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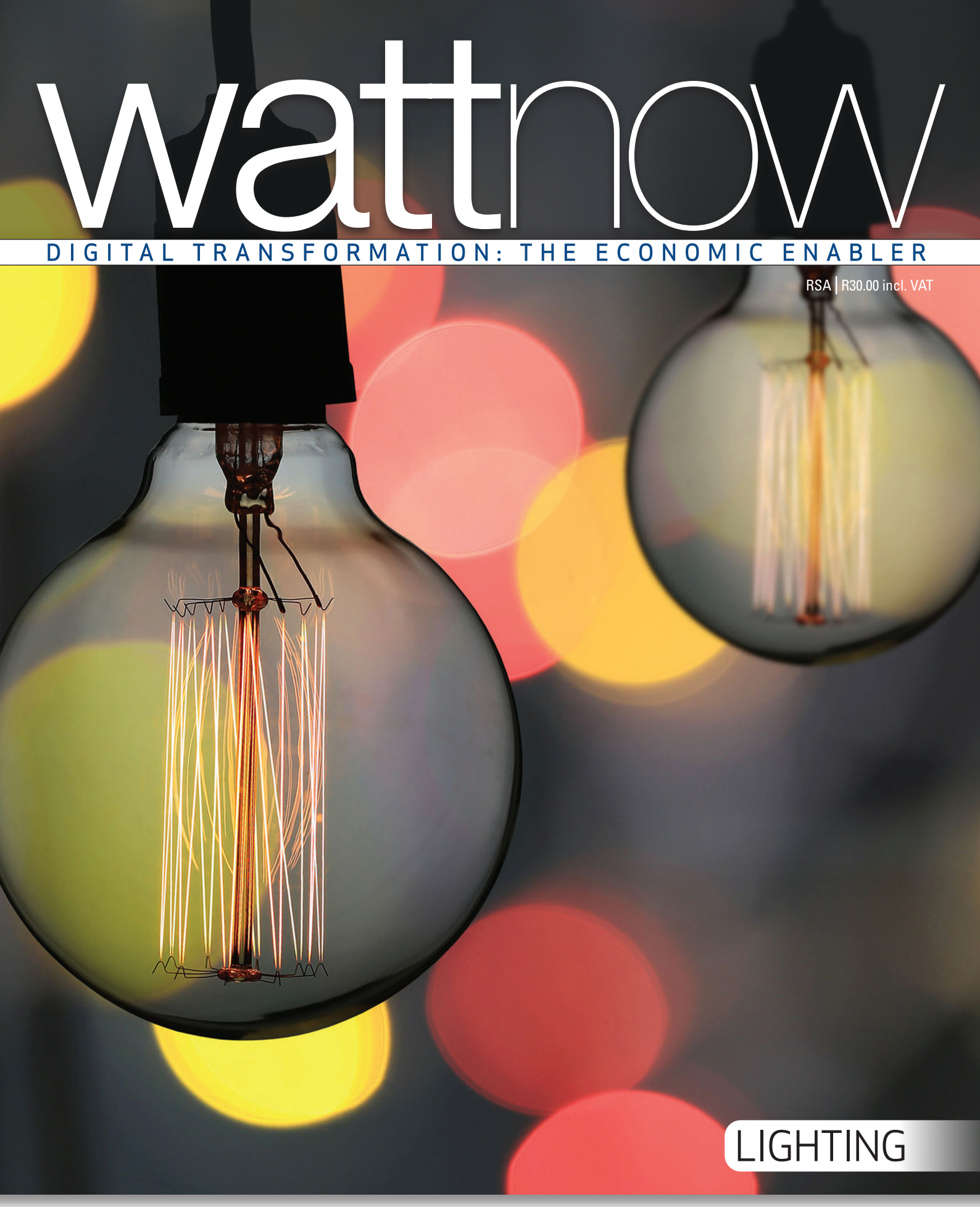

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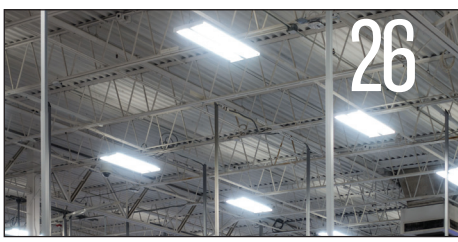


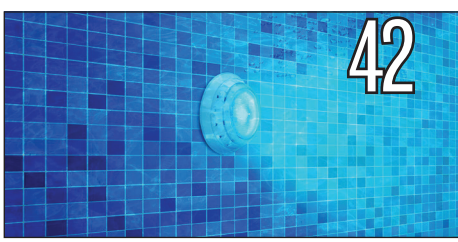


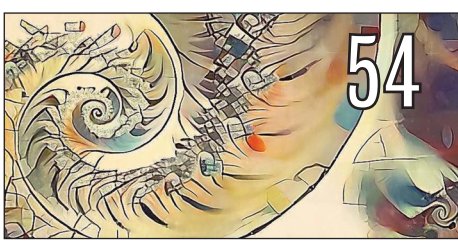



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Dear Valued Reader

It is November, and we have officially entered into the "Silly Season". Not only are we working ourselves to a standstill to finalise SAIEE's upcoming National Conference, but at the same time everyone seems to have a bounce in their step for the upcoming holidays. We have worked tirelessly this year and looking forward to just sitting with our feet up and being able to relax, but until then - there is still too much to do!

In celebrating the festive season, this issue aptly features Lighting - for those Christmas Lights!

Our first feature article, "Selecting the right industrial lighting" on page 28, outlines the evolution of LED Lighting and the many factors that decision-makers should look to address when considering the investment.

The uniformity of the colour of light generated by LED luminaires plays a significant role in many lighting applications. Page 36 sports a case study on a photometrical colour uniformity system.

With the rapid growth of the LED market, correct product selection is imperative to ensure LED performance and lifetime. The article, on page 42, highlights the proper use of LEDs in various environments.

And once again, Dudley Basson did not disappoint - with his article "The Golden Mean and Mandebrot" on page 52. Three mathematicians separated in history by several centuries, shared a common passion - the "Golden Ratio".

Thank you to all the contributors who made wattnow an excellent publication this year. Without your knowledge, time and effort to submit content, you would not have enriched our readers' lives.

We wish all our readers a wonderful festive season, surrounded by your loved ones.

Here's the November issue, enjoy the read!

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# The 50th Anniversary of the internet

**GEORGE DEBBO**
**2019 SAIEE PRESIDENT**

On 29th October 2019 the technical community around the world celebrated the 50th anniversary of the invention of the Internet. It started on this day in 1969 when a team at the University of California in Los Angeles (UCLA) sent a message over a network that they had configured to a terminal that was located at the Stanford Research Centre.

The team was led by Leonard Kleinrock, the Professor of Computer Science at UCLA, and who had pioneered the mathematical theory of packet networks, the technology that underpins the Internet.

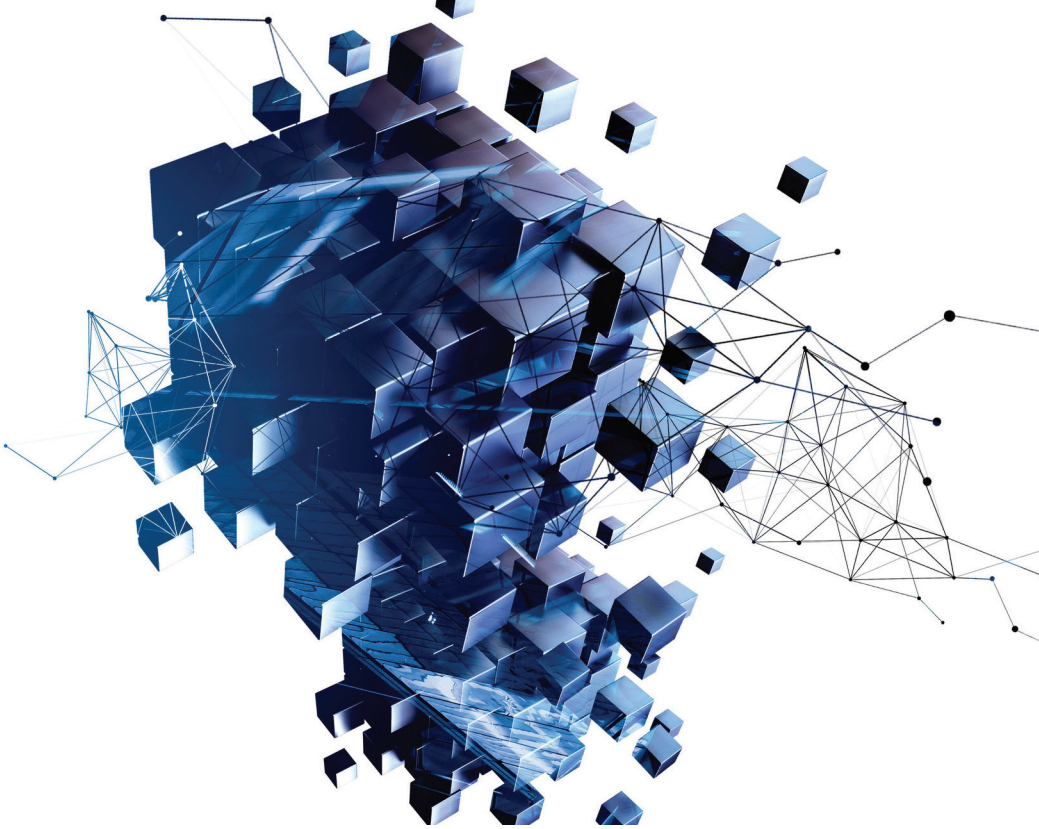
The set-up was as follows: on the UCLA side, a Sigma 7 Scientific Data Systems (SDS) time-shared computer that served the local post and undergraduate community, was linked to an Interface Message Processor (IMP), which was a packet switching node. In those days, before the advent of vast scale integrated circuit technology, the IMP was the size of a refrigerator.

A similar configuration was set up at Stanford except in this case the computer that was connected to the IMP was a Programmed Data Processor (PDP) machine from Digital Equipment. The two IMP nodes were connected via a communications link that was hired from the local telephone company. Presumably, as digital transmission technology was not commercially available at this time, it probably comprised a "nailed-up" telephone connection over which 56kbit/s data transmission could be accommodated. Notwithstanding, this became the first piece of networking equipment used on the Internet.

On the evening of 29th October 1969 at around 10 pm, the team at UCLA attempted to undertake a remote login on the PDP machine at Stanford. The two teams had a telephone call connection while they attempted this so they could monitor the message as it was typed on the UCLA side.

The typed message was "LOGIN" but only the "L" and the "O" where received. Unfortunately, as the "G" was typed on the UCLA side, the PDP machine at Stanford crashed resulting in the remaining part of the message was lost. The only message to get through was "LO", and this became the first message ever transmitted across the Internet.

Leonard Kleinrock laments the fact that they never had a prepared message to send as was the case with other significant inventions in the telecommunications world. For example, when Samuel Morse first demonstrated the telegraph between Washington and Baltimore on 24th May 1844, he sent the words "What hath God Wrought". Alexander Graham Bell, when



demonstrating the telephone for the first time on 10th March 1876, used the words "Mr Watson, come here. I want to see you".

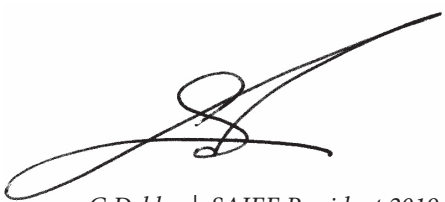
Shortly after this demonstration that was carried at the end of October 1969, two additional university computers were connected, and these four nodes became the basis for ARPANET, the precursor to the Internet that we have today.

ARPANET was developed under the auspices of the US Advanced Research Projects Agency (ARPA), to enable computer resources at the connected Institutes to be shared amongst mainly scientific users. It took advantage of the new concept, developed by Leonard Kleinrock, of sending information in small units called "packets" that could be routed via different paths and reconstructed at the destination. In 1970 the development of TCP/IP, by Vint Cerf and Robert Khan, allowed the orderly expansion of this network to the point where it could become a network of systems and service a far greater number of nodes.

The ARPANET was handed over as two separate components in 1980. The first component created an independent military network called the Defence Data Network. The second component created a network of scientific and academic computers funded by the National Science Foundation (NSFNet) in the US. In 1995 NSFNet turned the backbone of the Internet over to a consortium of commercial backbone providers which over the years has grown to the Internet that we know today.

Today the Internet connects over 4.4 billion people, some 55% of humans, as well as some 8 billion devices, the latter expected to grow to 50 billion with the advent of the Internet of Things. With the rapid and significant development of the World Wide Web (WWW), which runs over the Internet, this medium of communication will develop in the future to incorporate most of our needs as humans. The need to remain informed, to communicate and socialise, be entertained, and just as essential to be used to control, monitor and manage the world that we have built around us.

This is my last contribution to WattNow for 2019, so I would like to take this opportunity of wishing you and your families best wishes for the festive season ahead. Stay safe.



*G Debbo | SAIEE President 2019*
*Pr. Eng | FSAIEE*

# Sasol Award For Actom Turbo Machines

*Anton Hamman (second from left), Sasol's principal specialist sourcing of mechanical equipment, congratulates Chris Bezuidenhout, managing director of ACTOM Turbo Machines, on receiving the prestigious Sasol award. From left are: Leon Greeff, Sasol's senior manager, oxygen electrical & instrumentation; Mervyn Naidoo, ACTOM's Group CEO, and Nicholas Mokgosi, Sasol's senior manager E,C & I sourcing, category management.*

Petrochemical giant Sasol has recognised ACTOM Turbo Machines with one of its top 2019 awards for exceptional service in repair, refurbishment and ongoing maintenance.

The award in the 'Top Performing Service Supplier' : Large Enterprises category was recently made by Grace Nndwammbi, Sasol's senior vice-president supply chain to ACTOM Turbo Machines' managing director Chris Bezuidenhout at Sasol's head office in Sandton.

A division of ACTOM (Pty) Ltd, ACTOM Turbo Machines is the only large non-OEM business in its service category to win the award to date. Since its inception six years ago, it has become the largest non-OEM turbo-machinery and high-speed rotating equipment service provider in sub-Saharan Africa.

Sasol is very OEM-reliant in terms of service backup and parts supply, according to Anton Hamman, Sasol's principal specialist sourcing mechanical equipment. Nonetheless, ACTOM Turbo Machines has proved itself in service provision for turbo machines, where critical and complex skills are required.

*"We view turbo machines as the heart of our operations, so it is absolutely essential that the service provider has all the critical skills needed to ensure that the equipment is maintained to OEM specification,"* Hamman says. *"If you use a non-OEM company for this work, you must be certain they have the required skills and competencies to perform this work to the correct standard every time and understand the associated risks."*

He highlights that safety awareness was a critical aspect of this service. The 36 MW machines in Sasol's oxygen plant, for instance, are extremely large and heavy. This makes them difficult and potentially dangerous to work on.

*"ACTOM Turbo Machines has demonstrated its awareness of the hazards involved and rigorously applies all the procedures necessary to ensure that no one gets injured and that the work gets done as per agreed schedules,"* he says *"On turbo machines, we look for the best skills in the country and globally, and this is what ACTOM Turbo Machines offers."*

Bezuidenhout says ACTOM Turbo Machines was honoured to have received the award.

*"It signifies recognition of the highest order, which we greatly value and cherish,"* he says. *"It marks an important milestone for us in our ongoing drive to provide the best possible service to industry."*

He commends the company's maintenance and refurbishment teams on the achievement. ACTOM Turbo Machines has a long-term service agreement with the Sasol group, including Sasol Secunda, Sasol Sasolburg, Sasol Mining and Natref.

The agreement is to provide maintenance on a periodic basis at all these sites. At Sasol Secunda's oxygen plant, the company has a permanent presence of 40 personnel to attend to all 16 of the plant's oxygen trains.

# Results of first PMO Insights Report

Project Portfolio Office, a solution provider that helps organisations achieve greater project success, has released findings of the first ever comprehensive analysis of project management offices (PMOs) within South Africa. Project Portfolio Office equips businesses with processes to drive operational efficiency by either implementing a new project management office (PMO), operating a PMO, or optimising and maturing existing PMOs.

