2018***



(New) Introduction to Functional Safety:
 (The ideal preparation for the FS Engineer course)

Aberdeen: 4 June
 3 September
 3 December
Manchester: 1 October

FS Eng. SIS:

Aberdeen: 12/13 + 19/20 May (**Weekends**)
 5-8 June
 4-7 September
 10/11 + 17-18 November (**Weekends**)
 4-7 December
London: 22-25 October
Manchester: 2-5 October
Paris: 19-22 June
 27-30 November

FS Technician 2018: **Aberdeen:** 14-17 May

FS Eng. PH&RA 2018: **Aberdeen:** 11-15 June

C & C Technical Support Services is an accepted course provider of the TÜV Rheinland Functional Safety Training Program.

Email: info@silsupport.com
 Or Tel: +44 (0) 13398 86618

View our full Global schedule at:
www.silsupport.com

XXII WORLD CONGRESS OF THE INTERNATIONAL MEASUREMENT CONFEDERATION

— 3RD TO 6TH SEPTEMBER 2018



The Institute of Measurement and Control is proud to be hosting the XXII IMEKO 2018 World Congress in Belfast in just a few months' time. After over 5 years of planning we are getting close to the largest – and the most prestigious – event that the Institute has ever organised.

To do so has taken a team of experts that constitute the Local Organising Committee, supported by an International Scientific Programme Committee chaired by Professor Roman Morawski of Warsaw University of Technology, to manage the logistics, the finance and of course to ensure that the highest standards are set in the reviewing of the papers that have been submitted.

To date over 500 papers have come in from across the world, dealing

with all the major areas of activity in measurement science and engineering represented through the 23 Technical Committees of IMEKO. A wide range of sessions is being planned to accommodate presenting this wealth of new scientific knowledge in the measurement field in Belfast. The World Congress being held in the UK for the first time in over 40 years, and the Institute welcomes the active involvement of the National Physical Laboratory and the measurement and instrumentation industry. IMEKO 2018 is running in parallel with the third International Conference for Fibre-optic and Photonic Sensors for Industrial and Safety Applications (OFSIS) and the well-established Sensors & their Applications Conference, organised by the Institute of Physics.

Belfast, the capital city of Northern Ireland, looks forward to an influx of delegates to its famous Waterfront Hall for what promises to be an interesting and scientifically challenging World Congress. Lord Kelvin's quotation (he was born in Belfast) 'Knowledge Through Measurement', is the strap-line for IMEKO 2018 and sums up the theme of the Congress.

The invited speakers are some of the most distinguished in their field, with 2 Nobel Prize Winners providing keynote talks and a particular focus on 'the new SI' in a special session

coordinated by NPL on the last day of the event.

Plans for the industry exhibition are framing up well and will showcase some of the leading developments in industry from the UK, Europe and indeed across the world.

Our excellent and varied social programme, culminating in a tour and Gala Dinner in the prize-winning Titanic Centre will allow attendees, be they from industry or academia, exhibitors or contributors to get together in a relaxed and friendly atmosphere. After the meeting, Belfast is an excellent centre from which to explore the beautiful countryside and historic landmarks to be seen across the island of Ireland.

You can see how the plans are developing and register to attend at our website www.imeko2018.org. The detailed scientific programme is being put together following the reviewing of all the papers received and the sessions organised around major topical themes – it will be on the website once this is finished in May.

I look forward to welcoming you in September to Belfast.

Ken Grattan
President IMEKO

CONTENTS

FEATURES

TOO MUCH INFORMATION (COVER STORY)



Dr Maurice Wilkins, Engineering Director of the InstMC, considers how Standards Based Decision Support can help operators with abnormal incidents.

10-13

SIG SET TO DRIVE INNOVATION AND COLLABORATION

14-16



The newly formed InstMC's Flow Measurement Special Interest Group (SIG) is set to build on the success of the Flow Measurement Institute (FMI) it replaces, as it moves forward with an exciting programme of work in 2018.

OPINION PIECE

FUNCTIONAL SAFETY FOR MANAGERS



Steve Gandy contemplates the implications of not taking preventive maintenance seriously.

6-8

OPINION PIECE

VALIDATING GAS MONITORING EQUIPMENT

Stephanie Bell and Paul Carroll, with over 45 years' combined experience in measuring and monitoring humidity at the National Physical Laboratory, discuss the need for validating the performance of gas monitoring equipment under the conditions of use.



18-20

OTHERS

MESSAGE FROM KEN GRATTAN

The Institute of Measurement and Control is proud to be hosting the XXII IMEKO 2018 World Congress in Belfast in just a few months' time. After over 5 years of planning we are getting close to the largest – and the most prestigious – event that the Institute has ever organised.



3

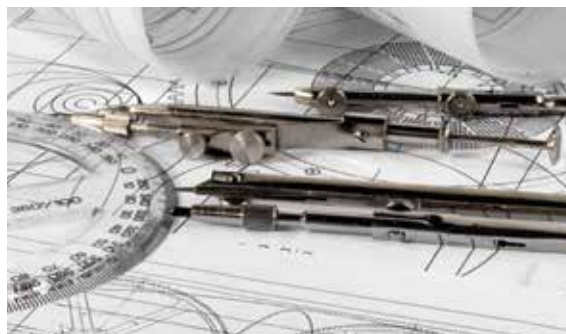
INTERVIEW

24-25

This month's interviewee is Senior Research Scientist, Dr Claire Elliott MInstMC, from National Physical Laboratory.



MEASUREMENT SIG 22-23



Introducing the Measurement Special Interest Group – a members' group promoting good measurement practice, on behalf of the Institute.

MEET THE TEAM

24



PRECISION

The magazine of the Institute of Measurement and Control

Publications Manager
 Danny Henderson
 E: publications@instmc.org

Published by: Institute of Measurement and Control
 87 Gower Street, London, WC1E 6AF
 T: 0+ 44 (0) 20 7387 4949
 www.instmc.org
 www.facebook.com/instmc
 www.linkedin.com/groups/117672

Chief Executive
 Patrick Finlay PhD CEng
 E: ceo@instmc.org

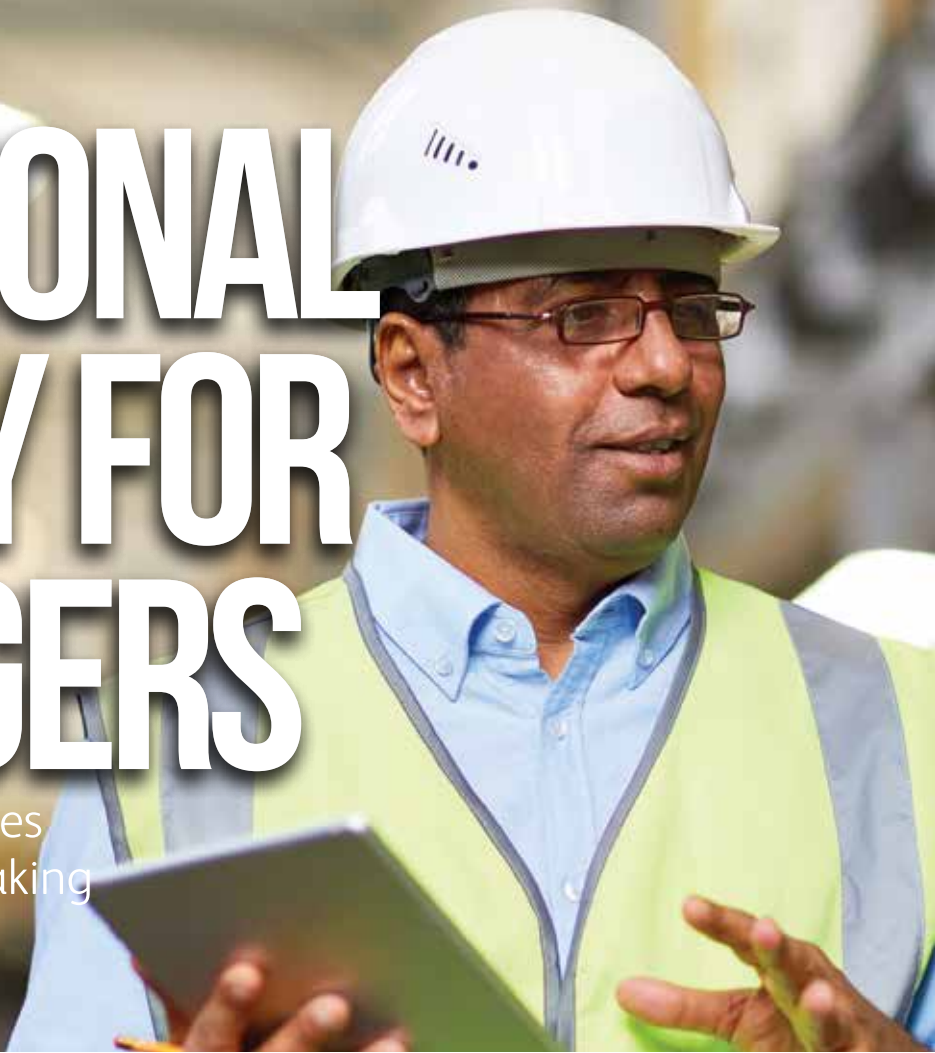
Design, print & mail fulfilment by HMCA Services Ltd
 Tel: 01423 866985
 Email: enquiries@hmca.co.uk