The survey, titled 'The PMO Insight Report 2019', saw PMO leaders, executives and managers, as well as portfolio and programme managers, from 161 participating organisations of all sizes across 19 different sectors – from ICT and financial services to construction, manufacturing, energy, and mining – providing input on current local trends within portfolio and project management. The 2019 report delves into the current state of local PMOs, including a look at the local adoption of Agile methodologies, top PMO functions and services, key PMO processes, critical challenges and priorities and more, while also making recommendations on how local PMOs could navigate significant challenges.

*"We are encouraged to see from the results of the first PMO Insights Report that, despite a turbulent few years characterised by an uncertain business climate and increasing competition, local businesses have confidence that effective project portfolio management (PPM) practices are essential to success,"* explains Guy Jelley, CEO and co-founder of Project Portfolio Office. *"This means that organisations within South Africa are seeing value from their investments in improving portfolio and project management practices."*

However, Jelley adds, the results also point to the fact that there is still more work to be done for PMOs to be recognised as trusted, strategic partners delivering ongoing value to the business and its structure.

Key findings from executive-level respondents to the survey include the following points:

- Only 22 percent of strategic projects are managed by project managers within the PMO, highlighting a certain level of distrust in the 78 percent that are managed by non-project manager or outside of the PMO;
- Twenty-five percent of PMOs do not provide any type of portfolio and project status reporting;
- Executives are emphasising benefits management for the alignment of projects, programmes and portfolios to strategy as a key improvement area they want to see their PMOs deliver.

PMO leaders, on the other hand, had the following to say:

- They are generally getting the C-Level support required, with only 15 percent of PMO leaders not receiving the funding needed to support a PMO, and 26 percent citing inadequate executive support;
- Fifty-six percent of PMOs aim to tackle the excessive time spent on reporting through the better use of reporting, analytics and dashboard tools;
- However, only 34 percent are planning to implement a benefits realisation process.

*"Our research found that there were disparities between the way that executives and PMO leaders view their PMO's performance when it comes to measuring maturity, formulating and driving strategy, executing strategic projects, and recognising the need to improve benefits and resource management capabilities,"* says Jelley. *"Executives continue to focus on bridging strategy formulation, as well as the execution, building and sustaining of basic project management capabilities, while PMO leaders are more concerned with governing the methodology, and the provision of tools and templates.*

*Guy Jelley*
*CEO and co-founder of*
*Project Portfolio Office*

*"The research reinforces the growing strategic value of the PMO, but also brings to light the clear gaps between the way in which executives and PMO leaders view the functions and services delivered within the PMO environment.*

*"It is clear from the survey results that the C-suite is looking to PMOs to become a stronger driver of overall business strategy, with the disciplines of project and benefits realisation management in particular key to achieving business value as a direct result of successful project delivery."*

To download the full report, please visit http://bit.ly/PMOInsights

# INDUSTRY AFFAIRS

## SAIEE CUT Student Chapter Walks away with coveted Award

The Central University of Technology (CUT) SAIEE Student Chapter was the recipient of the "Best Student Organisation" in the Academic Organisation category at the prestigious Vice-Chancellor Student Leadership awards for 2019.

The award criteria say that the trophy awards a student society that best exemplifies student life, governance and student services.

Among the activities they accomplished this year includes:

- Launching the SAIEE Student chapter at the university,
- Embarking on a project to develop an electronic registration system for laptops in the library.
- Organising motivational sessions for all engineering students before their June 2019 examinations.

Amongst those invited included the university Vice-Chancellor, Prof Henk de Jager and the Dean of the Faculty of Engineering, Built Environment and Information Technology, Prof Herman Vermaak.

A hearty congratulations go out to the CUT Student Chapter. You make us proud!

## ADF LAUNCHES FIRST-EVER AFRICAN DRONE BUSINESS CHALLENGE

- African entrepreneurs can submit business plans that identify new and innovative business models enabled through drone technology and data.
- Citizens of all African countries or diaspora are eligible to apply.
- 10 finalists will compete for cash prizes of up to 40,000 GBP.
- The deadline for business plan submissions is Monday, December 9, 2019.
- The Business Challenge finalists will exhibit and pitch their business ideas during the African Drone Forum in Kigali, Rwanda on February 5-7, 2020.

The African Drone Forum (ADF) is proud to announce the launch of the first African Drone Business Challenge, a business plan competition for African entrepreneurs to uncover new commercial use cases for drone applications that demonstrate a high potential for local impact.

The goal of the Business Challenge is to encourage African entrepreneurs to envision new opportunities that may emerge as a result of both the increasing rural connectivity in Africa, combined with new semi and fully autonomous systems for delivery, digital fabrication, and artificial intelligence for navigation and image analysis.

"Tech is there, but use cases beyond medical product delivery are the missing piece," said Jean-Christophe Zufferey, co-founder of senseFly. "We should spend more time analysing existing supply chains to see where and how drones make sense."

The deadline for business plan submissions is Monday, December 9, 2019. Finalists will receive notification in early January 2020 if they are selected to participate in the final pitch event at the ADF.

### BENEFITS

Ten finalists will be invited to attend ADF and will receive pitch training, exhibition space, mentoring, and the opportunity

# Afrocentric IP Celebrates 10 Years of IT Empowerment

Currently celebrating its 10th birthday, Afrocentric IP has shown that black owned and managed IT businesses are not only possible, but profitable...

Even with B-BBEE legislation firmly in place, the South African IT sector faces significant transformation challenges. Fully owned black owned companies remain a minority, while black management control has been slow to take root, and the industry continues to deliver disappointing returns when it comes to meeting employment equity targets.

Afrocentric IP bucks this trend. The company is one of South Africa's leading black owned IT operations and is currently celebrating its tenth successful year of business. It has an established a base of over 50 clients across all nine provinces and the SADC region, and has also launched new branches in Limpopo, Eastern Cape, and KwaZulu Natal.

*'The key to progress for our company has been getting the mix of ownership and on-the-ground experience in delivering contracts right,'* says Langa Kuboni, Afrocentric IP COO. *'This can be complex in the IT sector, which is characterised by long standing relationships between established companies. Creating a strong track record of project delivery has been a challenge we've overcome, and I think it's credit to everyone involved in the company that we now stand as one of the few black owned, managed and staffed IT companies in the South Africa.'*

Even though Afrocentric IP faced significant challenges in its first ten years, it is now very well positioned to prosper in a sector where changes to the B-BBEE Codes of Good Practice are pressurising local companies to dramatically improve their transformation performance. The codes were revised in 2017, in a process that effectively closed the fronting loopholes that existed in the 2003 and 2007 editions.

*Langa Kuboni*
*Afrocentric IP*
*Chief Operating Officer*

to pitch their business ideas live to a crowd of industry leaders, investors and government officials. The ADF will run concurrently with the Africa Tech Summit offering networking potential with over 1,000 participating digital leaders, tech corporates, technology regulators, banks, mobile network operators, and startups from across Africa and the globe. Finalists will compete for cash prizes up to 40,000 GBP.

## REQUIREMENTS

To submit a business plan, you must be a citizen of an African country or an African in diaspora, and business concepts that would operate within Africa. Participants can range from an individual entrepreneur or an early-stage startup to an innovation team within a small business, corporation, or government office that focuses on integrating new drone services or applications into their business models. Entrants do not need to be drone companies but should focus on concepts and customers for new business opportunities enabled by drone technologies. Significant consideration will be given to proposals that demonstrate both economic and social value to their communities.

If you have any questions, please contact Andi Fisanich (afisanich@worldbank.org) and Jonty Slater (challenge@africandroneforum.org).

# Schletter Group acquires three large-scale projects

With three new large-scale projects in Asia and Latin America, the Schletter Group continues its international growth course.

The PV plants in Nepal, Brazil and Honduras have a total output of 85 MWp and have all been mounted on Schletter's open area system FS.

*"These projects show that we are not only directing our efforts at the right markets but above all that we are pursuing the right sourcing strategy,"* says Florian Roos, CEO of the Schletter Group. "

*Our global network with own locations and selected suppliers makes us extremely flexible and allows us to realize several major projects at the same time. This is an increasingly important factor in the international project business."*

The major order from Brazil comprises several plants for projects by Schletter's Brazilian distribution partner HDT International. The projects have a total output of more than 50 MWp and are currently under construction in the regions of Minas Gerais and Sao Paolo. The Schletter Group has been working with HDT International since 2018 and plans to further intensify the collaboration. "Brazil is an interesting market for us where we intend to further expand our business," says Roos.

In the Caribbean, where the Schletter Group has been maintaining a strong footprint for several years, the company supplies the mounting system for a 10 MWp project of new customer Negratin S.L. This is the first project carried out together with the Spanish EPC contractor.

The project in Nepal has an output of 25 MWp and is currently under construction in Bidur, around 15 miles northwest of Katmandu. The solar plant is financed by World Bank as a contribution to stabilizing the supply of electricity in Nepal.

Roos expects the trend towards large-scale projects to continue. *"Project developers and investors are increasingly focused on economies of scale and yield optimization to ensure profitability of their projects with very little or even without state funding,"* the Schletter CEO adds.

*"With our mounting solutions that save both time and material, as well as our flexible supply chain, we are ideally positioned for this."*

# Unions strike while SAA is seconds from disaster!

Can a striking trade union ever find itself in a worse position than in negotiations with a bankrupt employer?

When an employer has no assets and the bank refuses to grant further credit, what is there to negotiate about, unless you are a responsible trade union who wants to engage honestly on matters aimed at saving the business.

If the employer is bankrupt and the staff component is completely disproportionate (as is the case of SAA), a union's negotiating power is so eroded that the last thing it can afford to do is to strike. What an employer would typically do in such a situation is to walk out and lock the doors behind him. Since the employer has nothing to offer or even negotiate about, it has nothing to lose and its risk is therefore extremely limited, if there is any risk at all.

That, however, is a 'real world' scenario. In the case of SAA, the employer behaves as if it is still solvent, which it isn't - especially if its salvation was dependent on further funding from a real-world commercial bank, and not State bailouts.

SAA pretends as if its service is indispensable, which is not the case. Its airspace market share (local and international) is in the region of 20 percent, which will be taken up by other carriers in the event of SAA's demise. This notion of indispensability, however, emboldens the trade unions to make unrealistic demands.

Then there is the issue of the SAA brand. The fact is that the brand is tarnished to such an extent that closing SAA will actually enhance Brand South Africa. Nothing tarnishes a brand more than attempting to create the impression that it is a flagship, while it is blatantly apparent that the opposite is true.

SAA can't be saved.

Every day that it continues to operate, the risk it poses to 'South Africa Inc' is multiplied. Therefore, the sooner government acts to terminate this liability, the better.

*Written by Gerhard Papenfus, Chief Executive of the National Employers' Association of South Africa (NEASA).*

# INDUSTRY AFFAIRS

## IEEE President & CEO visit South Africa


*From left: Prof Jose Moura (IEEE CEO) and Prof Manuela Veloso (IEEE CEO).*

During a recent whirlwind tour, between 30 September and 5 October 2019, IEEE South Africa and the SAIEE hosted these distinguished guests in Pretoria, Johannesburg, Cape Town and Stellenbosch.

Seven talks were presented to a combined audience of over 300 people which included retirees, senior engineers, young professionals, students and researchers.

The talks centred on Artificial intelligence, the 4th Industrial revolution and Big Data which sparked several exciting discussions between the guest speakers and the audience members.

Prof Manuela Veloso illustrated how Artificial Intelligence had been used to mimic trading (buying and selling of shares) on the stock exchange. The results were surprising, with a high percentage correlation since the AI was trained using graphic plots (historical trends) instead of actual trading data.

Prof Jose Moura (IEEE CEO) talked about the importance of fast, reliable and accurate processing of big data, which will now be generated within the IR4 universe to yield useful information for evaluating trends.

Events such as these highlights the importance of collaborating with sister institutions in service towards our combined members.

The Acting Chair IEEE South Africa hosted a senior executive meeting between both institutes, David Oyedokun, to foster the existing collaboration and plan the way forward.

## Fluke doubles troubleshooting power AND lightens the load

COMTEST is offering the Fluke 787B and 789 ProcessMeter™ that doubles the troubleshooting capabilities by combining the power of a safety-rated, digital multimeter and mA loop calibrator into a single, compact test tool.

Based on the trusted measurement capabilities of the Fluke 87 DMM, the 787B and 789 add the ability to measure, source and simulate mA with the accuracy and resolution that can be expected from a Fluke mA loop calibrator, giving users the ideal tool for troubleshooting and calibrating current loop applications.

The 789 has the additional features of 24 V Loop power supply and HART mode setting with loop power (adds 250 ohm resistor).

For more info, visit www.comtest.co.za

# CESA responds to MTBPS – Partnering for 'Value for Money' Procurement!

While Consulting Engineers South Africa (CESA) supports many of the provisions of Minister Tito Mboweni's 2019 Medium-Term Budget Policy Statement (MTBPS), the organisation believes that Government needs to place increased focus on revising its procurement policies and improving the quality of spending.

Chris Campbell, CEO of CESA, states, *"CESA has been requesting the urgent revision of the Procurement Practices for Consulting Engineering Services for a considerable time. We welcome the focus on improving spending efficiency and reducing waste and eagerly await the review of the existing procurement regulatory framework, through the Public Procurement Bill."*

For a considerable time, public-sector infrastructure projects have been plagued by poor planning and implementation. This is reflected in continued underspending, which reached 20 per cent of capital budgets in 2018/19. The Budget Facility for Infrastructure, a technical entity that reviews complex capital projects, has strengthened state capacity to consider and budget for large infrastructure projects and programmes. CESA is pleased to see that these interventions have begun to yield results, such as an improvement in the quality of budget bids and an associated reduction in rejection rates. The Consulting industry welcomes the 2019 MTBPS proposed allocation of R3.4 billion over the next three years for these projects, including student housing at three universities, school facilities and health infrastructure.

*"CESA is in support of Government's continued work with the private sector to strengthen infrastructure investment with efforts focused on raising the efficiency of spending and crowding in private-sector investment. National Treasury's review of public-private partnership regulation aimed at merging approval processes and reducing implementation timeframes is a step in the right direction"*, says Campbell.

*Chris Campbell*
*CESA CEO*

# Schneider Electric SA and Amtec Techniquip collaborate to boost local access to education

Energy management and automation specialist, Schneider Electric South Africa and Amtec Techniquip, a leading provider of locally manufactured educational equipment have recently signed a Memorandum of Understanding (MOU), which will see the organisations collaborating in creating access to education through the availability of a large range of practical training equipment for education.

As a result of the MOU, Schneider Electric South Africa will now be able to provide locally manufactured didactic benches, as Amtec Techniquip will be incorporating high-quality Schneider Electric components into their locally manufactured benches, delivered to education institutions in Southern Africa.

This is a major step forward in providing high-quality training equipment with local content. Didactic benches bridge the gap between theory and practice and form a critical part of the practical component for vocational training across the globe.

The collaboration also underscores Schneider Electric's ongoing commitment to providing world-class equipment to local education institutions. These locally manufactured didactic benches will for example be used at the F'SASEC (French South African Schneider Electric Education Centre) network partners across the country and at Schneider Electric partners and customers in Southern Africa.

*"Our MOU with Amtec Techniquip is an important step towards providing access to high-quality education and re-emphasises Schneider Electric's support of local businesses and content. Amtec Techniquip manufactures high-quality and innovative equipment which made them the perfect fit for our training solutions,"* comments Zanelle Dalglish, Head of Sustainable Development and Academy for Anglophone Africa, at Schneider Electric South Africa.

# Keeping heating costs down - invest now!

Over the past few years, there has been a significant shift from coal to natural gas. This has been primarily driven by low natural gas prices and increases in electricity rates.

The cost of heating your home, particularly during the colder winter months, makes up about 60% of energy bills. With ever-impending load shedding and the emerging coal crisis, one can keep heating costs down and still keep their home cosy by making smart heating choices. But getting the right information and deciding on an efficient and economical hot water heating system can be a daunting task.

Nicole Viljoen, Project Administrator at Energas Technologies, explains that in conventional heating systems (gas boilers, for example), the heated gases pass through the boiler's heat exchange surface, transferring the generated energy to the heat distribution system such as the underfloor heating and radiators.