Advertising sales in partnership with HMCA Services Limited
 Carol Rees -
 Allott & Associates Ltd
 Telephone: 01423 867264
 Email: carol@allottandassociates.co.uk



FUNCTIONAL SAFETY FOR MANAGERS

Steve Gandy contemplates the implications of not taking preventive maintenance seriously.



When teaching the exida FSE100 Course on the Functional Safety Lifecycle (SLC) I always ask the participants if they have direct control over their budget. It may not surprise you to hear that, in the majority of cases, the answer is “no”.

This is because the people that attend the FSE100 are usually, practitioners who have some (or in some cases significant) responsibilities for SLC activities but not for finance. They attend the course with the intention of

developing their competency and as a prelude to taking the Certified Functional Safety Expert (CFSE) or Certified Functional Safety Professional (CFSP) exam. Managers do not attend this type of course.

How committed management is to Functional Safety comes down to the company’s safety culture and how committed its management is to enforcing Process Safety. Often, management pushes back on the operations staff when it comes to maintenance spending, especially on preventive maintenance spending on Safety Systems. Management only wants to spend on essential repairs and not on preventive maintenance (i.e. replacing equipment that is coming to the end of its useful life).

For a Safety Instrumented System (SIS), it’s imperative that Proof Testing is carried out at the frequency specified in the Safety Requirements Specification (SRS). This includes replacing SIS equipment that is coming to the end of its Useful Life. Very often, managers have no idea why this is important to maintaining the

integrity of the SIS and its Safety Instrumented Functions (SIFs). It’s interesting that the 2016 edition of IEC61511 emphasises the importance of competency and the definition of roles and responsibilities of staff involved with SLC. This includes management.

The adjacent diagram illustrates the SLC, as defined in IEC61511:

The IEC61511 Standard is built around a safety lifecycle to provide a consistent approach to risk identification and risk reduction, in accordance with a company’s tolerable risk, following best practices. By following the SLC it provides a means of achieving an optimum design that balances risk reduction with performance. In the UK, COMAH (Control of Major Accidents Hazards), requires companies with hazardous processes to follow RAGAGEP (Recognised and Generally Accepted Good Engineering Practice) for which IEC61511 is recognised for the process industries. The primary areas of risk the SLC is looking to manage are:



systematic issues, either directly from not following procedures and/or lack of competency, or indirectly as a result of poor or no preventive maintenance causing critical equipment failures.

Defining Safety

What governs the SLC is Functional Safety Management (FSM), which requires a plan to be in place that defines how functional safety will be managed throughout the entire SLC. FSM requires that there be processes and procedures in place, that are monitored and audited. It also requires a competency plan to be in place to ensure staff are properly trained and regularly assessed. This needs to happen at all levels within the company, with anyone involved in SLC activities and/or tasks.

Accidents, such as Texas City Isomerization explosion in 2005, which killed 15 people and injured over 100 more, highlighted just how important it is to have the proper mechanical integrity and maintenance program in place.

FSM was clearly lacking and the final report issued by the Chemical Safety Board, highlighted deficiencies at all levels of management for not understanding the impacts of cost-cutting on the operations and maintenance of the plant. The

problem with management is that they are not being held responsible for these cuts when it comes to process safety.

Process safety is different from plant normal safety (often referred to as hard hat safety), which addresses the slips, trips and falls. Most companies monitor plant safety by tracking injury statistics and even reward managers for low incidents and/or injuries. This was true at Texas City where they tracked injury statistics, however, these statistics didn't include fatalities. Texas City had a history of fatalities with 23 fatalities over a 30 year period, prior to the 2005 accident but these were not included in its injury statistics.

Process safety, on the other-hand, addresses things like fires, explosions, releases of toxic, flammable and asphyxiant chemicals, which can cause significant injury, fatalities and/or environmental and equipment damage. Process safety needs to be monitored carefully and that's why preventive maintenance is so important.

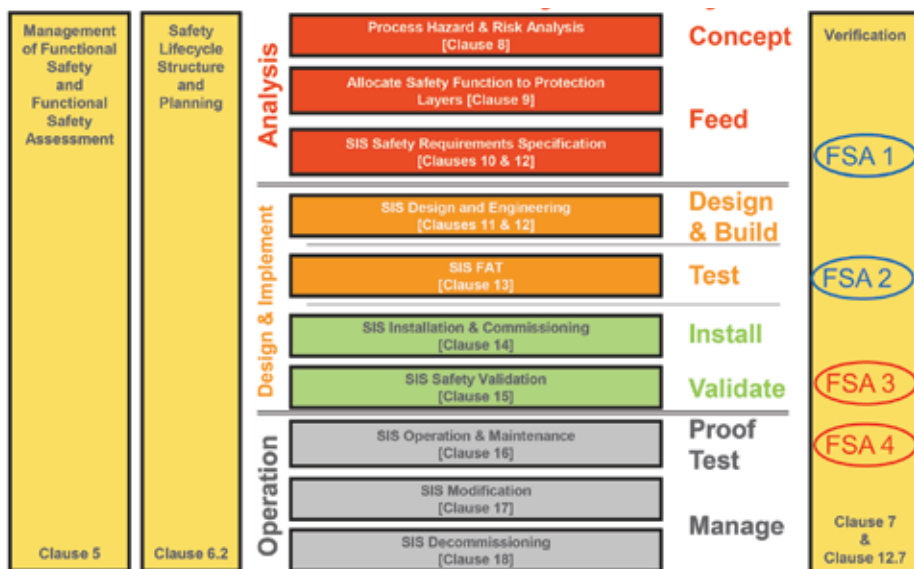
So, what does this mean?

It means managers need to be educated to understand the implications of not following through on the maintenance requirements for SIS and SIF equipment. Managers

- **Random Failures**
 - A failure occurring at a random time (so statistical methods work), which results from one or more degradation mechanisms, usually associated with hardware but humans can fail randomly also.
- **Systematic Failures**
 - A failure coming from a direct cause, which can only be eliminated by changing the design, manufacturing process, operational procedures, documentation, or other relevant factors (so statistical methods will not work and functional safety management is needed).
- **Cybersecurity Failures**
 - A failure coming from a direct and often deliberate cause, which can only be eliminated by on-going threat identification and mitigation.

Managers need to understand these failure modes and to also recognise that the majority of accidents are usually the result of

IEC 61511 Safety Lifecycle



Copyright © exida.com LLC 2000-2016



also have to be competent to make spending decisions (or cuts) on preventive maintenance and to realise what the potential implications are if mechanical integrity is not maintained. Trevor Kletz's maxim that "if you think safety's expensive, then try an accident" is very relevant and true. Accidents can cost a lot of money and loss of a company's reputation. The Texas City accident, mentioned above, cost BP around 1.5 Billion USD, in fines and compensation payments, plus the lost profit from the Isomerization Unit, which was down for more than 2 years. Had the plant been allowed to spend a fraction of that money, then the accident may have been avoided since critical equipment would not have broken down. It's very easy with hindsight for a manager to say that they didn't realise this was happening, or not happening, as the case maybe, when it comes to preventive maintenance. It is the manager's job to know what is going on, which can be gleaned by reading audit reports, walking around and listening to staff.

Having the right safety culture is imperative because staff can only do so much to ensure that the integrity of a SIS is maintained. Culture must come from the top and managers need to understand this and to ensure they actively encourage employees to speak up and to highlight deficiencies that need to be addressed. Developing an open and learning environment for the company should be a priority, whereby employees are not afraid to



speak up and/or be able to halt a process if they feel it's unsafe to continue operating. Therefore, it behoves managers to have some formal training and awareness of what process and functional safety is all about. They should understand the SLC and its requirements, especially when it comes to the operation and maintenance of the SIS. Recognising the importance of adhering to the SRS, when it comes to proof testing, repair time, bypassing, spurious trips, etc. is extremely important.

Managers should ask themselves:

- How many functional safety assessments have been carried out?
- When was the last functional safety audit conducted?
- When was the last performance review (i.e. FSA 4 completed)?
- Have we had any incidents that resulted in serious injuries and fatalities?
- Have I seen any audit reports and/or incident reports?
- Is maintenance following the proof test requirements?
- Is Management of Change being followed correctly?

- Who is responsible for signing off on repairs and work orders and is this being done correctly?
- Are staff being periodically assessed and is this being recorded?
- Do we have a properly managed training program and how is competency being assured and assessed?
- Are all procedures properly documented and being followed? What documentary evidence is there of this?

If the answer to any of these questions is "I don't know", then this should be the catalyst to begin looking in to the SIS operation and maintenance. Managers should be able to demonstrate competence according to IEC61511:2016, by having:

- knowledge of the legal and regulatory functional safety requirements
- adequate management and leadership skills appropriate to their role in the SIS safety lifecycle activities
- understanding of the potential consequence of an event

Managers must read audit reports and be clearly informed since ignorance is no excuse. Having the right Safety Culture is imperative; management needs to understand and support FSM or it won't work.

In conclusion, managers who fail to ensure compliance could risk legal action in the event of an accident resulting in loss of life or serious environmental impact. Here at exida we have many books, white papers, blogs and courses to help managers to improve their knowledge and competency. Don't be a victim of ignorance in process safety - get educated.

Steve Gandy CFSP, MBA, DipM, MIET – VP Global Business Development at exida a company specialising in production certification and knowledge automation system safety and security.

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

TOO MUCH INFORMATION

Dr Maurice Wilkins, Engineering Director of the InstMC, considers how Standards Based Decision Support can help operators with abnormal incidents.

Challenges Facing Process Operators

According to a 2012 report by the Energy Practice of Marsh Ltd, a division of Marsh McLennan, the 5 year loss rate (adjusted for inflation) in the refinery industry over the period 1972-2011 continued to rise, with incidents occurring during start-ups and shutdowns continuing to be a significant factor as shown in figure 1 below.

These losses are occurring at a time when control systems and instrumentation on process plants have improved substantially. So why are they happening?

During normal operation, processes run mostly untouched by operators, especially in continuous plants. But if an incident occurs, there is often too much information, which increases operator mental workload and so they can become confused and make mistakes. Humans are not designed to cope with masses of information, especially when they are under stress. Start-ups and shutdowns of process units are considered to be 'normal' operations, along with grade changes and other transitions, however these are amongst the more error prone operations that again increase the mental workload of operators.

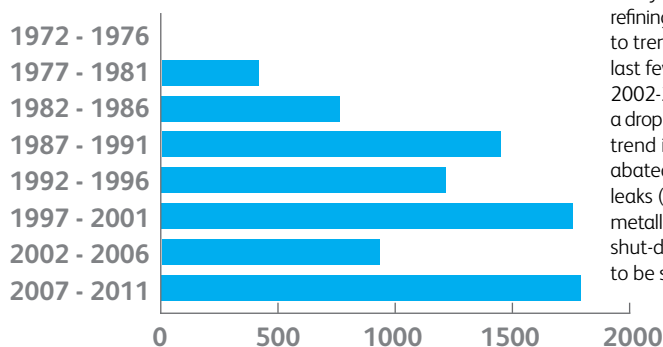
Texaco Refinery, Milford Haven

A clear example of extreme operator mental overload happened on

Sunday 24 July 1994, when a lightning strike started a fire on the crude distillation unit (CDU), which eventually led to an explosion on the fluid catalytic cracking unit (FCCU). Although the media put the blame on the lightning strike, the incident report stated that "these events, though significant in initiating a plant upset, were not the cause of the release and explosion that occurred five hours later. These consequences resulted from subsequent failures to manage the plant upset safely". Luckily, although there were some serious injuries, no one was killed.

Amongst many other things, the report cited bad alarm management, bad display design and a failure to follow procedures. For example, it stated "From the limited amount of alarm information relevant to the event which was preserved from just one of the journals, it was seen that in the last 10.7 minutes before the explosion the two operators had to recognise, acknowledge and take appropriate action on 275 alarms. At times during the morning operators were doing nothing but acknowledging alarms". It went on to say that the chances of operators restoring control manually were reduced as the incident progressed due to them being overloaded by a "barrage of alarms". There were 2040 alarms configured and of those in the DCS 87% were high priority. During the incident, the operators had to cope with alarms coming in a

Fig 1: Refinery Losses 1972-2011



Five year loss total in the refining sector have continued to trend upwards over the last few years. While the 2002-2006 period presented a drop in losses, the increasing trend is unlikely to have abated. Piping failures or leaks (corrosion or incorrect metallurgy) and start-up and shut-down events continue to be significant causes.

had to cope with alarms coming in a rate of one every 2-3 seconds, which resulted in many being cancelled due to their nuisance. There was no evidence that a vital high level alarm on the flare drum which went off 25 minutes before the explosion was ever seen.

In addition the report indicated that the FCCU graphics were not designed in a way that helped the operators to control the process. There were limited amounts of process data and colour was not used in a way to highlight important data. It also said that there was information on the graphics, such as the structure of plant items, which had no relevance to plant operation and shouldn't have been there. Finally, several procedures had fallen into disuse from lack of practice and documenting them. I will discuss later how standards and better design could maybe have helped in this incident.

Managing Mental Workload in a 'Life or Death' Incident

Many airline pilots are chosen due to their ability to handle stressful situations calmly and they go through extensive mental workload training on simulators, covering every kind of incident that could happen. In fact on the 'Miracle on the Hudson' US Airways flight 1549, which landed safely on the Hudson after a bird strike on January 15th, 2009, none of the crew had ever met each other, but their calmness and following procedures to the letter, saved the plane and many lives.

Can we use machines to guide humans and the deductive power of humans (given a logical number of options) to make the correct decision? Mary L. Cummings, Director of the Humans and Automation Laboratory (HAL), at MIT and a former Navy F-18 pilot, who is doing research into human-automated path planning optimization and decision support has said "Humans are doing a pretty good job, but they do it even better with the assistance of algorithms" and "This research is really showing

the power of how, when algorithms work with humans, the whole system performs better." She maintains, letting computers analyse masses of information generated during an incident and giving the operator options as to how to alleviate the incident, may help to manage the mental workload.