*"Afterwards, the combustion gases are released into the atmosphere through the boiler's flue. A certain amount of heat is lost because of steam that forms during the burning process is being pushed out. Due to this, the released steam carries an untapped amount of evaporation energy,"* says Viljoen.

This is where a high-efficiency condensing boiler is the right choice if you are looking for a greener and more efficient boiler. This is because condensing boilers can make better use of the heat they generate from burning fuels, such as gas.

At just 11 kW output, Viessmann's newest and smallest system boiler will provide end-users with an optimum-sized, efficient and reliable boiler with a lower price tag. The new Vitodens 200-W responds to demand from installers for system boilers that closely match the heat demand of the majority of modest-sized, well-insulated homes.

*"Not many homes have a heat load of more than 10 kW, yet most system boiler ranges start at an output of around 19 kW. This means that the majority of system boilers in the UK are oversized,"* explains Viessmann Marketing Director, Darren McMahon.

*"Homeowners are buying larger boilers than they need and once installed, the boiler cycles more than it needs to, increasing running costs and wear and tear. A correctly-sized boiler will be more efficient and last longer.*

*"The Vitodens 200-W 11 kW model means installers no longer have to 'range rate' larger boilers. System boilers can now be fitted where heat-only models may have been chosen previously. The boiler has a higher heat output rating of 17 kW for the generation of hot water, so there is no trade-off between space and DHW heat."*

UK Best Buy-awarded Viessmann Vitodens 200 gas-condensing boilers, supplied locally by Energas Technologies, are available as a wall-hung boiler (Vitodens 200-W) and floor-standing storage boiler (Vitodens 222-F), with outputs from 11 kW to 60 kW.

*"The boiler combines unparalleled flexibility with maximum efficiency, making it your ideal choice for a new installation or economical retrofit in large residential or commercial applications,"* concludes Viljoen. wn

CERTAINTY THROUGH CERTIFICATION AND COMPLIANCE

# Are you an ELPA member?

## IN SOUTH AFRICA, LIGHTNING IS A REAL THREAT

- South Africa experiences ±24 million lightning strokes annually
- With ± 500 related fatalities every year

The Earthing and Lightning Protection Association (ELPA) was formed to bring the industry together, reduce the burden and upskill engineers to protect the consumer, establish a uniform interpretation of the codes of practice, and help to regulate and advise the lightning protection industry.

## JOIN US TODAY AND START MAKING A DIFFERENCE!

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# The importance of surge protection in the lightning protection arena

In order to understand the need for surge protection, it is important to understand how lightning causes damage. The sources of lightning damage are quite different, and we use different types of mitigation techniques and equipment to protect different items.

**BY** IVAN GROBBELAAR, SENIOR ENGINEER, DEHN AFRICA

There are two areas of concern when evaluating a building or structure, namely the structure itself, and all incoming cables, meaning IT equipment as well as power. From this, the four sources of damage are derived, as per the following possibilities:

- Having a lightning strike directly to the building, or
- Near the building, or
- Directly to an incoming line, or
- Near the incoming line.

Nearby strikes cause lightning surges. In striking neighbouring buildings, surrounding objects or areas next to incoming lines, the lightning current coming down generates a magnetic field, which is cast over the structure or lines. This magnetic field that is cast generates an induced current on the incoming line or on the cables inside the structure. To prevent resulting damage to electrical equipment, we use surge protective devices (SPD) to reduce the induced effects of lightning. To prevent burning or mechanical damage, we attempt to avoid direct strikes to a structure by means of a system of lightning rods, also known as external lightning protection.

By installing external protection, you will protect yourself from structural damage, but this will not necessarily prevent your

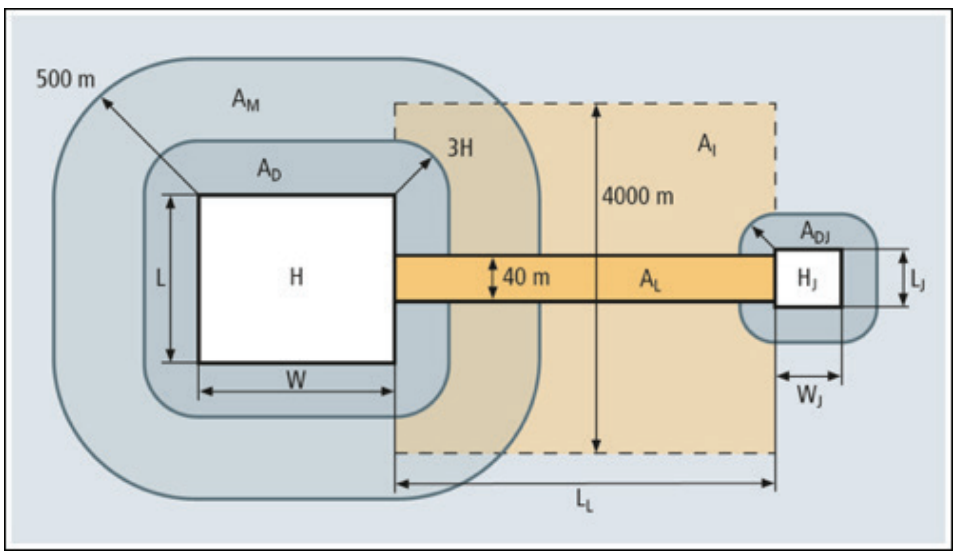



*Figure 1: Areas from which lightning strikes can cause damage to a building, its incoming lines and its systems*

electronic equipment from being damaged (for example TVs, internet routers and appliances such as kettles, fridges, microwaves and so on). Therefore, in order to protect equipment, you need surge protective devices.

The calculation from the SANS 62305-2 standard to evaluate the risks are as follows:

- The area to be considered for direct strikes is a radius around the structure, which is three times the height of the structure,
- The area to be considered for surges is a radius of 500m around the structure and can be up to two kilometres away in both directions for incoming lines.

See figure 1.

We can therefore see that the risk of resultant surges exceeds that of direct lightning strikes, meaning that the correct installation of surge protection devices is extremely important.

Other benefits of surge arresters include the minimising of switching surges coming from the grid. This is a very relevant topic when seen against the background of recent load shedding from the South African grid.

Over the years, DEHN has developed numerous market-leading surge arresters, with the latest offering being the new DEHNguard ACI surge protective device. This technology is a first in the market and a product of DEHN exclusively. The DEHNguard surge arrestor with ACI technology allows the user to save space, time and costs. DEHNguard is a pre-wired, complete unit that consists of a base part and plug-in protection modules. Its benefits include:

- Safe dimensioning and the elimination of mistakes: The new switch/spark gap combination is integrated directly into, and ideally adjusted to, the arrestor. A connection cross-section of just 6mm² makes for easier installation and saves time that otherwise needs to be spent dimensioning the cross-section.
- Being able to withstand temporary over-voltages (TOV) to increase system availability and save on maintenance and repair costs. Temporary over-voltages - for example, caused by loss of neutral - can destroy conventional surge protective devices. The new ACI arrestors have a much better TOV withstand.
- Zero leakage current increases the service lifetime of arrestors. ACI arrestors also avert the accidental tripping of the insulation monitoring and contribute towards operational safety.

*DEHNguard with ACI technology has recently become available in South Africa through DEHN Africa and its partners.*
*For more information, contact DEHN AFRICA: +27 11 704 1487.*

# Professional-grade sunshine

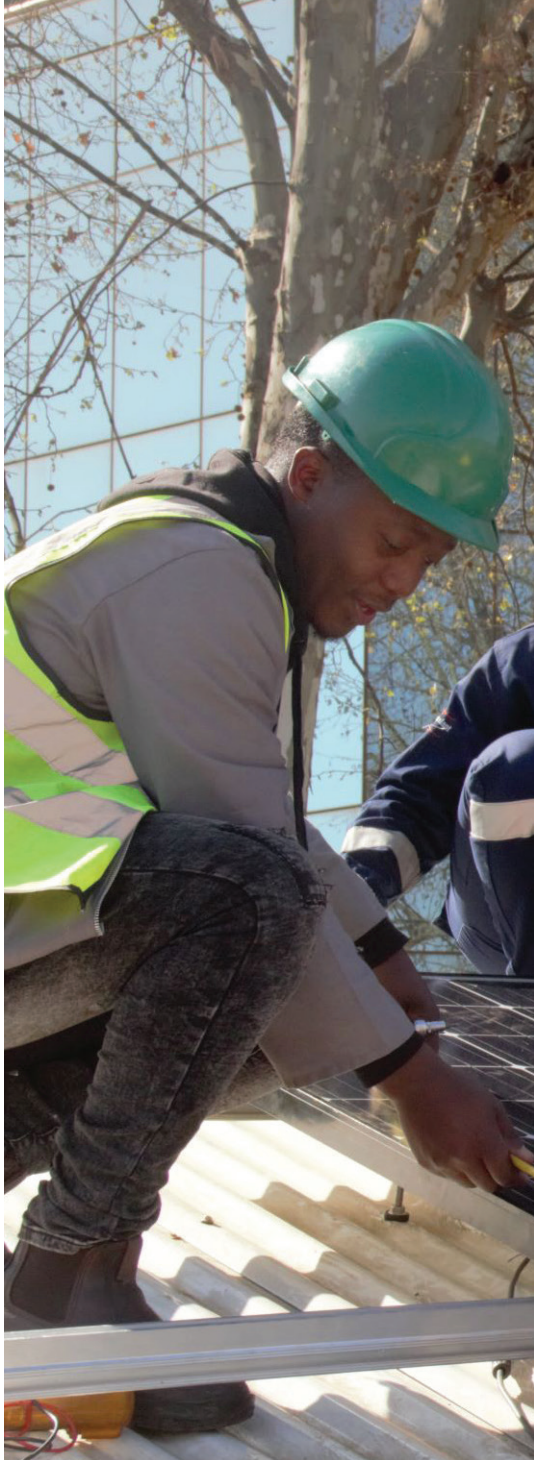
## - Harness solar energy for your business

South Africa is regarded as one of the best solar resources in the world. On average, most areas in South Africa get close to 3 000 hours of sunshine a year; with a 24-hour global solar radiation average of about 220 W/m2. That is about 4.5 to 6.5 kWh/m2 of solar radiation levels a day that could be converted into electricity.

For businesses, harnessing this resource does not only boost their bottom line by reducing electricity costs (where tariffs are set to rise by 80% soon); it also frees them from relying on the grid as well as harmful and expensive diesel power generation alternatives; which ultimately reduces their carbon footprint, and helps them meet their corporate sustainability goals.

When it comes to energy supply, corporates that harness solar energy are never in danger of struggling to operate or losing time and money during blackouts. *"For most domestic installations, there is no cost of opportunity – it doesn't matter if a person brushed their teeth by candlelight. But if a factory works with machinery, a lot of money is lost when there is no electricity. So, the cost of opportunity often outweighs the cost of having a solar PV system"*, said Resolution Circle's Electrical Consultant – Dennis du Plooy.

He explained that in the industrial market, *"businesses need to harness the maximum power supply during their productive hours - that is when everyone is at work. Other systems apply during weekends and holidays, but the most important thing is to have the demand during the week"*.



The main advantage of having a solar system is self-consumption – where the self-generated solar electricity isn't fed into the grid, but directly into the building – especially during peak hours. Industry have realised just how economically viable solar is when it is distributed directly into their distribution board. That, and the fact that people are at work during peak hours.

*"I think the agile workforce of today is also allowing for this system, where outside of the sun's peak, people work remotely, and only*

*get to the office when the sun is at its peak*" said du Plooy.

Corporates investing in solar can also get intelligent energy managers which will either store excess energy for use during off-peak hours or feed it back into the grid. If a business generates more electricity than it consumes, it can be fed back into the grid, and the business gets credits from the city or municipality for the electricity. Businesses might experience power outages, hefty electrical bills, tariff increases, expensive diesel power generation costs, while struggling to reduce their carbon footprints and meeting their sustainability goals – one thing that is for sure, South Africa will never be short of sunshine.

As a technical training hub that also offers a Solar PV installation short learning programme, Resolution Circle is also passionate about energy efficiency management – to a point where electrical engineering students who are part of our P2 Work Integrated Learning Programme implemented a project they dubbed #Sunny18. Where they developed a grid-tied system that works with micro-inverters instead of string inverters, which are normally used in grid-tied systems. The system can be used as a power backup for an office space that is not connected to an uninterruptible power supply.

Resolution Circle have a Super Solar School offering exciting workshop-based training programmes. wn

http://www.resolutioncircle.co.za

# Motor System Efficiency High On Global Agenda

With electric motors consuming almost 70% of industry's energy, companies are always looking for better motor efficiencies. For many years, motor efficiency has been well defined; however, when driven by a variable speed drive (VSD), the VSD efficiency and the total efficiency of the VSD and the motor has not been well understood.

For many years, motor efficiency has been well defined.

Choosing the right product combination can also be more difficult as manufacturers' data is not always easily comparable. This is where the international IEC61800-9 standard comes to the rescue, according to global motor and VSD manufacturer WEG.

The IEC61800-9 standard – based heavily on the previous EN 50598 standard – gives manufacturers a clear framework for grading a complete motor system. End-users can compare the overall efficiency of a manufacturer's products, irrespective of design and component selection.

The IEC61800-9 standard uses the Extended Product (EP) approach. This considers the efficiency of the Motor System, which is comprised of the Motor, the Basic Drive Module (BDM), the Complete Drive Module (CDM). Together, these make up the Power Drives System (PDS), which also includes any switchgear and controls.

This terminology sounds confusing but is just a technical way to say: Switchgear + VSD + Motor. The efficiency levels are defined by considering eight different operating points, covering low to high speed and torque. The user can easily compare his application load and speed requirements to the motor system defined speed and torque points.

The EP approach employs a semi-analytical model to calculate the efficiency of each of the components at the operating points of the driven equipment. The calculations are also based on tested and verified values. This results in the most efficient component selection for the application.

Using this standard, the user may be assured that:

- A motor complies with the defined motor efficiency levels of IE1, IE2, IE3, IE4 or IE5;
- A VSD complies with VSD efficiency IE0, IE1 or IE2; and
- The manufacturer's motor and VSD used in combination will meet or exceed a system energy standard of IES0, IES1 or IES2.

Using this EP approach, the European Commission expects the increasing use of more efficient systems to help achieve its targets for carbon dioxide ($CO_2$) reduction. In line with these efforts, WEG VSDs and IE2 motors in combination achieve IES2.

And significantly, WEG's VSDs and IE3 efficient motors exceed the highest system levels of efficiency. Additionally, WEG has product lines that exceed even IE4 and IE5 classifications.


Recognising that global population growth and economic development is driving up energy demand around the world, the European Union has set stringent targets to reduce $CO_2$ emissions. These aim to cut emissions by 40% by the year 2030. This means creating more renewable energy sources, and also increasing the energy efficiency of industrial systems. Studies suggest that almost half of global energy consumption comes from industry – followed by commercial and residential use.

The EC's regulation 640/2009 already requires that all electric motors operated from a variable speed drive or inverter must adhere to a minimum of IE2 to be eligible for sale. Fixed-speed applications must meet a minimum of IE3 to comply.

Where a motor does not operate at its nominal torque and speed, the variable speed drive represents a significant opportunity for energy optimisation. In addition, the greater the range of speed variation results in a greater PDS efficiency. Using WEG's IE2 motors with any WEG variable speed drive can achieve an efficiency classification of IES2. However, using other WEG lines of motors with the right drive, much better levels of efficiency can be reached.

WEG has a complete line of variable speed drives which exceed the IE2 requirements outlined in the IEC61800-9 standard. When combined with its robust and reliable motor line, the products create an integrated solution for all applications. wn

# Celebrating 28 Years of Excellence

Mike Visser
CEO | Power Quality

Power Quality is a diversified organisation for earthing and lightning protection providing consulting services, training, fault finding, installations, testing, certification, risk analyses, inspections, earthing audits, and turnkey solutions. Over the years, we have become specialised contracting professionals servicing the African continent. We strive to deliver with the highest regard for customer satisfaction, quality and integrity. We provide world-class earthing and lightning protection solutions.

Power Quality continues to enjoy on-going and strong beneficial relationships with many respected local and international companies. We pioneered the planned maintenance testing and inspecting of earthing and lightning protection systems with AngloGold and Sasol in the early 90s.

Power Quality has earned the reputation of being one of the most skilled and experienced companies in the earthing and lightning protection industry with a history of cost-effective innovation in mobile lightning protection systems.

## MISSION

Our mission is to provide our clients with certainty of reduced risk from expected and unexpected climatic events such as lightning strikes and any electrical overvoltages. We aim to ensure that all systems, whether internal or external, remain safe and free of damage, should an unexpected lightning strike or electrical over-voltage occur.

## VISION

Our vision is to become the leading company in the earthing and lightning protection industry by providing world-class services within a win-win philosophy. Finding reliable, durable, and cost-effective solutions to client's requirements while surpassing the client's expectations provides for a safe and protected South Africa, our goal.

Our CEO Mike Visser is the founding chairman of the Earthing and Lightning Protection Association (ELPA), which was formed to protect the consumer, the industry, and the members. Mike gathered the industry players who were installing code of practise compliant earthing and lightning protection systems and suppliers of compliant materials and equipment to form ELPA.

The association is working with the Department of Labour to raise the recognition of the specialised skillset of lightning protection installers (the backbone of our industry) to the level of a trade qualification, protecting the specialists our industry has developed.

In spite of Power Quality's growth, our team of over 30 dedicated staff have an average of six years experience within the company. This proofs our win-win philosophy of developing our staff.

Mike has also been called on to provide expert witness testimony services in arbitration before the courts.

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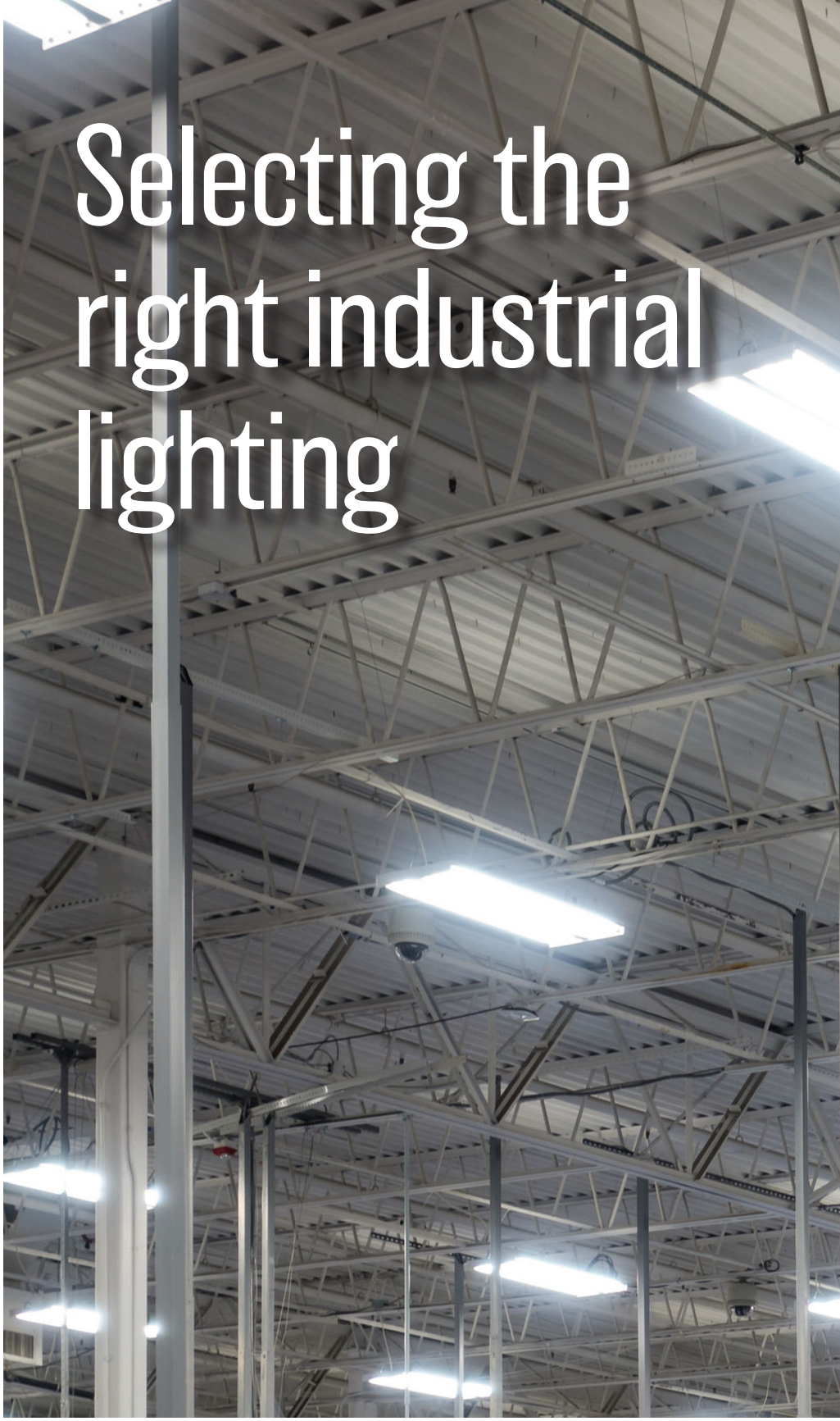
# Selecting the right industrial lighting



It is easy to take lighting for granted. We live in an age where buildings can be illuminated around the clock without a second thought. By selecting the right industrial lighting, an energy-efficient, comfortable and safe working environment can be achieved.

This white paper outlines the changing evolution of LED lighting and the many factors that decision-makers should look to address when considering such a significant investment.

## SCOPE

The rapid rise of light-emitting diode (LED) lighting as a viable option for commercial and industrial applications has flooded the market with a wide array of products and information – this can create confusion among specifiers. This white paper was produced to raise awareness around LED luminaire capabilities for industrial environments and the considerations required for each application.

## LIGHTING FOR INDUSTRIAL WORKPLACES

Over a century on from Thomas Edison's introduction of the commercially viable incandescent light bulb, it is easy to take lighting for granted. We live in an age where buildings can be illuminated around the clock without a second thought. This can be especially true of industrial settings, where consideration of lighting has traditionally taken a back seat to the more urgent demands of round-the-clock production schedules and tight control of costs.

However, those who fail to recognise the vital role of lighting in industrial environments may be missing out on

# Industrial Lighting

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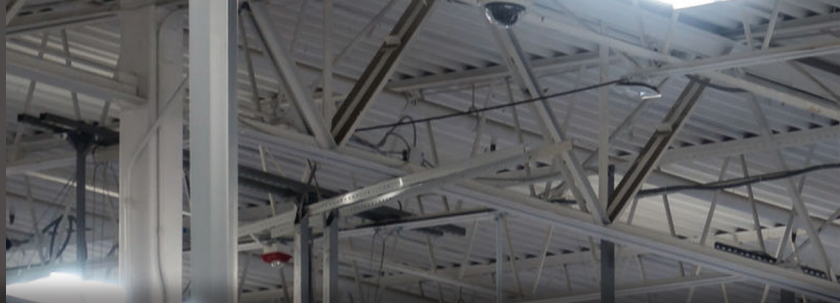

significant gains. In manufacturing, warehousing, power generation and other industrial workplaces, a duly commissioned lighting scheme can enhance the wellbeing and productivity of employees, which has a contributory influence on the quality of their output. Additionally, significant cost savings can be secured by selecting the most efficient solution based on a given building, its occupancy and its primary functions. Thirdly, continuity of production can be supported by reliable and consistent lighting schemes that are sufficiently robust to withstand harsh working conditions.

The challenge lies in trying to gain an understanding of the available options. Lighting replacements and upgrades may only arise on the management agenda approximately every decade. At the same time, the technology of lighting has advanced beyond recognition in recent years, most notably with the rise of LED luminaires, which have arrived with a raft of new specification criteria. Given these conspiring factors, business and facilities leaders could be forgiven for approaching lighting decisions with a degree of trepidation.

## CHANGING TECHNOLOGIES

For a long time, low bay lighting was favoured in industrial buildings for its low cost and simplicity. High-intensity discharge (HID) lamps were prevalent in this category. Compared with the sophisticated luminaires available today, these were relatively rudimentary devices, incorporating either mercury, metal halide (a combination of mercury and halogen) or SON (sodium) gases that facilitate the creation of an electric arc between two electrodes. However, HID lamps suffer from shortcomings that limit their efficacy, lifespan and safety.

In some cases, they can take between five and ten minutes to produce their stated output, due to the slow process of building up the required level of gas pressure internally. Equally, after being switched off, they cannot be immediately switched back on as the necessary cooling and reheating processes take time to complete. This has historically been problematic in brief instances of power failure, for example.

Towards the end of their lives, HID lamps can fail in problematic ways, either requiring larger voltages to maintain their arc discharge or, in some cases, exploding due to the deterioration of components caused by thermal stress, mechanical vibrations or the involvement of chemicals. The disposal can also be challenging, particularly for lamps containing mercury, which require specific safety procedures to be followed.

Replacement of such lamps with LED luminaires can be enormously beneficial for organisations aiming to maximise productivity by creating a comfortable and correctly lit working environment, while also achieving energy and cost efficiencies.

An LED luminaire typically uses 50-60% less energy than a traditional light source, such as a fluorescent or HID lamp. However, it is worth noting that such performance depends on the use of luminaires incorporating high-quality LEDs and associated electronic drivers, plus excellent thermal management characteristics and optimised optical distribution. By ensuring optimum lighting arrangements, several important considerations need to be applied, ranging from detailed interrogation of product specifications to careful assessment of application-specific criteria including distribution of light, colour rendering and resistance to harsh environmental conditions. This white paper seeks to explore these considerations to help the owners and managers of industrial buildings, along with the contractors, consultants and specifiers who support them to select the most suitable lighting scheme.

Firstly, let us look at the two significant reasons why lighting matters.

### PRODUCTIVITY

Adequately designed and carefully implemented lighting schemes can have a beneficial effect on the wellbeing and productivity of employees, which in turn creates a platform for business growth. This is one of the significant benefits of a properly designed lighting scheme but often becomes a secondary consideration in the quest for energy savings, which have been amplified by the rise of LED technologies that enable relatively simple cost reductions.

Employers increasingly recognise the duty of care they have towards their employees and consideration of staff needs is vital for morale. What's more, forward-thinking businesses understand that employees are more likely to be 'at the top of their game' when they are immersed in a comfortable and stimulating environment.

This can include a well-designed workstation, a comfortable office temperature and appropriate lighting. Demonstrating this duty of care will undoubtedly foster a greater sense of

staff satisfaction, increase motivation and productivity and lead to more staff retention. All of which ultimately contributes to driving up company profits.

Improved lighting is an essential element in the overall mix.

In its guidance to employers, the Health and Safety Executive recommends that lighting should be considered principally at the design stage. Still, it also emphasises the importance of ensuring the illumination is suited to the specific tasks being carried out, which may evolve.

A growing body of research underlines this vital link between lighting and wellbeing. *"Lighting for People"*, a research paper that was produced as part of the European Union's programme for research and technological development, has drawn together a wealth of research to demonstrate just how important lighting is on human health and wellbeing.

For instance, Karin CHJ Smolders and Domien GM Beersma from the Department of Chronobiology at the University of Groningen in the Netherlands report that: "*Workplace lighting can, in addition to providing sufficient light to conduct work-related visual tasks, affect employees' alertness, mood, cognition, sleep-wake pattern and health.*"

However, this area of academic research is not a new phenomenon. As long ago as 1977, a study by Bennett, Chitlangia and Pangrekar demonstrated that when illuminance was increased, individuals took less time to carry out simple tasks such as map reading, probing needles and measuring the diameter of bolts. An adequately illuminated working environment can also enhance physical safety, particularly in hazardous industrial facilities where excellent visibility can reduce the likelihood of accidents involving heavy plant and machinery.

For all of these reasons, lighting replacement and upgrade projects should

# Industrial Lighting

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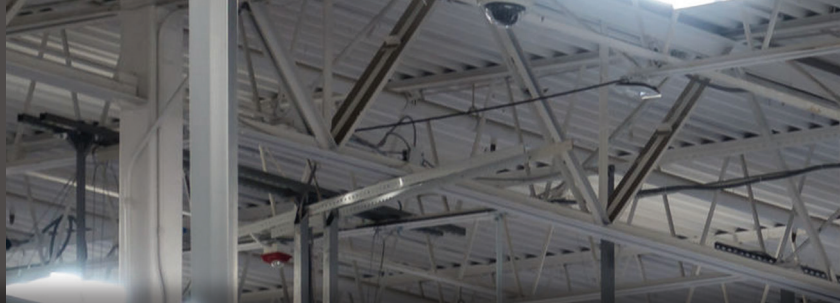

ideally prompt the establishment of stakeholder groups
or committees comprised of business and facilities leaders and staff, all of whom may have their perspectives on lighting requirements.

**ENERGY USAGE**

Energy efficiency today is a significant factor in the decision-making process for industrial, warehousing and manufacturing operations, as a result of rising energy costs, regulatory pressures and widespread expectations of environmental performance.

In extensive facilities such as factories and warehouses, lighting can consume as much as 50% of the total electricity bill, so it's unsurprisingly a prime target for efficiency savings. Where lighting systems are 15 to 20 years old, the adoption of newer technology can bring the running cost of lights down by 50% or more.

This is one of the significant reasons why LED lighting has risen the purchasing agenda in recent years. Once considered a premium product carrying a prohibitive upfront cost, LED luminaires are becoming more prevalent by the day thanks to advances in affordability and availability.
The appeal of LED lighting lies in its highly efficient ability to generate more light per unit of electricity than almost any other available technology.

In terms of their lifespan, they last up to 50 times longer than
a conventional incandescent lamp and around five times longer than a compact fluorescent energy-saving light bulb.3 For busy industrial applications, the reduced regularity, cost and disruption of maintaining lighting is a considerable advantage.

High-brightness LEDs are relatively expensive to produce because of the precise production techniques involved in the manufacturing process. However, the comparatively higher initial outlay must be weighed against the total cost of ownership, which is typically much lower than conventional lighting because of the inherent energy savings and reduced requirement for maintenance and replacement bulbs. In many cases, the payback period can be remarkably short.

Again, this is dependent upon the purchase of adequately engineered LED lights used in luminaires that are designed and built specifically for the purpose.

Having considered both the role of lighting in the workplace and its contribution to capital costs and overheads, let us now look at some of the specific considerations that apply to the selection process.

## SELECTION PROCESS

**PERFORMANCE CRITERIA**

We have reached a point of maturity with quality purpose-built LED luminaires where the performance is now often well more than 120 luminaire lumens per circuit watt (Ll/cW). It is important to note, however, that, in comparing performance criteria, the Ll/cW figure must refer to the output of the fitting rather than just the LED source. Certain aspects of the fitting can affect the efficiency of the LED, so buyers need full knowledge. Furthermore, the stated operating wattage must be the actual operating wattage of the luminaire. Scrutiny of both figures will help ensure accurate payback calculations.

The practical life of the LED luminaire can be up to five times longer than fluorescent and HID alternatives. Like all light sources, an LED source will gradually fade over some time but, crucially, this decline is far slower than for other forms of lighting. This is an essential consideration for industrial facilities that need consistent and reliable lighting without the disruption of regular maintenance work and compact fluorescent lamp replacement procedures.

A lighting device is considered to have failed at the point in time when the lumen value has depreciated to 70% of the initial lumen value. This is similar to the approach taken with conventional discharge lamps.
Therefore, the 'practical life' is defined as the period between the LED first being activated and the point at which its output falls below 70% of its initial output. This is symbolised by the letter 'L' so, to give an example, a quoted specification might look like the following: 'L70, 50,000 hours' or' 50,000 to L70'.

Although this standard is usually sufficient for conventional light sources, which are typically directly replaceable, some additional clarity is required when determining the expected lifespan of LED lamps or luminaires with non-replaceable LEDs.

For this reason, a further metric was added to the equation. The letter 'B' is used to denote the percentage of the sample batch, which are no longer producing 70% or more of the initial output after the specified period.