Humans have emotions and get stressed. There is no better example of this happening than in a crisis, as illustrated by the Texaco case. Some humans are able to handle crises in a very calm way, as shown by historical heroic efforts in war and peace, but the majority tends either to try to do everything, panic or just switch off. So when even the best operator is faced with many alarms coming in at the same time and other things happening around him, he will likely try to look at as many as he can and work out a scenario and possible solution, but that may be too late. It would be much better if the system provided him with options and guidance – or decision support.

Standards Based Decision Support

Decisions are made by assessing the problem, collecting and verifying information, identify alternatives, anticipating consequences of possible decisions and then making a choice using sound and logical judgment based on available information.

Few humans in a crisis are able to do this without help. Either they find it difficult to manage the situation to give them time to gather enough information to make a sound decision or they just run out of time trying to make the decision. With decision support and guidance this task becomes more manageable.

In key areas such as human machine interface design, alarm management and procedure management basic decision support may be developed. In support of this, industry standards are either available or being developed. For now, I am going to concentrate on The International Society for Automation (ISA), a

globally recognised standards development organisation, which is developing standards based on the three areas mentioned above. They are providing or will provide a good basis for decision support:

- ANSI/ISA-18.2-2009 – Management of Alarm Systems for the Process Industries
- ANSI/ISA-101.01-2015 – Human Machine Interfaces for Process Automation Systems
- ISA-TR106.01 – Technical Report: Procedure Automation for Continuous Process Operations – Models and Terminology
- ISA-dTR106.02 Working Draft 16 – Technical Report: Procedure Automation for Continuous Process Operations – Work Processes

ANSI/ISA-18.2, which has been a standard since 2009, provides requirements and recommendations for the activities of the alarm management lifecycle. The lifecycle stages include philosophy, identification, rationalization, detail design, implementation, operation, maintenance, monitoring & assessment, management of change, and audit. ISA18.2 has also been adopted by IEC and so is a recognised international standard.

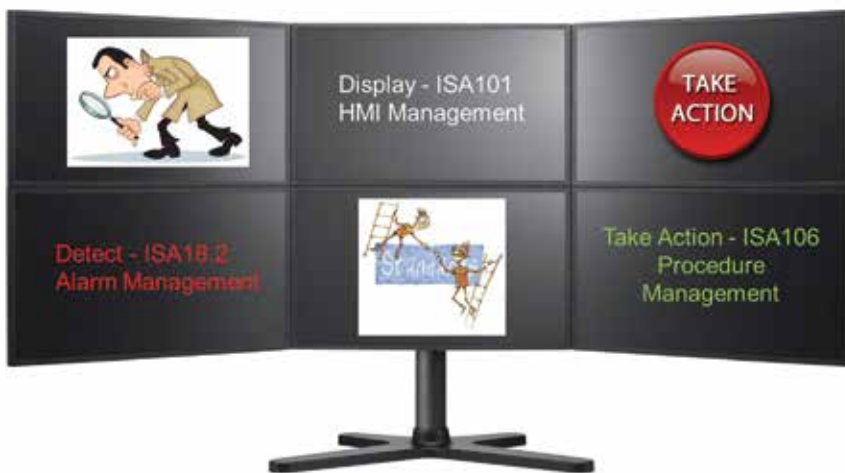
ANSI/ISA-101.01 has been a standard since 2015. It is directed at those responsible for designing, implementing, using, and/or managing human-machine interfaces in manufacturing applications. The committee is now developing technical reports showing how the standard can be applied.

The ISA106 committee has produced two technical reports, one addressing models and terminology and the other work processes. The committee will then develop a standard to provide good practices to address many of the human performance limitations that can occur during procedural operations. The technical reports as they stand give a good basis for us to start developing decision support systems.

Standards Working in Harmony for Decision Support

If configured correctly, well planned alarms could trigger procedures in many abnormal situations and a well-designed human machine interface could bring a developing incident to the attention of the operator in a timely manner. We call this Advanced Decision Support

Fig 2: Standards Based Decision Support



Alarm management should limit alarms to what the operator has time and ability to handle by developing an alarm philosophy and rationalisation program. The alarms should then be continuously monitored and optimised. In that way we can ensure the right alarms are detected and then either the operator or the system can take action.

With good HMI management, the operator displays are designed based on operator tasks and incorporate human factors such as colour, layout and navigation. They should provide situation awareness through trends and profiles and provide clear indications of items that need attention.

Finally, procedure management can help the operator to put corrective actions in place or actually take corrective actions automatically. It can also prevent actions from taking place if the initial set up is not correct for a start-up or transfer and so on.

The airline industry is amongst the safest and most automated in the world – in fact most modern aircraft would not be able to fly without the use of computer guidance, yet procedures play a big part in the way aircraft are operated. Pilots need to go through many procedures before, during and after a flight.

The first recorded procedures were introduced by test pilots in

1935 after a crash of the B-17 Flying Fortress almost caused the programme to be abandoned due to a gust lock still being engaged at take-off. It was said that the plane was too complicated to fly. The test pilots developed procedures for take-off, flight, before landing and after landing. Boeing delivered 12 of the aircraft to the Air Corps and they flew 1.8 million miles without a serious mishap. Every type of plane from small private planes to the largest jumbo jet now uses procedures for all aspects of the journey and not following them

could lead to a pilot losing his licence to fly (or worse).

In the same way the start-up and shutdown of a process requires standard operating procedures (SOPs) which are designed to ensure the process is started up or shut down the same way each time. However, these are sometimes 'modified' by experienced operators who may see a better way of doing things. In the case of both the pilot and the process operator, there are ways that these improved procedures should be evaluated and turned into current practices. In the case of an aircraft, the consequences of not doing this are obvious, but in a process plant, a tweak here and a tweak there may go unnoticed until things go wrong. As with the operation and maintenance of aircraft, the goal of operations and decision support is to capture the knowledge of the best and hopefully calmest operator on his/her best day under all conditions.

Figure 3, below, depicts the methodology for capturing best practices procedures. The goal of this approach is to "distil" best operating practices and find the right balance between manual, prompted and automated procedures, documenting and implementing the procedures and then executing continuous improvement cycles on them. Automating every procedure does not always provide the best solution; neither does manually executing every procedure. What does provide the best solution is to consciously examine events that caused production interruptions, then examine the

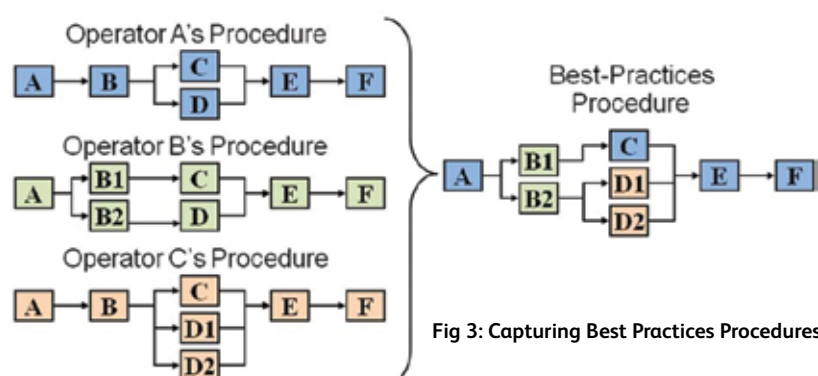


Fig 3: Capturing Best Practices Procedures

procedure operations associated with those events, document them and determine what type of implementation will provide the best economic return while improving safety, health and the environmental metrics for the facility.

A modular procedure consists of logical steps and as shown in Figure 3, each operator has started with the same SOP but has modified it to handle different situations and styles of operating by adding additional steps. On the right-hand side is the resultant “best-practice” procedure.

Milford Haven Revisited

Now let’s revisit the Texaco Milford Haven refinery incident. In terms of a set of circumstances where the system could have potentially provided the operators with the correct information at the right time and possibly even taken corrective actions, this was a ‘perfect storm’.

Texaco had a DCS, but while the technology didn’t exist at that time to provide the kind of highly optimised HMIs that we have today, many things could have been done to reduce the operator mental workload and possibly have avoided the incident.

Alarm management could have reduced the number of high priority alarms so that those that activated were timely and did not overload the operator and if many activated at the same time, the system could have identified the possible ‘main actor’ enabling the operator to take action, or even taking action itself. For instance, the flare drum high alarm that was missed could have triggered a procedure.

These days we have better historians and data analysis tools, able to identify incidents as they start to occur and we can use intelligent displays to help the operator to see where the main activities need to take place.

Procedures should have been followed and the incident report recommended improved training and document keeping. But again today, a procedural assistant

could give clear communications regarding;

- What was transpiring as the incident unfolded
- Next steps according to approved safety procedures
- Safety hazards associated with missteps

The incident report cited the inability of the operators to be able to carry out mass and volume balances. A procedure assistant could have helped with this and triggered actions or prompts as a result of an imbalance.

Can Standards Based Decision Support Help Mental Workload in a Crisis?

In the human factors section of the Texaco Milford Haven refinery incident report, one of the key factors mentioned was that the preparation of shift operators and supervisors for dealing with a sustained ‘upset’, and therefore stressful, situation was inadequate and that better overview facilities should have been provided.

This article has shown that issues often exist with humans in the workplace during times of crisis and stress. In some cases having the right human (or humans) in the right place can be beneficial – and often this is the case. But we need to be prepared for the situations where the operator gets overloaded or takes things for granted or when an inexperienced operator is working at the time things start to become unstable.

In times of abnormal operations, systems are configured to produce lots of data – humans are not configured to handle or interpret them. However, when presented with the right information, in the right context, during an abnormal condition, humans are able to do things machines cannot. They can evaluate the situation and provide the “thought process” on what action to take, with the guidance and support of automated systems.



Texaco had aDCS, but while the technology didn’t exist at that time to provide the kind of highly optimised HMIs that we have today, many things could have been done to reduce the operator mental workload and possibly have avoided the incident.





SIG SET TO DRIVE INNOVATION AND COLLABORATION

The newly formed InstMC's Flow Measurement Special Interest Group (SIG) is set to build on the success of the Flow Measurement Institute (FMI) it replaces, as it moves forward with an exciting programme of work in 2018.

By Brian Millington
Managing Director
TUV SUD NEL

The new SIG started in February thanks to a merger of the original FMI's membership with the InstMC. "The potential of the group will be significantly enhanced with the support of the Institute" says Brian Millington, Managing Director of NEL (National Engineering Laboratory). It will leverage the skills and resources of its members and backers to facilitate the development of flow measurement expertise, infrastructure and technology. In this way it will address the many flow measurement challenges facing industry and the research community."

Building on the FMI's success

The original FMI was founded by NEL and Coventry University in 2014, attracting more than 550 members from across the world, including representatives from oil & gas operators, manufacturers, academia, service companies and research laboratories. When it became clear that the FMI had grown to a point

where it required more support than its core group of volunteers could provide, the new SIG was created. That actively compliment NEL's role as part of the UK National Measurement System, delivered by BEIS. As such, NEL provides a major programme of research, development and knowledge dissemination concerning leading-edge flow measurement challenges. It also leads the development of measurement standards and provides independent traceable calibration to national standards.



Strategy, research and knowledge transfer success

From its start, the FMI's core goal was to help companies compete in the global marketplace by directing research and innovation in flow measurement that would deliver significant tangible benefits for industry. The new Group will continue with this important work and build on the earlier success, all of which was achieved without any direct funding, sponsorship or member subscriptions.

In the area of strategy and leadership, the FMI had already delivered a strategic plan to the UK government. This plan prioritised the future needs of flow measurement R&D and infrastructure across all industry sectors. The group also drove the growth and engagement of the flow measurement community and created a knowledge-sharing website and member mailings. It developed a proposal for a collaborative £15m World Centre of Excellence in Flow Measurement and Fluid Mechanics, and initiated a collaboration with the Dutch National Measurement Institute (VSL) to enable its members to develop joint proposals for EMPIR research funding.

In the research and infrastructure sphere, the FMI helped drive the development of a new high pressure single-phase calibration facility, a new Faculty Research Centre in Flow Measurement and Fluid Mechanics at Coventry University and a unique collaboration between four universities, which led to a £1.2m application made to EPSRC funding for flow measurement research. It also created a database

of commercial test and research flow measurement facilities, along with a capability statement detailing flow facilities at leading universities.

FMI's legacy includes the annual flow measurement conference and support for post graduate students. The most recent conference in 2017 at Coventry University addressed key issues relating to collaboration and the dissemination of information and technology alongside findings from current research projects. Other knowledge transfer work includes a flow measurement training competency matrix, a strategic outline for developing standardised and accredited training and input to the National Measurement System's gap analysis about flow measurement standards.

Meeting the challenges facing industry

The fast pace of scientific and industrial advancement has placed significant demands for innovation in flow measurement. According to Brian Millington, these challenges include improving measurement accuracy for fiscal regimes in the oil and gas industry and researching flow measurement in challenging process environments such as those found in the nuclear industry. Other areas of interest include supersonic flow modelling for water industry applications and addressing fluid flow issues with clean fuels.

In response, the new Group will continuously review the future priorities for flow measurement research and infrastructure. This will be done with all stakeholders including end-users, instrument manufacturers, regulators, trade bodies and research associations.

The work will encompass the full breadth of flow measurement applications. By leading collaborative, industry-wide initiatives and being a focus for information and research, the Group will be a catalyst for global flow measurement innovation.

A programme of practical action

In the immediate future, the Group has a number of exciting projects under development. These include a Horizon Scan project that will involve discussions with industry and stakeholders.

Continued overleaf...



The fast pace of scientific and industrial advancement has placed significant demands for innovation in flow measurement.



This will identify flow measurement priorities across different industry sectors. It will also produce a 'rolling' document that will detail who is doing what in terms of industrial and academic research. The document will then be available to inform research decisions, allocate funding and help organisations form collaborative ventures. Previous projects highlighted a set of 55 initial research priorities, including: providing flow measurement traceability suitable for critical frontier applications; improving environmental impact modelling; and creating fit-for-purpose industry standards for flow measurement in complex flow situations.

This summer the SIG will also be running its yearly R&D conference at Cranfield University. This will spotlight current research and will be open to everyone with an interest in the area. Unlike many commercial conferences, it will be a cost-effective event to attend, and will provide opportunities for members to get involved, to see what's coming up, form collaborations and initiate joint research projects.

The Group will also be moving forward with a number of other projects, including skills accreditation work. This will develop the existing skills framework for flow measurement to create a trailblazer apprenticeship scheme, covering all levels of training from technician to PhD. The new group also aims to work with existing process control and instrumentation qualifications to give flow measurement specialists a specific qualification that will enhance professional standing and help with the development of the profession.

HOW TO JOIN The Flow Measurement SIG

For more information and details of how to join please visit:

<https://www.instm.org/Special-Interest-Groups/Flow-Measurement>



The Flow Measurement Group is one of the InstMC's many SIGs which operate in areas including automation and control, cyber security, digital transformation, functional safety, measurement, standards and systems. All of these groups provide an opportunity for like-minded engineers and scientists to network, share ideas and expertise, collaborate, learn and keep abreast of news and views. They are driven by groups of volunteers who work or have expertise within the topic area. They all promote the sharing and the advancement of knowledge.