In other words, B is the proportion that has fallen below the required performance level or failed. Taken together, the metric

quoted might be 'L70B10 50,000 hours,' which means that 90% of the batch is still performing at a minimum of 70 of the lumen value after 50,000 hours. To provide even more detail, a manufacturer can additionally quote figures for different timespans, for example, 'L70B10 50,000 hours' and 'L70B5 42,000 hours.'

Over time, the metric of 'L80' is expected to be introduced to provide a simplified parameter for the performance criteria of a luminaire.

**A CLOSE-UP INSPECTION**

Testing an LED for an expected lifespan of 50,000 hours would take 5.7 years and is therefore impractical. Usually, figures are extrapolated from a testing period of 6,000 hours during which measurements are taken. Specialist photometric laboratory equipment is necessary for accurate measurement.

Furthermore, it is essential to remember that numerous factors can influence the lifespan of LED lighting, including operating conditions such as humidity and heat, and the incorporation of heat sinking or ventilation to reduce the build-up of heat at the LED junction.

The Lighting Industry Association acknowledges in its Guide to LED Lighting the difficulties that buyers may face when deciding between products: *"Like all products, there are good ones and bad ones. As technology develops, many more companies are offering LED products for sale, and there are plenty of rogue claims being made for the performance of poor quality products. Always look to buy from a reputable manufacturer and look for evidence that authority or a third party have verified the performance. Buying poor quality LEDs is a false economy. We would recommend looking at the light output rather than the wattage to judge the lamp."*

By looking at the lumen performance of the LED luminaire and not just its wattage, the specifier will be able to compare the actual performance of the LED luminaire against a conventional lamped luminaire. This will identify the benefits of reduced energy consumption for a real application while retaining the correct illumination level and quality.

A reputable manufacturer should be able to provide a set of information that includes the lumen distribution and lumen performance of the complete luminaire, not just the LED.

This information should also specify the life of the LED or luminaire, the ambient temperature range that the luminaire is designed to operate in, the initial colour temperature and colour rendering (Ra), along with the colour tolerance in terms of the numbers of steps off the Macadam's ellipse.

In the latter category, a quality LED will typically be three to four steps for commercial and domestic applications, whereas, for industrial applications, a wider tolerance will usually be acceptable. The product data should also indicate any colour shift through the life of the LED. It is vital to consider the specific demands of different industrial applications, which can range from blast furnace facilities to clean rooms in which close examination of tiny electronic components is essential. Each of these environments comes with its unique requirements and challenges.

**TAILORED TO THE TASK**

First and foremost, the lighting scheme must be appropriate to the tasks being conducted in a given space. It is important to note here that this could vary in separate areas of a site. An automotive production line, for example, might involve heavy-duty metalwork at one end and precision spray painting at another. While the former might require robust high-bay luminaires to provide even and efficient distribution of light on the floor to ensure the utmost safety, the latter may demand advanced task lighting that enhances workers' ability to conduct a close-up inspection of small details.

Without the provision of lighting that is aligned to the particular task being undertaken, employees may not be able to fulfil their duties as quickly, accurately or safely as they would like. Bearing in mind the pressures mentioned earlier, in terms of maximising productivity, retaining competitive advantage, achieving efficiency and delivering quality end-products to customers, the marginal disadvantages of inappropriate lighting could escalate into a significant setback.

**COLOUR RENDERING**

Lighting can have a considerable impact on how humans perceive colours. A surface that looks to be brilliant white under one light may have a yellow tinge under another light. In many circumstances, this does not present an issue, but in some applications, the accurate perception of colours can be crucial. In electronics, for example, a close examination of tiny electronic components is inherent in the quality assurance process. The same is often true in particular pharmaceutical, laboratory, printing, painting and food manufacturing

# Industrial Lighting

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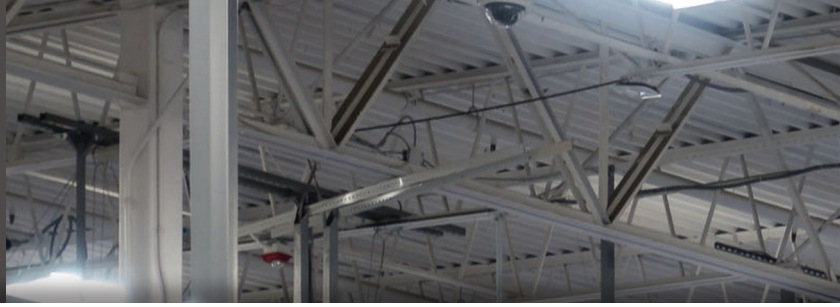

environments. The paint finishing process in automotive plants, for example, relies upon extremely accurate colour matching.

A luminaire's ability to display coloured objects in their actual colour is assessed in terms of colour rendering, which is measured in the context of a colour rendering index (CRI) based on RA units. Accepted practice, formalised by the EN12464-1 standard, is that a level of RA80 should be delivered in permanently occupied workspaces. This is generally the level that should be expected in offices and standard factory environments. In warehouses that are not permanently occupied, a level of RA60 is broadly acceptable. At the other end of the spectrum, where accurate representation of colour is crucial, a level of RA90 is recommended.

While metal halide lamps have shown to perform at a level of between RA40 and RA60, SON lamps are typically measured at around RA30. LED luminaires, which generally deliver superior quality of light, perform more consistently in terms of colour rendering, as well as colour temperature.

**CLEANLINESS AND HYGIENE**

In sectors where regular and thorough cleaning is essential to regulatory compliance and quality assurance, a luminaires' ability to withstand washing procedures is another important consideration. There are many areas where this applies, including food and beverage manufacturing. In these cases, it is not just the front panel of the luminaire that must be washable but any exposed fittings. A general rule is that there must be no horizontal ledges where dirt could build up.

In the electronics industry, where designated clean rooms are prevalent, the elimination of dust is critically essential. Standards are applied that specify the maximum amount of dust particles that can exist in the space, measured in microns per cubic metre. From a lighting perspective, the most crucial characteristic of a luminaire is that it is tightly sealed to ensure no such particles could escape from within.

The general rule for hygiene is that the selected luminaires must be able to accommodate the cleaning regimes that are applied in a given environment. These regimes could range from wipe- clean procedures to jet washing. In the latter case, the ingress protection offered by a luminaire becomes a key consideration in the selection process.

Ingress protection is measured in terms of IP rating, as defined by the international standard IEC 60529. The IP rating is comprised of two figures, the first of which refers to protection against solids and the second of which relates to protection against liquids. In the first category, 6 denotes complete protection against the ingress of dust.

This is an essential specification in many industrial applications, such as woodworking, where high volumes of dust could potentially find their way into the body of a luminaire that is not sufficiently protected, thus interfering with its regular operation.

In the second category, a rating of 5 denotes protection against water jets, 6 indicates protection against powerful water jets, 7 enables submersion up to 1m and 8 enables submersion beyond 1m.

In some applications, a rating of IP65 may be acceptable, while applications with rigorous cleaning regimes that involve jet washing might seek a rating of IP66 or higher.

**A MEASURE OF STRENGTH**

Industrial operations are often characterised by harsh conditions, which require luminaires that are robust enough to withstand environmental factors and impacts. Alongside the IP rating of a luminaire, buyers should also consider the IK rating, which denotes impact protection.

In the manufacture of construction materials, for example, where debris or forklift vehicles could come into contact with luminaires, the luminaires must have some degree of resistance to the impact. One factor that enters this equation is the likely height at which the lighting will be positioned. Luminaires that are close to the workspace, such as task lighting, are more likely to be struck with an object than their high-bay counterparts.

Impact protection is not only a concern in rough or heavy industrial workplaces but also in others such as food manufacturing, where any breakage that causes loose debris could create a risk of contamination. The glass used in conventional lamps has been a particular concern for the food industry since glass cannot be detected by the x-ray equipment that may be used to identify contaminants in the end product.

This is one significant benefit of installing LED luminaires, which do not contain glass but are nevertheless protected by a polycarbonate front plate. Another consideration in some applications might be the presence of corrosive substances

such as fatty acids, which may damage plastic parts of luminaires. Again, the particular specifications of the plastic used within the luminaire should be closely interrogated during the selection process.

**EXTREMES OF TEMPERATURE**

Ambient temperatures in industrial and manufacturing buildings can vary wildly from freezing temperatures in cold stores to extremely high temperatures in boiler rooms or furnaces. Selecting a luminaire that will withstand such extremes is essential. One of the characteristics of LED lamps is that they emit far less heat into the working space than their incandescent counterparts. The reduced heat they generate (approximately half that of HID lamps) is generally dissipated through the back of the unit.

As a result, LED luminaires are well suited to cold storage rooms, where conventional lamps may raise the ambient temperature to a point where refrigeration equipment must work harder to maintain a sufficiently low temperature.

Another unique benefit of LEDs is their ability to switch on instantly, even in cold environments. Unlike conventional lamps, which can take up to several minutes to reach full luminance, LEDs do not need much time and may, therefore, act as an aid to productive working.

In cold store applications, the energy efficiency of LED luminaires can be dramatically enhanced with the addition of automated presence control, whereby passive infra-red (PIR) sensors may be deployed to detect movement and activate light sources accordingly.

In general terms, a standard ambient temperature of 25°c is used by reputable manufacturers as a basis for testing and any small and temporary fluctuations above that, in the summer for example, can usually be accommodated. However, hot environments, such as those found in the ceramics and metalwork industries, can adversely affect the lifespan, output and energy efficiency of LED luminaires.

# Industrial Lighting

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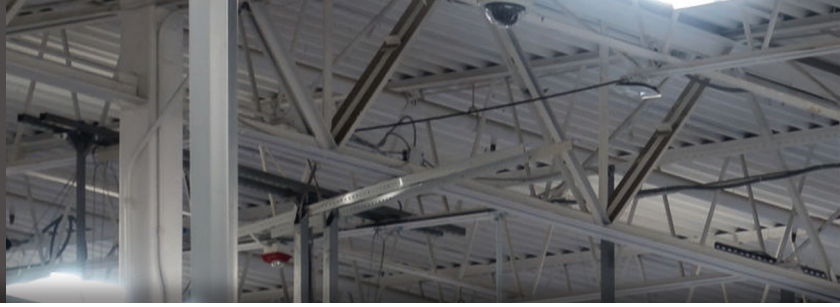


Careful consideration of the luminaire's specifications may be required in such circumstances and particular attention paid to the thermal management capabilities of the unit.

**TAKING CONTROL**

As we have already established, energy efficiency remains high on the agenda of those responsible for the running of industrial buildings. Often in industrial and warehouse applications, workspaces are illuminated with background light due to the area being unoccupied for periods.

By adding switching or dimming controls, it allows these unoccupied spaces to be switched off or down to a lower background level of illumination, allowing even more significant savings. The actual level of savings is dependent on the individual building and operating procedures but can add significantly to the overall energy savings with no adverse effect on either safety or productivity.

Therefore, the introduction of LED luminaires to replace old incandescent lamps can dramatically reduce monthly energy bills, but further efficiencies are possible with the use of control systems. Indeed, an industrial organisation's ability to meet increasingly strict sustainability regulations might depend to some extent on the use of controls to maximise the efficiency of lighting.

The practice of manually switching lighting on and off is becoming increasingly anachronistic with the growing use of control systems that can activate and de-activate lighting automatically in response to specific inputs.

Presence detection is one crucial area of control. Occupancy sensors send a signal to activate lighting when a person enters a space and switch off the light when the area is empty.

There are two main types of detection technology, the most common of which are passive infra-red (PIR) sensors. These have distinctive detection patterns that must be taken into account when deciding on the location and direction of the installed sensors. The second category is microwave movement sensors, which emit a continuous wave of microwave radiation that is disrupted by movement.

Again, the mounting of these sensors during installation is of paramount importance in ensuring accurate detection and minimising nuisance activations. Light levels can also be subject to controls. In this case, the control system, using photocells, can detect changes in daylight and activate artificial lighting accordingly. This is common in outdoor areas but increasingly used indoors too as part of a technique known as daylight balancing. The advantage is not only that costs can be reduced, but the provision of natural daylight can make an essential contribution to health and wellbeing, as described earlier in this white paper.

A note of caution here is that controls in industrial environments must be applied with care, and due consideration must be given to the tasks, equipment and risks that may exist within a given space. For example, an operator of moving or dangerous equipment could potentially be plunged into darkness or dimmed light if the control system has not detected human movement. Similarly, the inspection of a plant room may involve extended periods of stillness, during which the person carrying out the review could find themselves in darkness due to the control system. Both scenarios may place the respective staff members in danger.

It is no coincidence that controls have risen in popularity alongside LED since these luminaires are dynamic enough to enable frequent on-off switching without adversely affecting their lifespan and will provide full illumination immediately, rather than taking time to warm up and cool down.

Like many traditional light sources, LEDs can be dimmed, if paired with a suitable control mechanism and dimming driver. Dimming technologies, which usually fall under the definition of DALI (digital addressable lighting interface) enable control of light levels. Still, any assumption that dimmed lights save energy is incorrect due to the counter-intuitive relationship between dimming and energy usage.

Depending on the specification of the LED driver, the energy used by a dimmed light may be higher than when it is producing full output. One area of development sees real-time control of how a workspace is illuminated handed to the individual within that space. Personal preferences can differ, and it is now possible to enable individual lighting control via web connectivity and associated protocols.

**HAZARDOUS ENVIRONMENTS**

In hazardous industrial environments, ATEX compliance becomes the primary concern, and this applies as much to

lighting as any other equipment. Buyers may want to consider explosion-proof luminaires, depending on whether the risk profile of the space classifies it as zone zero, one or two.

These considerations apply not only in industries that are generally considered as hazardous, including chemical processing and power generation but even in sectors such as food manufacturing, where particles of flour or coffee in the air could be highly flammable if ignited.

In these cases, specialist advice should be sought from an established lighting supplier with the necessary certifications and experience.

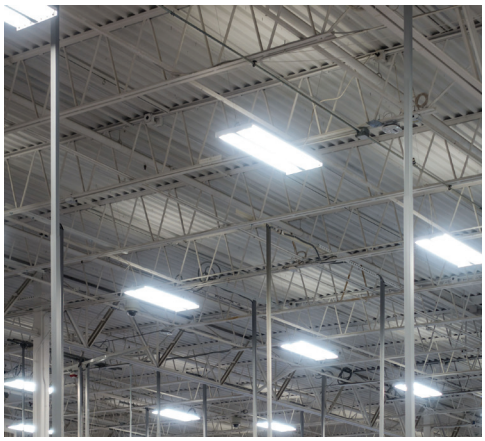
## CONCLUSION

In summary, industrial buildings stand to benefit significantly from a close evaluation of their lighting needs and a detail-orientated investigation of the available options. In doing so, those responsible for such buildings can ensure their lighting schemes optimise productivity, comfort, safety and energy efficiency.

However, to achieve these goals, it is essential to scrutinise product specifications and give due consideration to the specific application needs of varying industrial environments.

When selecting a luminaire, specifiers and buyers must examine factors such as light output and distribution, colour rendering, resilience, suitability for cleaning, ability to cope with temperature variations, controls and protection against explosion. wn

*White Paper courtesy of Eaton.*



# Measuring colour uniformity

The colour uniformity of light generated by LED luminaires plays a significant role in many lighting applications. This makes it an important parameter to measure in both the R&D stage and during the quality assurance process. MKS Instruments has stayed abreast of this challenge by developing a new feature for its FluxGage photometrical system: the colour uniformity measurement function. It allows quick evaluation of optical assemblies for colour mixing and beam shaping. This whitepaper presents this novel feature of the system.

**BY I** EFI ROTEM, DANIEL SEBBAG, ASSAF HALEVY, SIMON RANKEL

## THE TECHNOLOGY

What makes the FluxGage system (for a detailed introduction, see [1]) unique is its use of solar panels that are covered with a very finely perforated black layer (see Fig. 1). These diffusive pinholes create the effect of hundreds of radiometers surrounding a light source. In the FluxGage system, all these 'radiometers' are electrically connected, so the data obtained are not angularly resolved but measure the total flux, so far-field conditions are not required. This makes the FluxGage a very compact instrument for measuring total luminous flux – smaller than an integrating sphere, and certainly much smaller than a goniophotometer.

In addition to the radiometer array, a spectrometer senses the spectrum of the DUT (device under test), which is used for calculating colour parameters such as CCT, CRI, TM30, etc. A fast photodiode is used to measure flicker.

The spectrum is also used in calculating the total flux for correcting the non-photopic spectral response of the solar

panels according to Equation (1), where: R(λ) is the responsivity of the solar panels (including the pinholes) in [A/W·nm]; Φe(λ) is the spectral flux of the DUT in [W/nm]; S(λ) is the normalised measured spectrum; and V(λ) is the photopic function [1].

$$(1)\ \Phi_v = \int \Phi_e(\lambda)V(\lambda)d\lambda = I\frac{\int S(\lambda)V(\lambda)d\lambda}{\int R(\lambda)S(\lambda)d\lambda}$$

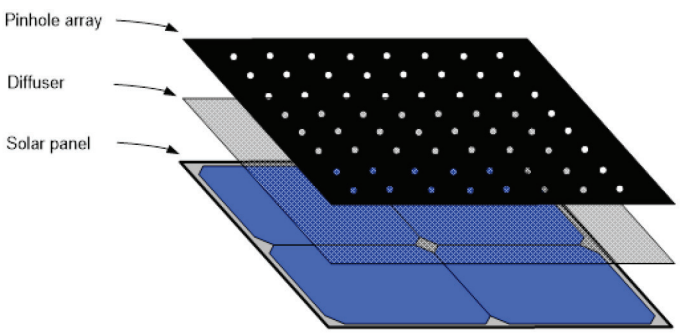



*Figure 1: Absorber structure*

# Measuring Colour Uniformity

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Because the spectrum is measured at only one position, it is not averaged as with an integrating sphere, and the above calculation assumes the DUT emits uniform spectra in all directions. While this assumption is justified when measuring luminaires that are well colour- mixed [2], it may be inaccurate for measuring bare LEDs, for example.

The latest enhancement of the FluxGage integrates smart colour sensors into the system: The AS7261 spectral sensing engine from AMS [3] is a tristimulus XYZ+NIR (near-infrared) sensor device that relies on silicon interference filters to accurately reproduce the tristimulus spectral functions. Built into the bottom of the device, the four AS7261 sensors serve several purposes:

- Adding four extra measurement points for colour, thus improving the accuracy.
- Measuring colour uniformity: Since the colour is sampled in five positions, this addition is useful for measuring colour-mixed luminaires – information that is not available when using an integrating sphere.
- Measuring illuminance at several areas from below the DUT. While the measurement is done in the near field and therefore not useful for obtaining precise angular data, it can be used in production testing.

## COLOUR UNIFORMITY MEASUREMENT

### INSTRUMENT GEOMETRY

An image of the FluxGage system is presented in Figure 2. The solar panel absorbers on the inside walls define the measurement cavity. The small, white baffle in the centre indicates the position of an optical fibre placed behind a diffuser;

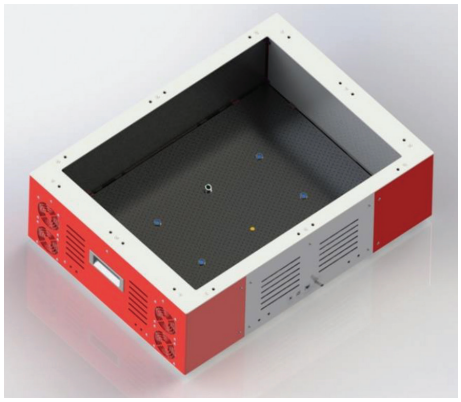

*Figure 2: The FluxGage system*

it guides light to a spectrometer that is mounted inside the system. The small orange dot indicates the position of a photodiode that is used to measure the light's temporal characteristics, i.e., flicker. The four blue circles indicate the position of four diffusers that are positioned above the AS7261 colour sensors.

In this configuration, the diffusers provide a cosine corrected angular sensitivity for each of the colour sensors, and a metal ring slightly limits the field of view of each sensor. By making the metal rings taller, the field of view of the colour sensors can be limited to a defined area directly above them.

### SOFTWARE INTEGRATION

The FluxGage's dedicated software has been upgraded to support the new colour-sensing functions. Now it also displays – in real-time – colourimetric parameters like CCT, Duv and the colour coordinates of each sensor.

The software development kit (SDK) was further updated to include colour data for seamless integration into existing projects and automation.

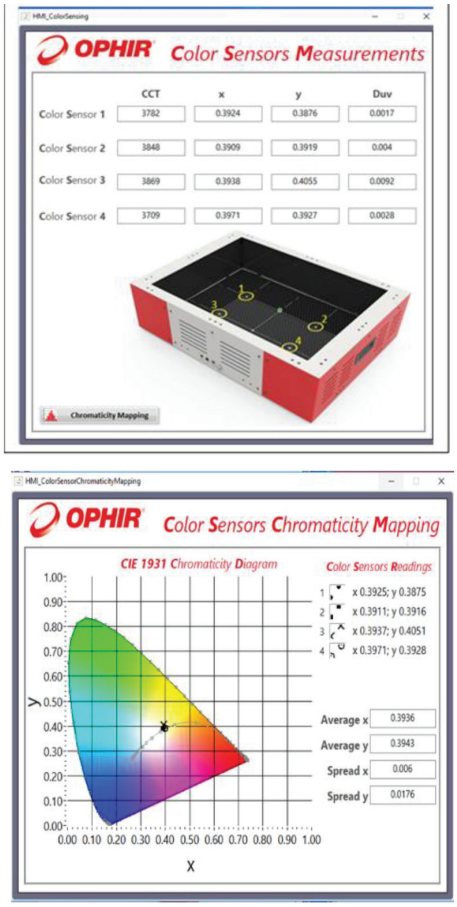


*Figure 3: Colour coordinates real-time measurements.*

## CALIBRATION

All AS2761 sensors come factory pre-calibrated; that means a calibration matrix is already stored in each sensor. This matrix is used to translate the raw signal from the sensor's independent channels into calibrated XYZ tristimulus values, from which colour parameters such as CCT and Duv can be calculated. Since the colour sensors are placed below the PTFE diffuser and the glass plate that cover the photovoltaic cells (see Figure 1), a two-step in-situ calibration process is needed to improve their performance. In the first step, three thermally stabilized LED sources (CCTs of 2,700K, 4,000K, and 5,600K)

are placed above the FluxGage's calibrated spectrometer port and measured precisely. From the XYZ tristimulus values read for each LED source, a reference matrix M is built:

$$M = \begin{pmatrix} X_{2700K} & X_{4000K} & X_{5600K} \\ Y_{2700K} & Y_{4000K} & Y_{5600K} \\ Z_{2700K} & Z_{4000K} & Z_{5600K} \end{pmatrix},$$

In a second step, the LED sources are placed, one after another, above each one of the sensors. From the tristimulus signals measured by the colour sensors, we build a sensor response matrix R:

$$R = \begin{pmatrix} X_{2700K} & X_{4000K} & X_{5600K} \\ Y_{2700K} & Y_{4000K} & Y_{5600K} \\ Z_{2700K} & Z_{4000K} & Z_{5600K} \end{pmatrix}$$

The correction matrix C, which satisfies:

$M=C^*R,$

is calculated via

$C=M^*R^{(-1)}$

The correction matrix is calculated for each sensor and then saved in the sensor's internal memory. If we measure the three calibrations LED sources with each sensor after calibration, we can evaluate the residual error introduced by noise during the calibration.

## EXPERIMENTAL RESULTS AND VALIDATION

### VALIDATION

An Ophir FGC100 FluxGage calibration LED source was used to verify the validity of the calibration. The Ophir FGC100 is a stabilized, broad-spectrum, white-light LED with a CCT of 3,770 K; it is spectrally uniform in its angular distribution, meaning

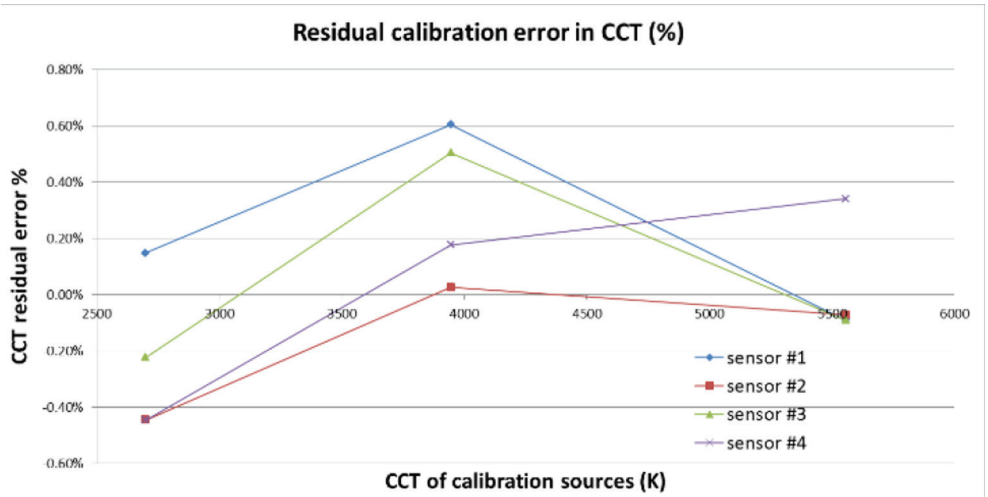


*Figure 4 presents the residual error in CCT for each sensor; it shows the residual error in CCT (K) is ±0.6% for the three tested CCTs of 2,700K, 4,000K and 5,600K.*

| | SPECTRO-METER | COLOUR S.#1 | COLOUR S. #2 | COLOUR S. #3 | COLOUR S #4 |
|---|---|---|---|---|---|
| CCT (K) | 3775 | 3790 | 3762 | 3774 | 3755 |
| CCT error (%) | 0 | 0.40% | -0.35% | -0.03% | -0.53% |

*Table 1. Validating the colour sensor calibration*

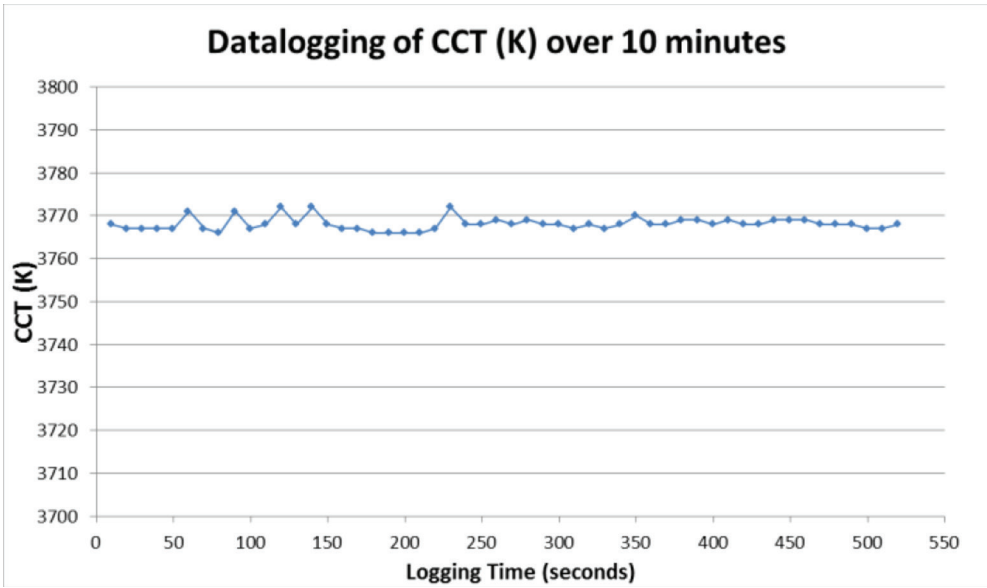


*Figure 5. CCT datalogging over a 10-minute time span.*

# Measuring Colour Uniformity

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that it emits the same spectrum in all directions. The FGC100 is first positioned over the FluxGage's spectrometer, and its spectrum and CCT are recorded.

In the next step, we place the FGC100 precisely over each colour sensor and record the XYZ and CCT values. The results are shown in Table 1

### THE PRECISION OF THE COLOUR SENSOR'S MEASUREMENT

To assess the colour sensor's repeatability and short-term noise effects, an Ophir FGC100 stabilized LED source with a CCT of 3,768 K is placed over colour sensor # 4 and measured every 10 seconds over a time of 10 minutes. The FluxGage software's data logging function is used to record the data.

The average CCT is found to be 3,768K ±0.04% (one standard deviation). The precision of the colour sensor can be defined as ±0.08% at a k=2 (95%) confidence level.

### DYNAMIC RANGE

In addition to measuring colourimetric parameters, the FluxGage colour sensors can also be calibrated for measuring illuminance - providing illuminance measurements at five different points under the tested luminaire. Each sensor is thus effectively an independent photometer integrated into the FluxGage.

The illuminance data can be used to understand and validate the angular distribution of the luminaire. The RGB sensors embedded into the FluxGage system have adjustable gain and integration time, which allows for a broad dynamic range: 140lux-5Mlux.

## CONCLUSIONS

The latest addition of smart tristimulus colour sensors to the FluxGage boosts the measurement system's capabilities. It makes it ideal for fast testing, both in the R&D stage and for quality control testing in a production environment.

Total flux, colour parameters, flicker, illuminance and colour uniformity, can now be accurately measured with a single system. The colour distribution of LED assemblies and luminaires are quickly evaluated with the FluxGage. Also, this new colour-sensor functionality enables useful comparison of the colour- mixing performance of LED lenses, reflectors, diffusers and homogenizers, among others. This allows the optics that provides the best colour uniformity to be selected for particular applications.

In-house calibration provides high accuracy (±0.6% in CCT) and high repeatability (±0.1%) in the 2,700K – 5,600K range for colour measurements, as well as an extended dynamic range for illuminance measurements.

An intuitive user interface makes it possible to use the stored results for analysis – quickly and automatically if desired.

With this enhanced capability offered by the system, users can additionally gain a fast understanding of the angular properties of the light and the colour-mixing performance of the measured luminaires. wn

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[1] Efi Rotem, Raphael Cohen, Shimon Elstein, Daniel Sebbag, Ephraim Greenfield. "FluxGage: A Photometric Test System for LED Luminaires Based on Solar Panels," Proceedings of LED Professional Symposium 2016, Bregenz, Austria.