This summer the SIG will also be running its yearly R&D conference at Cranfield University. This will spotlight current research and will be open to everyone with an interest in the area.





IMEKO

XXII World Congress • Belfast 2018

Knowledge through Measurement

3 - 6 September 2018

Waterfront Hall Conference and Exhibition Centre
Belfast, Northern Ireland



VALIDATING GAS MONITORING EQUIPMENT

Stephanie Bell and Paul Carroll, with over 45 years' combined experience in measuring and monitoring humidity at the National Physical Laboratory, discuss the need for validating the performance of gas monitoring equipment under the conditions of use.

With the explosion in the variety of technology readily available to purchase and the apparent ease of installation, it is no wonder that measurement equipment is now considered crucial in more and more industries. But where there are highly flammable gases present, a different sort of explosion is on the minds of the engineers, and performance validation of gas monitoring equipment is vital.

The measurements that are required to validate the performance of gas monitoring equipment must be both sensitive and accurate, even if other factors in the operational environment are changing. This makes a very complicated – and often bespoke – set of parameters to validate against, which an end user is not typically set up to achieve.

“Why is gas safety of interest to NPL humidity experts?”

We are interested primarily because water vapour (humidity) is present in almost all gas environments and the influence of water vapour can be very important – sometimes

even tiny amounts matter. For example, trace levels of water vapour are critical for highly pure gases such as those used in electronics manufacture, gas circuits in nuclear power facilities, fuel (natural) gas, and for alternative fuels – such as hydrogen for vehicles.

Poor control can cause condensation in compressors, corrosion in pipelines and other serious consequences. These interests led us to develop a novel facility which can generate gases (and blended gas mixtures), with known water vapour concentration, at a range of pressures.

Over the last few years, the humidity measurement team at NPL has been developing the new “Multi-Gas, Multi-Pressure” facility, which is now a national capability and is used to validate gas monitoring equipment.

The facility provides measurement traceability to the the International System of units (SI) through defining measurements of dew-point temperature, and can be used to recreate the humidified environments under which sensors are typically used in natural gas pipelines, at elevated pressures.

Furthermore, it can also be used to generate gas mixtures which can be varied to simulate different conditions relevant to individual end users – for example with air, inert gases, methane and other pre-made cylinder gas mixtures, at pressures up to 3 MPa, or 30 bar. Thus, in addition to calibrating humidity measurements, the facility can also be used for other studies, such as humidity- and temperature-controlled tests of gas leak detection equipment which is used to ensure that safe levels of explosive gases are not exceeded.

Water vapour can cause condensation and corrosion

Water vapour is one of many components in natural gas that needs to be monitored and controlled. This can be anywhere in the gas supply chain – from processing plants, to pipeline transmission entry and exit points. Water content affects pricing at custody transfer, and it also must be within limits to avoid risk of condensation, corrosion or even hugely disruptive blockages. Water content is also of interest to large consumers of gas, such as electricity generation companies, for reasons of efficiency, emissions control and avoidance of potentially damaging effects of condensates. In these cases, the problem condensate can be water, or hydrocarbon, or it can be methane hydrate formed in the presence of methane and water, depending on temperature, pressure and gas composition. Thus, accurate

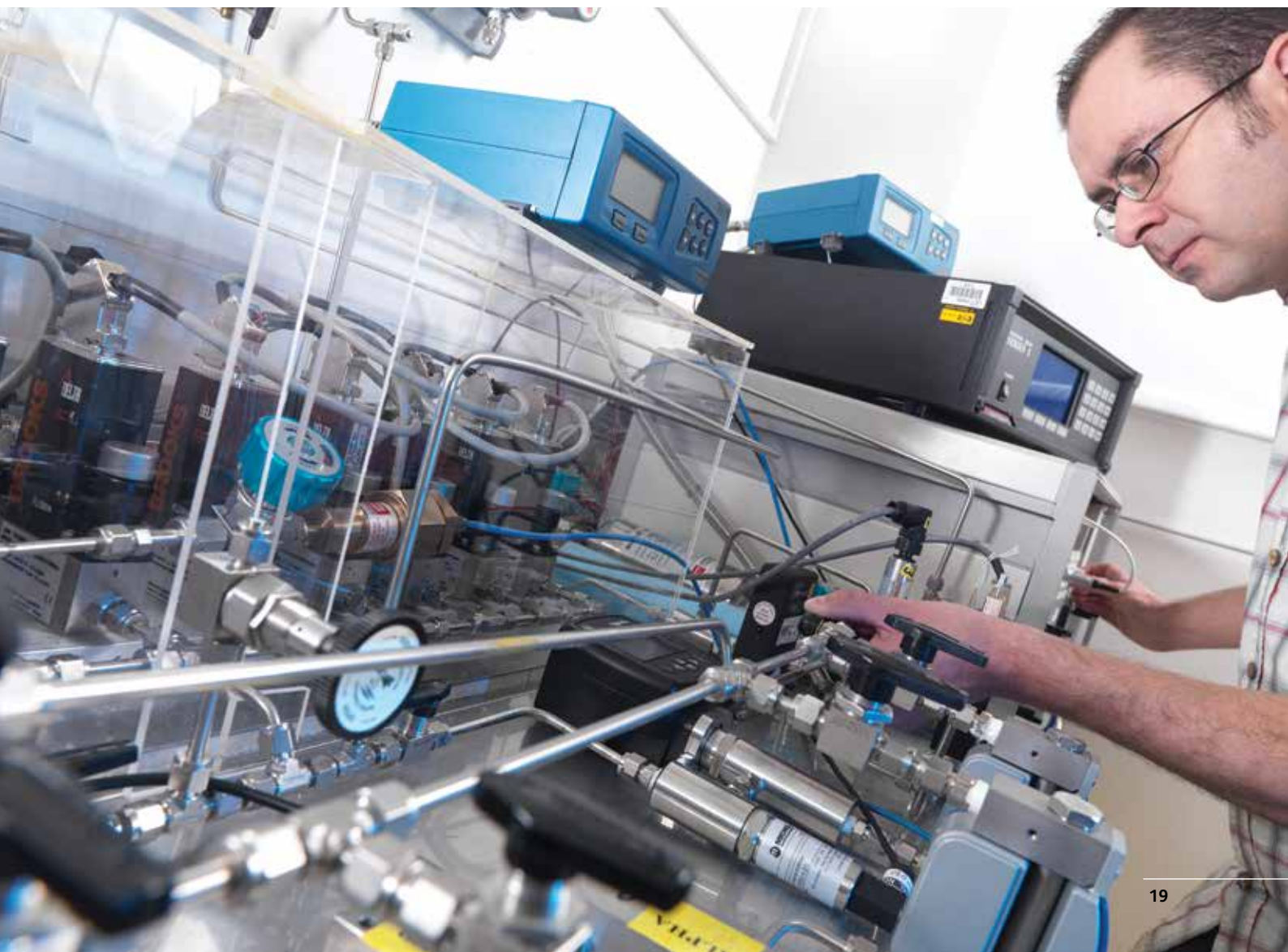
measurement of water content is an essential part of control of the process.

The position and choice of conditions for performing the measurement depends on operating at the right pressure-temperature combination. This is essential to ensure all components are in gas phase (unless condensation of water or other components is deliberately sought—for example when measuring hydrocarbon dew point).

What have we learnt about the performance of gas monitoring equipment?

Through developing the “Multi-Gas, Multi-Pressure” facility, and using it for several in-depth studies, we have learnt some surprising truths about some of the gas monitoring equipment in widespread use.

Perhaps the most commonly used humidity sensors (hygrometers) in



natural gas are electronic capacitive sensor “dew point probes”, which operate either at gas line pressure, or at atmospheric pressure.

Although relatively simple to operate, these devices can suffer significant drift, especially in the harsh environments concerned. For sampled gas expanded to near atmospheric pressure, a wider set of instruments can be used. These include electrolytic phosphorous pentoxide sensors and, increasingly, spectrometers based on absorption of infrared light by water vapour. For detectors of other gas species, the sensitivity and speed of response is not always as initially expected.

Unfortunately, it has been found that the measurements don’t always directly give the information needed. Firstly, in natural gas some humidity sensing principles are not purely selective for water vapour – they can have sensitivities to components in the background gas mixture, or to influences of pressure or temperature. This means that compensation is needed to correct for those effects. Secondly, the instruments don’t always directly measure the quantities and units of interest. Sensing principles variously measure water dew point (temperature at which liquid or solid condensate would form), or partial pressure, or water fraction by mass or volume, or mass of water per unit volume, or others. To interpret and apply measurement results, conversions are often needed, but this is not straightforward.

Although problems of instrument drift, and sensitivities to gas species, pressure and temperature, can all be reduced through access to reliable calibrations and measurement checks, better correction methods are also needed.

The next challenge – gas non-ideality

For simple “ideal” gases, some properties can be scaled simply in proportion to conditions of temperature and pressure – this follows from what is known as the “ideal gas law”. But this does not

apply for more complex gas and water mixtures. To overcome this complication there are numerous approximations that attempt to adapt the ideal gas law for real gases (e.g. as recommended in the published standard ISO 18453:2005 “Natural gas. Correlation between water content and water dew point”). However there is some doubt about the equations used, which appear to give discrepant results, particularly in the dew-point temperature range below 0°C.

A simpler approach is to account for non-ideality using “water vapour enhancement factors” but the published values of enhancement factors are scarce, and more work is needed. In air, water vapour enhancement factor affects humidity values by around 0.5 % at atmospheric pressure, around 5 % at 1 MPa (10 bar), and by more at higher pressures. For water in methane and higher hydrocarbons the enhancement factor is larger, and poorly known, as there is scant published data for complex gases and mixtures.

Using the new “Multi-Gas, Multi-Pressure” facility, we hope to take on this challenge and measure a variety of industrially relevant enhancement factors. This is presently possible in the dew-point range 60 °C to +15 °C, traceable to the SI within an uncertainty of ± 0.12 °C ($k = 2$) for dew-point measurements in air, inert gases, methane and pre-made cylinder gas; at pressures to 3 MPa. Looking forward, we hope to soon increase the range of the facility and help enable end users to follow this simpler approach.

A link to NPL’s humidity research: www.npl.co.uk/temperature-humidity/research/humidity-and-moisture-research



Although problems of instrument drift, and sensitivities to gas species, pressure and temperature, can all be reduced through access to reliable calibrations and measurement checks, better correction methods are also needed.





COMPANION COMPANY SCHEME BENEFITS

Companies involved in measurement, instrumentation & process control are welcome to become members of our Companion Company Scheme. Over 100 leading businesses already benefit from CCS membership.

Over the past 70 years, the InstMC has become an established and recognised professional body in the Measurement, Control and Automation industry. InstMC is widely acclaimed for its continuous efforts to facilitate the exchange of information aimed to improve instrumentation and control industry standards. The Institute supports the development of our Member Companies through a wide range of business oriented benefits:

- ▶ Opportunity to organise networking events and services;
- ▶ Discounted advertising space on InstMC platforms;
- ▶ Introductory article in InstMC journal;
- ▶ Certificate acknowledging InstMC Corporate Membership (CCS) and status within the industry;
- ▶ Possibility to submit internal news articles and technical material on InstMC Website and Journal.
- ▶ Discounted Exhibitors and Conference fees.

MEASUREMENT SIG

Introducing the Measurement Special Interest Group – a members' group promoting good measurement practice, on behalf of the Institute.

Good quality, timely and appropriate measurements are at the heart of reliable manufacturing systems, process monitoring and in many more applications including patient health. Even our lives are regulated, controlled and kept safe by appropriate traceable measurements in the associated industries and technology – the time on our clocks, weights and volumes of food that we buy, temperature of cooking and sterilising ovens, manufacturing measurements when making a product, volume of fuel in our cars or wine in our glasses and so on.

The Institute has a role in supporting the measurement infrastructure that is required to ensure that metrology (measurement science and engineering) is used appropriately and that an understanding of its importance is shared widely. In

order to formalise this process and to expedite it within the Institute's membership and hopefully beyond, a Special Interest Group (SIG) has been created from a group of metrology practitioners covering a range of industries.

The new Measurement SIG is an Institute members' group and aims to meet the Institute's responsibility to:

- promote high standards of professional competence in the discipline of measurement
- inform and support its members in their careers
- provide a bridge between academic research and industrial practice
- encourage students into engineering and science
- engage with the wider public
- inform government policy

Role of the Measurement SIG

During 2017, a small group of individuals, industrialists and government representatives were invited to discuss formation of the Measurement SIG. Several lively discussions have been held, and the energy and excitement in the room has resulted in creation of a steering board and three working groups, in order to set the structure of, and initiate, the Measurement SIG.

Three working groups (WGs) were chosen to cover the most important activities which the Measurement SIG could champion and the most ready to make an impact on the measurement communities. Each WG follows its own theme:

- Training
- Technology Transfer
- Marketing

The first, Training, is already actively bringing together key stakeholders such as: within Industry, the National Physical Laboratory (NPL), Government, Universities and other training organisations, to develop a new national training framework for measurement. It is intended this will cover the entire learning spectrum from school to doctoral students to create a pathway both those who want a career in measurement (known as metrologists) and those who interact with measurement (e.g. engineers). It will not only cover core subjects that are independent of the particular industry an individual resides in or the technology an individual uses, but it will also cover specific measurement technology subjects (e.g. surface texture measurement) to allow the learning to be flexible to an individual's and/or company's need.

The second, Technology Transfer, aims to address the widely recognised problems associated



with transferring technology from the innovators and the end users. The Technology Transfer WG is developing an intellectual property 'safe' environment for innovators and industrialists to demonstrate and explain their ideas and needs. If this is successful then the Institute will enable UK business to be better prepared for the future, whilst also making sure that innovators are prepared early-on to include the key features in a product that end users need – including developing the required training.

Technology Transfer aims to address the widely recognised problems associated with transferring technology into industry (e.g. where the technology is intended to be deployed in a high risk environment and must be thoroughly proven to operate as expected). By providing an intellectual property (IP) 'safe' environment for innovators and industrialists to demonstrate and explain their ideas and needs, the Institute is intending to enable UK business to be better prepared for the future, whilst also making sure that innovators and manufacturers incorporate early, the key features that end users will need – including developing the required training.

The third, Marketing, aims to raise awareness of the Measurement SIG within the membership of the Institute (and encourage the involvement of Institute members in the activities). Furthermore, it also aims to raise the awareness of the importance of Measurement Science and Engineering across all industries and through academia and schools, and finally to highlight the option of metrology as a career.

Recent and upcoming events of note

As you may be aware, four of the units of measurement (namely the kilogram, kelvin, ampere and mole) are expected to be redefined during 2018 in terms of associated physical constants. What you may not be aware of is that the General Conference on Weights and Measures which is being held in Versailles in November – where the decision is expected to be made – is open to the public. To be among the first to hear how to access this event – please join the Measurement SIG mailing list.

To celebrate this momentous occasion, and the practical implementation which is due to happen on 20th May 2019, the Institute is leading a Festival of Measurement. This will be launched in September 2018 and run until May 2019. Many exciting activities are being planned by the Institute, but in order to make the biggest impact – we are also asking members to support the Festival however they can: maybe through sponsoring the Festival or by branding any measurement-related events over the time period as part of the Festival?