[2] "Accuracy Validation of FluxGage," White Paper, https://www.ophiropt.com/led/white-paper-articles

[3] https://ams.com/as7261

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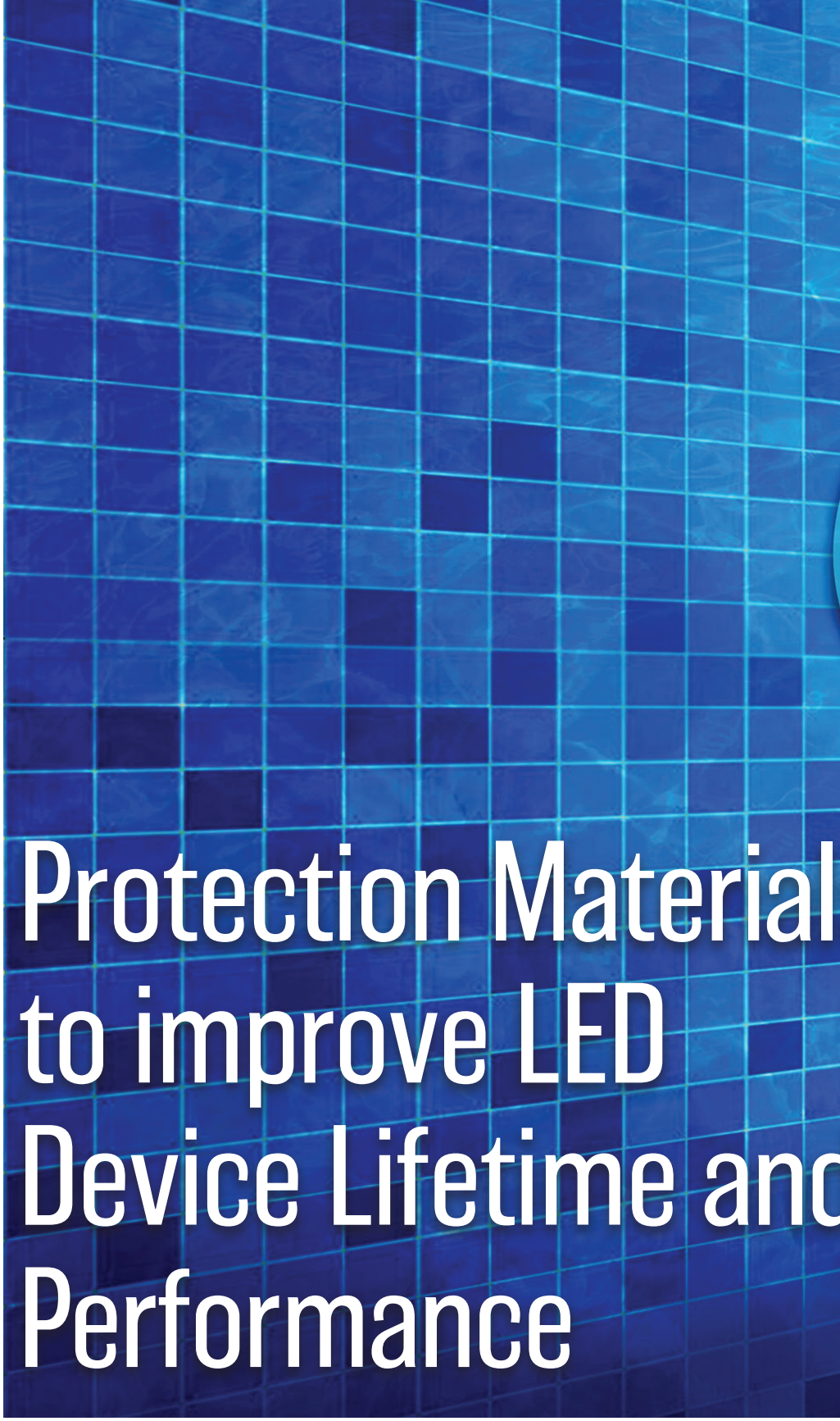

# Protection Material to improve LED Device Lifetime and Performance

With the rapid growth of the Light Emitting Diode (LED) market, correct product selection is imperative to ensure LED performance and lifetime. Jade Bridges, Electrolube's Global Technical Support Manager, will highlight the use of LEDs in various environments and introduce how to specify appropriate protection under such conditions.

**BY** | JADE BRIDGES
GLOBAL TECHNICAL SUPPORT MANAGER, ELECTROLUBE

LED applications are becoming increasingly more diverse; design requirements, location or the function of the product are all elements that prove the challenges that face LED designers are continually evolving. LEDs, like most electronic devices, will perform well until external influences start to deteriorate performance. Such impacts can include the electrostatic attraction of dust, humid or corrosive environments, chemical or gaseous contamination, as well as many other possibilities. It is therefore

imperative that the end-use environment is considered in detail to ensure the correct products can be chosen.

The LED lighting market is expected to grow into a $70 billion industry by 2020, taking a 70% market share in just five years (Forbes). This growth is attributed to the advantages LEDs offer over traditional lighting forms in terms of adaptability, lifetime and efficiency. It is therefore easy to understand why LED lighting is being used in a vast array of applications including domestic lamps, industrial lighting for factories, lighting for marine environments, architectural lighting and designs, to name just a few.

# LED Device Lifetime

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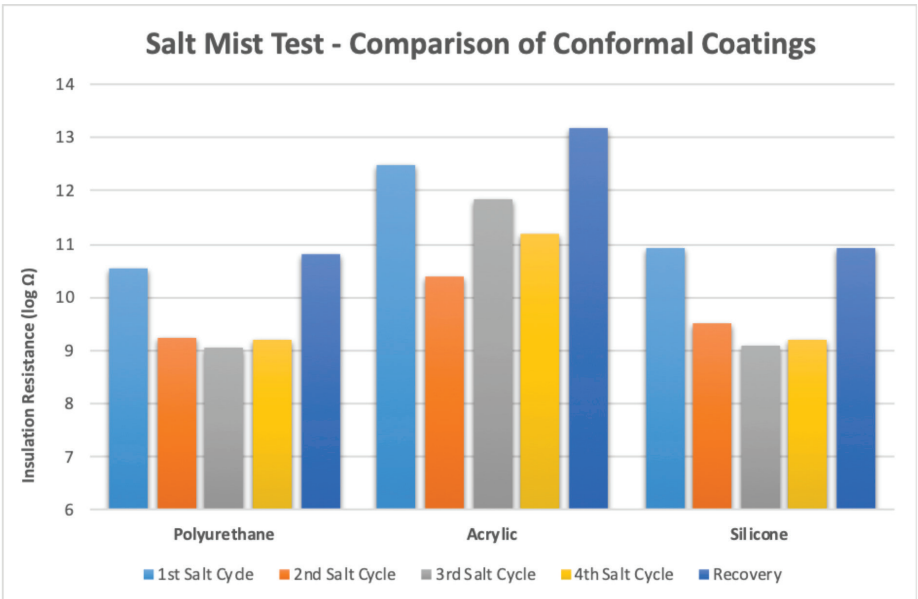



*Graph 1 – Comparison of conformal coating performance in a salt mist environment*

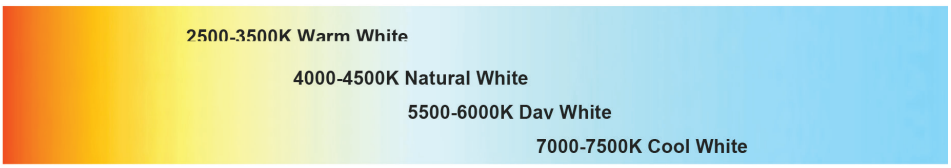



*Image 1 – Typical Colour Temperature Bands for LEDs*

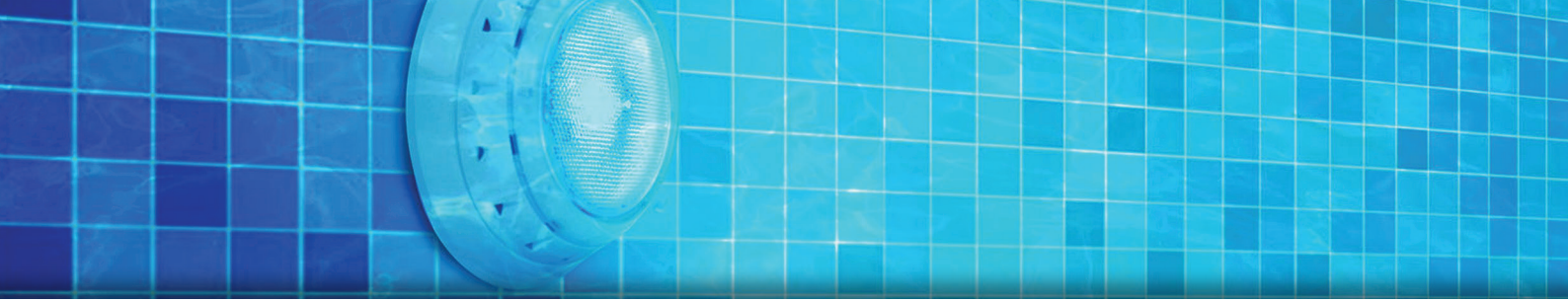
Comparing the environmental conditions in a standard architectural lighting application with that of a marine environment can help us to understand the potential causes of LED deterioration.

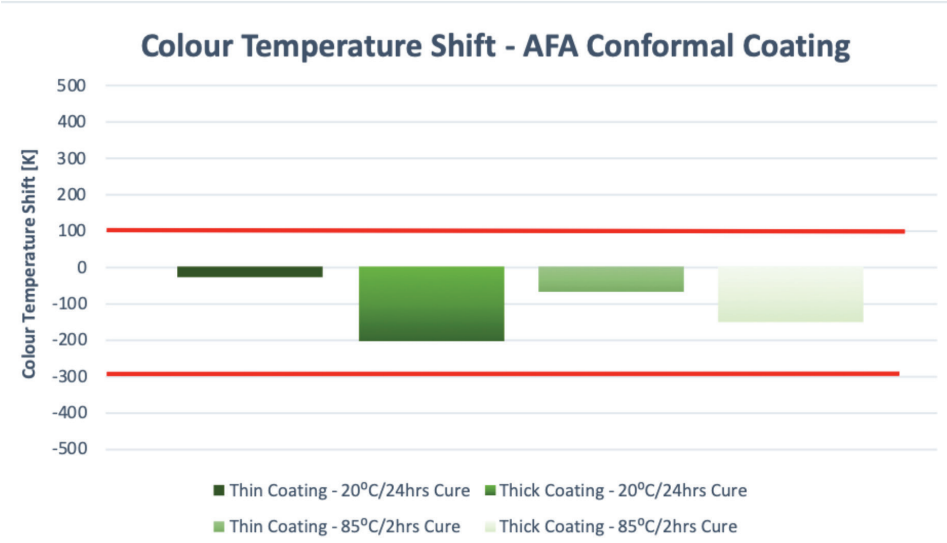
In an architectural lighting application, it is possible that the LED itself is covered due to the design of the unit, or that the orientation of the LED is such that it is only likely to be exposed to global changes in ambient temperature and humidity. In a marine environment, an LED light may be splashed or immersed in saltwater and all cases, it will be in a salt mist environment for the majority of its operating life. Conditions with high salt can cause corrosion on Printed Circuit Boards (PCBs) and thus dramatically reduce performance much faster than general conditions of varying humidity. Typically, conformal coatings and encapsulation resins are used to offer a high level of protection in each of these environments.

Conformal coatings are thin lacquers which conform to the contours of a PCB, allowing proper protection without adding any significant weight or volume to the board. They are typically applied at 25-75 microns and are easy to apply by spraying or dipping techniques. For protecting over the top of LEDs, it is crucial that the coating used has excellent clarity and that it remains evident throughout the lifetime of the product in the desired environment, i.e. the coating may be required to have superior Ultra Voilet (UV) stability if the product is outdoors. Thus, the best type of conformal coatings is based on acrylic chemistry, offering both the clarity and colour stability combined with excellent humidity and salt mist protection.

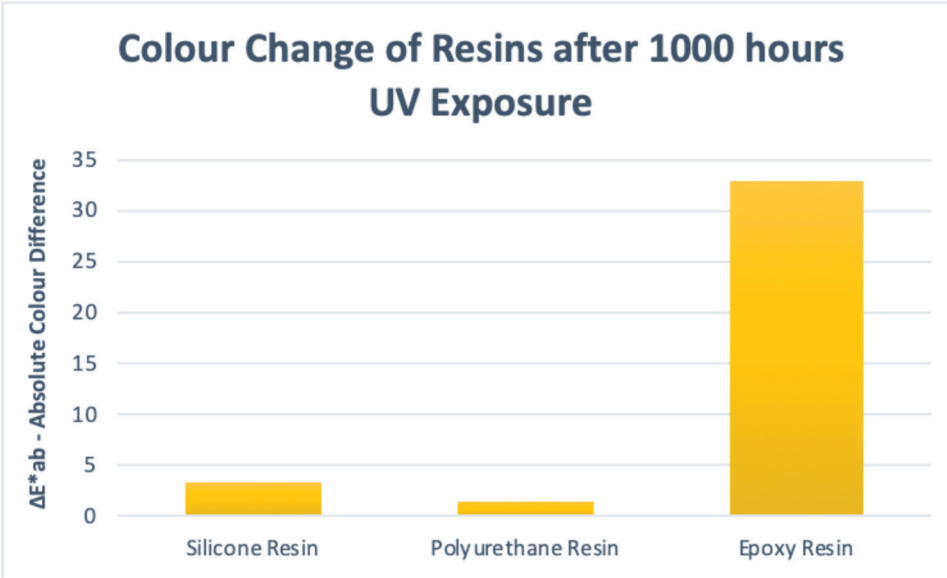
Typically, acrylic conformal coatings are solvent-based products, where the solvent used is a carrier fluid to allow a thin film of resin to be deposited on the substrate. The solutions used are classified as Volatile Organic Compounds (VOCs); as this solvent is only present on the LED for a few minutes during the application stage, it is not considered a long term issue for most systems. In some cases, LED manufacturers do have specific requirements regarding the use of products containing VOCs, as well as other particular chemicals, and these will be listed in the LED literature. In general, a chemical compatibility check will assist in confirming if a solvent-based conformal coating is suitable for use with the desired LED; conformal coating manufacturers such as Electrolube can help with such testing.

As well as considering the effect of the coating applied on the LED, it is also essential to understand the impact on colour temperature. Colour temperature shift has been an ongoing issue when considering the type of protection media to use and it is understood that no matter what material is placed directly over the LED, it will cause an interaction that leads to a colour temperature shift. This shift is typically from a warm temperature to a cooler temperature and will vary between different LED types and colour temperature bands. Also, it will differ depending on the protection material applied. This is another area where acrylic conformal coatings offer advantages over other chemistry and






*Graph 2 – Colour Temperature Shift Example – Electrolube AFA*




*Graph 3 – Comparison of standard resin chemistries after 1000 hours exposure to UV light*

product types. In Graph 2, the results of the colour temperature shift of a 'warm' light LED are provided. Different thicknesses and cure mechanisms have been utilised to highlight the possible changes in colour temperature.

The red lines indicate the boundaries of the particular type of LED used; i.e. the colour temperature could be anywhere between these lines when the LED is purchased.

The thin and thick coatings referred in Graph 2, represent the typical minimum and maximum thickness that conformal coatings are applied, i.e. 25 and 75 microns. By using such a thin film, the colour temperature shift is minimised and in turn, is manageable within the same boundaries given by the LED manufacturer (as indicated by the red lines on the graph). In an ideal world, conformal coatings would be applied to all LED applications due to their ease of application, minimal effect on volume and weight of the unit, versatility in use and finally, their effect on colour temperature shift.

As we all know, it is often not possible to have one solution for all applications, however. Conformal coatings offer an excellent level of protection in humid and salt mist environments, as shown above. However, they do not provide the highest level of protection in environments with frequent immersion in water, chemical splashes and also corrosive gas environments. It is in such situations that we advise the consideration of an encapsulation resin to offer the increased level of protection.

Encapsulation resins are also available in many different chemistry types, including epoxy, polyurethane and silicone options. Typically epoxy resins offer more robust protection in terms of mechanical influences. Still, they do not provide the flexibility of the other chemistries, which can lead to problems during thermal cycling, for example. Besides, standard epoxy systems do not offer the clarity and colour stability of other systems. Silicone resins do provide excellent clarity and also perform well in temperature extremes.

In contrast, polyurethane resins offer a combination of exceptional flexibility, transparency and a high level of protection in harsh environments. Graph 3 shows the difference in the clarity of the three resin chemistry types by examining the colour differences of the resins after 1000

# LED Device Lifetime

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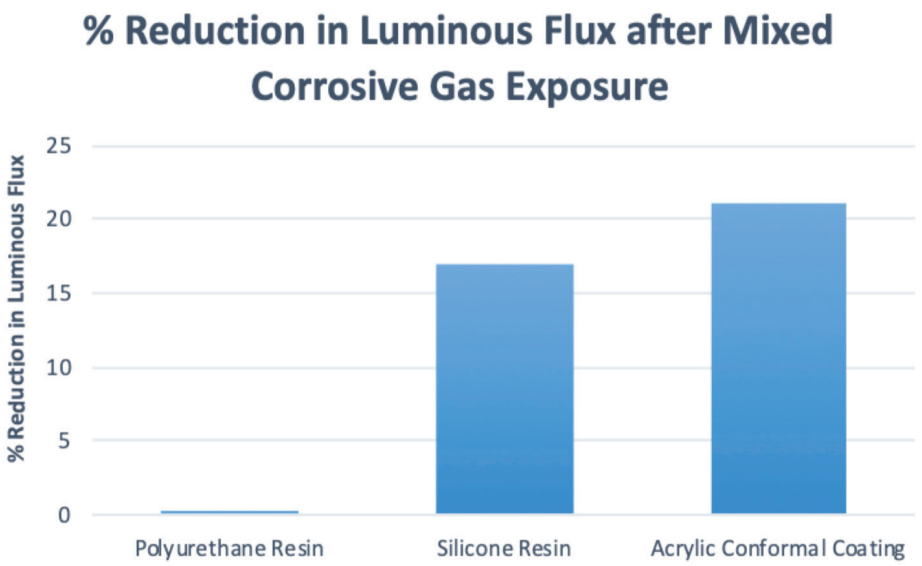
hours of UV exposure, thus highlighting the stability of each resin in outdoor conditions. The silicone and polyurethane resin outperform the standard epoxy system in this case.