UK government support for measurement

The UK government has long understood that being able to achieve reliable measurement is essential for underpinning regulation and global trade. In 1884 the UK signed the Metre Convention, which was set up to coordinate international measurement capabilities and develop the metric

system. The UK government continues to support this work through National Measurement System (NMS) funding – as improvements in measurement accuracy and international collaborations continues to be the key for the UK economy to develop. A link is provided at the end of this article to the National Measurement Strategy, and the highlights from their most recent annual review.

Membership of the Measurement SIG

If you would like to keep up to date with the activities that have been started, or get more involved – please update your profile on the website: Members may opt-in to the Measurement SIG through the online portal (the option is located inside "My personal details" once you have logged into the Members-only area).

All expressions of interest, comments and ideas are also very welcome. We are particularly interested in hearing from Members in academia or teaching – as this sector is under represented on the Steering Board at the moment.

Webpage: www.instm.org/Special-Interest-Groups/Measurement

For further information – please contact Claire.Elliott@instmc.org

UK measurement strategy: www.gov.uk/government/publications/national-measurement-strategy

NMS: annual review 2016-2017: www.gov.uk/government/publications/national-measurement-system-annual-review-2016-to-2017

Main Author: Andy Morris (chair of the Steering Board)

Contributors: Jeremy Stern, Mark Thomas, Steff Smith, Claire Elliott

Q&A

Dr Claire J Elliott

This month's interviewee is Senior Research Scientist, Dr Claire Elliott MInstMC, from National Physical Laboratory.



What was the root of your interest in Engineering?

Enthusiastic physics and chemistry teachers in my school were key to my choice of studying both subjects at university. At the time, I thought it was sensible and interesting. Before university, I never thought about 'a career' in the way I do now, nor what I would do with the degree – I was just continuing my studies.

It was whilst I was at university that I decided that I wanted to do something that would matter to the world, and matter in the short-term. I also began to understand that although science and mathematics had been presented as having 'only one right answer', that in fact outside of the exam hall, everything was a lot less black-and-white. The theory might have one correct answer, but if you were really trying to make something – whether measurements or a physical object – it is not possible to do so perfectly. There will always be some uncertainty.

At a careers event, I heard about NPL and how important good measurement practice is, as a core part of ensuring high quality product manufacture and to underpin global trade. Knowing the limitations of our observations of the world (our measurements) allows us to understand how much we can really explain. Improving the accuracy of those measurements allows us to test the theories, find the nuances, develop more robust manufacturing techniques and ensure that essential products will perform as they are needed to.

As I progressed through university, leaning towards physics rather than chemistry, I found myself as the only woman on more and more courses.. Maybe it made me work harder, or maybe it was just that I wanted to work hard. Nature or nurture? It is difficult to be sure – but I graduated with a PhD and was excited to land a job with NPL.

Working at NPL has given me fantastic opportunities to learn about the discipline of measurement science, whilst not being limited to working with any one industry. I have developed and demonstrated new high-accuracy technology, and I have been able to assist a wide variety of companies which have taken on board and implemented the improvements that good measurement practice provides. I still enjoy the fact that this makes a difference today, and underpins international collaboration and the development of pioneering new technologies.

What is your vision of Measurement Science in the UK in 2020?

2020 is really not that far away! With the rise of the amount of equipment and technology that is sold as a sealed box with a set of specifications and a front panel user-interface, I hope that in the next few years the UK population begin to understand that the quality



of the product has nothing to do with sleek design, but actually how accurate and relevant the measurement results are that it is producing.

Many of the numbers which are output and labelled as 'measurement results' are very hard for engineers to check in sufficient detail (when the technique is hidden) – let alone for someone sitting at home trying to decide, for example, how much insulin they need. This can only be helped by having a robust and recognised quality system, which takes into account how the installer and end user are going to use a device.

I have recently been working with a fantastic team to support the Institute's new Measurement Special Interest Group which is aiming to develop collaborative approaches to these problems and I am excited to see where these activities will lead. The Festival of Measurement is taking its first steps towards engaging as many people in the UK in the idea of 'measurement' as possible, leading up to the revision of the kilogram, Ampere, Kelvin and mole definitions in May 2019. The technology transfer working group are developing a neutral forum for two-way communication between industry engineers and innovators. (Read more about this on Page xx.). It would be great to see the UK leading the way on these internationally relevant activities.

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

One of the best things that UK government can do right now is to support and enable people to retrain – wherever they are in life. Addressing career choices and options for young people is important, but is also a longer-term solution. Enabling those who find themselves out of work or in roles that are being changed very quickly e.g. through the implementation of robotics, need to upskill or transfer

to equivalent roles in different industries. I often hear the phrases "a job for life" or "I don't have a maths brain" – both are myths which need to be addressed. The skills and experience people have is indispensable – but retraining mid-career or mid-life is not something that the UK is culturally used to. Although the Apprenticeship Levy is open to all ages, those taking up the opportunity for engineering who are later in life (and, also, women) is much lower than it could be – which also indicates that support for a wide culture change is needed.

What do you do in your free time to relax?

For me relaxing takes two stages. For my mind, I like to plan and make sure things are laid out in advance. I strongly believe in the old adage, from Eisenhower: "plans are useless, but planning is indispensable" although I'm beginning to see the value in mindfulness too. For my body, I find exercise and sport relaxing – exactly what I choose to do changes; but is currently attending a local gym and learning ballroom dances with my husband.

Given one wish what would that be?

As a person, my answer would be to take away any fear or worry about dying from everyone affected. Lives should be lived, great things aspired to, friendships made and dreams achieved – but because we can, not because we're under pressure to solely support dependents or hide truths about who we are.

I have developed and demonstrated new high-accuracy technology, and I have been able to assist a wide variety of companies which have taken on board and implemented the improvements that good measurement practice provides.



OUR CORE TEAM

OFFICERS

President

Professor Graham Machin



Honorary Treasurer

Colin Howard



Honorary Secretary

Dr Graeme Philip



Engineering Director

Dr Maurice Wilkins



Chief Executive Officer

Patrick Finlay

Tel: +44 (0)20 7387 4949

patrick.finlay@instmc.org



IT and Communications Manager

Aytan Malka

Tel: +44 (0) 20 7387 4949 Ext 6

communications@instmc.org



General Manager

Velda Wong

Tel: +44 (0)20 7387 4949 Ext 4

general.manager@instmc.org



Publications Manager/ Events and Conferences

Danny Henderson

Tel: +44 (0) 20 7387 4949 Ext 8

publications@instmc.org



Bookkeeper and Subscriptions Manager

Jennifer Bisnauth

Tel: +44 (0) 20 7387 4949 Ext 1

admin-subs@instmc.org



IT Support (Trailblazer Apprentice)

Aaron Leigh

Tel: +44 (0) 20 7387 4949 Ext 8

aaron.leigh@instmc.org



Professional Registration and Membership Manager

Leila Atherton

Tel: +44 (0) 20 7387 4949 Ext 7

membership@instmc.org



Digital Marketing Assistant

Sydney Reed

sydney.reed@instmc.org



Head of Communications Stephanie Smith

Tel: + 44 (0) 207 387 4949 Ext 3

steff.smith@instmc.org





Making collaboration a reality

Meet YuMi[®], short for you and me

Meet YuMi, the assembly, inspection and testing robot solution that will help robots and humans work together to create a smarter future for UK manufacturing. Providing greater throughput, accuracy and repeatability, YuMi advances robot technology to allow humans to focus on equally important tasks such as programming, management and creativity. To find out more about YuMi's capabilities, visit <http://bit.ly/YuMiInstMC>

ABB



Cyber Security for Industrial Automation and Control Systems

Security Risk Management Training

September 2018 Scotland

November 2018 London

December 2018 Manchester

www.methodcysec.com

=Method | We do this
Cyber Security every day

p: 01462 713313

e: support@methodcysec.com

w: www.methodcysec.com