Comparing the performance of various products in harsh environments can also highlight preferred product choice based on end-use conditions. For example, Graph 4 illustrates the effect of corrosive gas environments on an acrylic conformal coating, a polyurethane resin and a silicone resin by examining the % reduction in luminous flux of the LED after exposure to a mixed gas environment. These results clearly illustrate the importance of choosing the correct product for the environment. Although the conformal coating does not deteriorate in terms of its surface insulation resistance in a corrosive gas environment, it is not adequate protection for LEDs.

It allows the gas to pass through the thin coating and penetrate the LED, thus degrading its performance over time.

A similar effect is also seen with the silicone resin. However, in this case, despite the protection layer being considerably thicker (2mm vs 50 microns), the gas is still able to pass through the resin and affect the LED. When you compare the result of the silicone resin to the polyurethane material, it is evident that there is a difference in performance exhibited by these two chemistry types as the silicone resin is permeable to the gas. In contrast, the polyurethane resin at the same thickness is not. In such cases, an optically clear polyurethane resin, such as Electrolube UR5634, would be the most suitable protection media to prevent the corrosive gases from adversely affecting the LED.



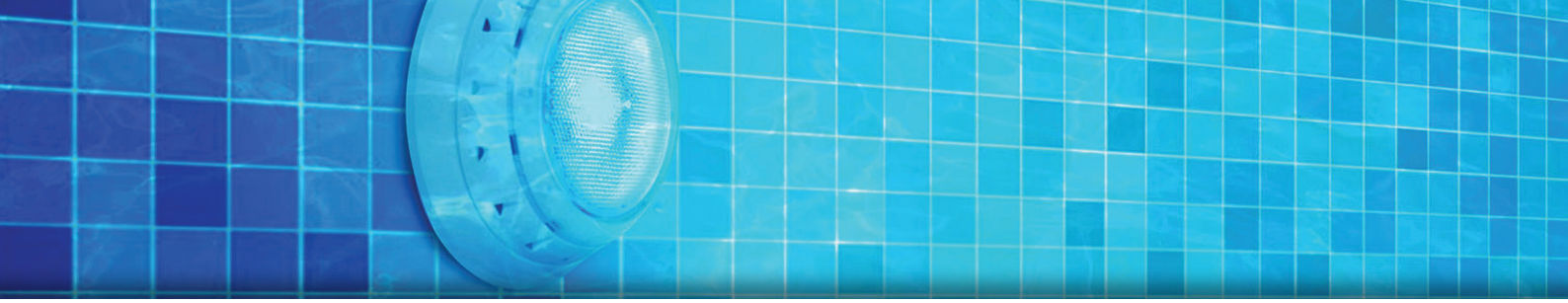

*Graph 4 – Change in luminous flux after exposure to mixed corrosive gas*

*Image 2 – L to R: Comparison of diffusing (UR5635) and clear (UR5634) polyurethane resins*

Polyurethane resins have been highlighted as suitable resins for the protection of LEDs in many different environments. Besides, they can also be adapted to offer additional benefits, such as pigmented systems used for covering the PCB up to, but not over, the LED.

Such resins are used for protection of the PCB, offering an aesthetically pleasing finish while adding to the performance of the luminaire by reflecting the light off the PCB and increasing light output. There are also specialist resins that can be used to diffuse the light from the LED. Resins such as Electrolube UR5635 can offer two solutions in one; protection from the surrounding environment and diffusion of light, potentially eliminating the need for diffuser covers and caps.

Encapsulation resins offer a high level of protection in a range of environments. They can be tailored to suit application requirements either by choice of chemistry



type or by adaption of the formulation of a particular resin. It is essential to return to the subject of colour temperature shift, however.

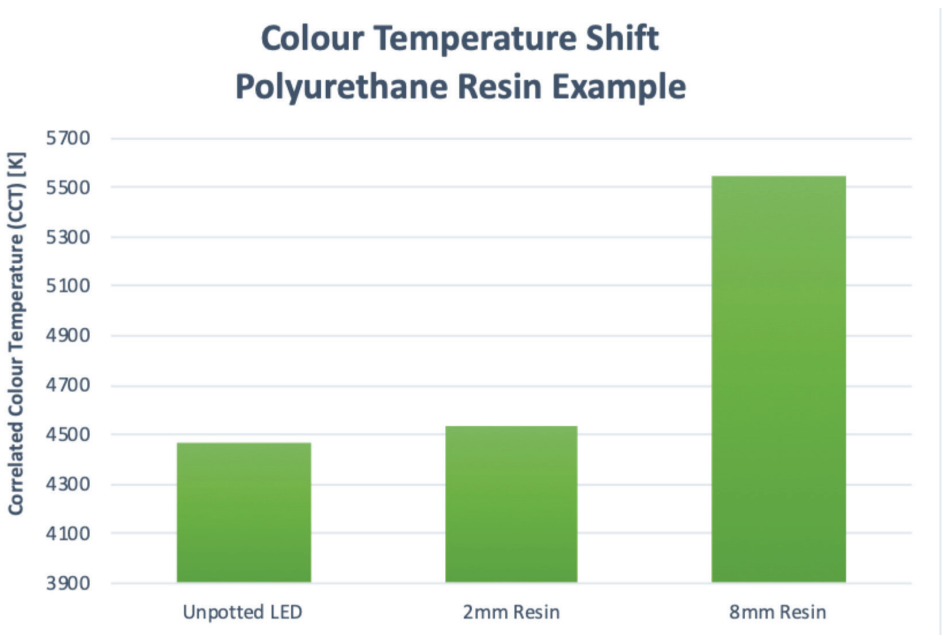
Earlier in this article, we discussed the minimal effect on colour temperature exhibited by thin-film conformal coatings. When comparing the thicknesses of conformal coating to encapsulation resins, it is evident that part of the increased level of protection that resins offer is due to the ability to apply a much thicker layer. Resins can be used at 1-2mm or much higher depths. However, this depth will also affect the level of colour temperature shift observed.

Graph 5 shows the typical colour temperature shift of LEDs covered with different thicknesses of polyurethane resin. It is clear that the thickness directly correlates to the degree of colour temperature shift, thus highlighting another vital consideration when choosing suitable protection media. We do know that colour temperature shift will occur, but the paramount factor is the repeatability of the change for the LED used. If the switch is consistent, the difference can be accounted for by re-considering the original LED colour temperature band, for example.

This article has discussed the various considerations required when choosing protection for an LED system. Evaluating the environment is essential to specify a product successfully, both in terms of end-use performance and suitability for production processes.

Conformal coatings offer the best combination of ease of application and incorporation into the design, with an excellent level of protection in humid and salt mist environments. They also exhibit the lowest effect on colour temperature due to the small thickness applied. When conditions become more challenging, the switch to encapsulation resins is advised. In this case, the choice between chemistry types will be dictated by the end-use conditions and particular environmental influences.

Also, the thickness of resin applied should be considered to ensure sufficient protection is achieved while minimising the effect on colour temperature shift where possible. By providing efficient heat dissipation and protection from external environments, the efficiency and lifetime of LED systems can be increased. LED systems can now also be used in a broader range of settings and by offering LED designers support through considered material development, Electrolube is continually providing support for this ever-evolving industry. wn




*Graph 5 – Effect of resin thickness on colour temperature shift*

# Some Reflection On Our Noble Institute

I find it hard to believe that I spent 12 years at SAIEE. It seems like yesterday that I was appointed as Business Director, and then as CEO when the SAIEE structure changed in 2011.

**BY** | STAN BRIDGENS | PR ENG | SAIEE PAST PRESIDENT

The first time I retired was in 2001, from City Power, after which I consulted privately for six years before joining the staff of the SAIEE in 2007. Now in 2019, I retired for the second time, and I look forward to the changes this will bring.

As I look back over my 60 years of employment, many things come to mind. Some good, others that should be forgotten. Events and situations as they relate to the Institute are put forward here with the desire of possibly influencing the new cohort of SAIEE Members charged with taking our noble Institute forward.

I had the honour of being the first Deputy President of SAIEE (after some 95 years of existence) when it was decided that a deputising function was essential to support the President in his official duties.

I was honoured to be congratulated as the first-ever Deputy President by doyens like Dr JDN van Wyk and Dr R B Anderson. The main reason for creating the position of Deputy President was to support and deputise for Presidents who hold positions in public, academic and local government entities. Official duties would be shared between the President and his Deputy. I deputised for President Derrick Plowden in 1997 and then enjoyed the invaluable support of Alf Schultze as Deputy President.

In 1998, after three years as an Office Bearer, when I was elected as President of the SAIEE the metamorphosis of the new South African democracy was in full swing, particularly in the Local Government sector. Albeit turbulent times coping with a flood of new legislation and procedures, I was privileged to meet and interact with the professionals and decision-makers.

I was not aware at the time that my Presidential reign and serving as Past President the next year would set me on the path for what was my second term of employment as CEO of the SAIEE.

My 12 years' service at the Institute has passed with the speed of light! This time was most enjoyable as it allowed me to remain in contact and associated with so many engineers that I had worked with over some 50 years.

I received a 50-year SAIEE Membership certificate in 2016. Now I look forward to the 60-year membership celebration in 2026 – if I am still around!

I believe I have learned a few things heading up a voluntary professional association, and perhaps there is value in sharing these with new members and those charged with leading.

This Institute has endured and survived for 110 years - surviving the changing political regimes, turbulent and violent times, recessions and upheavals. This has been, and still is, a voluntary association of engineers that has made and can still make meaningful contributions to the development of South Africa country.

I find myself asking:

- how has the Institute managed, and what has it done, to subsist and thrive for so long?
- what has been the key to this bond that requires effort from volunteers over-and-above regular employment and responsibilities?
- what have been the strategies adopted by the SAIEE to successfully ride the turbulence and radical changes that South Africa is so famous/infamous for worldwide?
- what has been the magic glue that has kept this entity intact?
- and more importantly – will the tried and tested strategies of the last 110 years be enough to see the Institute survive in the future?

Given the current volatile political, commercial and financial scene that prevails not only in SA but also worldwide - surely there must be something to learn from the success story of the SAIEE?

History proves one certainty - change is inevitable and our Institute is no exception. Modern communication advances, empowerment from social connectivity and the increases in artificial intelligence competence will continue to happen. The evidence of which is already with us and making a huge impact.

Many of these changes have forced people and businesses to think and act differently; large and powerful entities, who have been around far longer than our noble Institute, have disappeared.

So, what is the future of the SAIEE going forward and growing in what appears to be an accelerating pace of disruption and change?

Firstly, the SAIEE is comprised of likeminded people who interact with the engineering fraternity and the community.

In order to move forward we must ask the question – what is there to learn from the last 110 years? More importantly, what is to be learnt from the past that can be used to overcome the disasters of late in the macro arena so as to ensure the future sustainability of our voluntary professional associations?

There are some things I have experienced and learned during my 12 years as an executive of a non-profit, non-taxable voluntary organisation. In sharing these perhaps some answers may emerge.

To start with some of the idiosyncrasies/ peculiarities:-

1. The elected Board (Council) is continually changing in composition; every year the newly elected President is encouraged and entitled to exercise his/her preferences and priorities. These initiatives should be externally focussed in outreach and separate from the functions and accountabilities of the SAIEE administration staff.

Headed up by the CEO, the administration must ensure that operational matters be contiguous and ongoing following an overlaying business strategy. The SAIEE employees are not required to change like the Council Members – as this is where the permanence and continuity are maintained.

The challenge to the administration is accommodating the changes in the elected/voluntary cohort of Council, while maintaining the continuity and sustainability in the operational space. Not easily perceived by the casual observer is the challenges faced by the CEO, and his/her staff, of adapting and serving a changing boss, Chairman and Board every year!

Unless there is a separation of duties and responsibilities between the administration and the elected voluntary Board, a voluntary association will fast lose direction and focus as well as, more importantly, lose relevance to its members and the engineering fraternity.

The performance of State-Owned Enterprises (SOEs) of late is an excellent example of what the dangers are of political interference in the running of these entities. Unfortunately the SAIEE, by the very nature of its structure, is prone to the same risks as SOEs.

# Some Reflection

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Proper governance and separation of duties/accountabilities are paramount if entities like SAIEE are to avoid the same fate as many of South Africa's SOEs. The SAIEE administration should be resourced and adequately equipped to run the business of the SAIEE while the elected cohort be mandated to build the professional competence and outreach relationships of the SAIEE with the macro fraternity.

2. Secondly, the criteria set for the election of membership and composition of the SAIEE Council need to be adhered to. The simple rules for election to membership are an educational qualification, professionalism and contribution to electrical engineering research or practice.

   The Institute is a-political, a-religious, gender oblivious, no age restrictions and of course non-racial in its election process for members. The Constitution and By-laws have clearly stated this from 1909 and these fundamental principles has been the cornerstone of the SAIEE ethos to date. The only criteria stipulated for membership – did you qualify in electrical engineering, what is your experience and are you professional in your conduct? These criteria are therefore timeless and immune from any decree by anyone or any entity, and have enabled the SAIEE transform effortlessly while the tides of demography have changed South Africa.

   The SAIEE, in terms of its registration under the erstwhile Transvaal Ordinance, is governed by its Constitution and By-Laws. 0bviously there must never be (and never has been) any conflict with the ruling government and any statutory or promulgated legislation.

3. Lastly, SAIEE is solely responsible to its members who have approved the governance in terms of the Constitution and By-Laws. The broad spectrum of its membership, from all sectors and levels of the economy/communities, ensures that fairness and equity prevail. Inherent in having a comprehensive and encompassing membership base is the assurance of an association that must hear and listen to its constituents. Failing to align with the voice and sentiment of the members is a recipe for failure. The SAIEE has practised this philosophy very successfully and should continue to do so.

So, what can be deduced from the above for the good of the SAIEE going forward?

The elected membership representatives of SAIEE must understand the above-mentioned fundamentals when they are elected and "wear the Institute's hat" while deliberating or deciding on SAIEE matters.

The elected executive members of the SAIEE must be self-disciplined in order to discount their preferences, biases and perhaps inhibitions in their thinking that may manifest from what is a carryover from their company, work situation or consulting arena.

The SAIEE has managed to grow because majority consensus has always ruled. Individuals who have attempted to "trump" Institute business, in any way, have found, in my experience, that the rules and unique ethos that exists have ultimately governed.

The wisdom of those before us, and whose shoulders we all stand on in our quest for improvement, must be respected.

Does the saying "if you do not know where you have come from, you surely cannot be sure of being successful going forward" apply more to voluntary associations than other entities? I think so, given that our Institute relies on a voluntary decision to join and voluntary effort to share.

The macro scene in which the SAIEE operates is changing radically. If that is not enough, the change is so rapid that populism and expedient solutions are rife. To try to keep-up may lead to severe anxiety and stress – the evidence of this anxiety in the commercial arena is apparent when a CEO's malfeasance and misbehaviour to win or appease the greedy shareholders. In SAIEE's case, we are is feeling this pressure through volunteers not having the time nor the freedom to devote to the cause. It is time for sober reflection. Knowing where SAIEE came from and why it exists is one thing; what to do going forward is not only essential to consider but also deserves the respect of the past!

The needs and aspirations of all people are very similar. People and their basic needs have not changed. The rapid progress and development taking place has undoubtedly provided a vast choice and confused many as what is a need and what is an unnecessary want!

It is sometimes challenging to distinguish the enormous difference between needs and wants in our modern society. Members charged with the welfare of the Institute must ensure that the needs of younger and future members are met. To make

the mistake of addressing the wants at the expense of needs is undoubtedly unwise. The SAIEE should be steadfast in promoting competency and professionalism, and needs to engender a sense of discipline in young minds. Similarly, decision-makers for matters of the Institute, should be aware of, sensitive to and recognise when their own ego's or wants are driving them in their decisions that affect the Institute.

I would think here is something to note for longevity - certainty and consistency- that this is a need for everyone. Steadfastness is a condition everyone strives to acquire in their work and private life. So, is this one of the factors the SAIEE needs to inculcate?

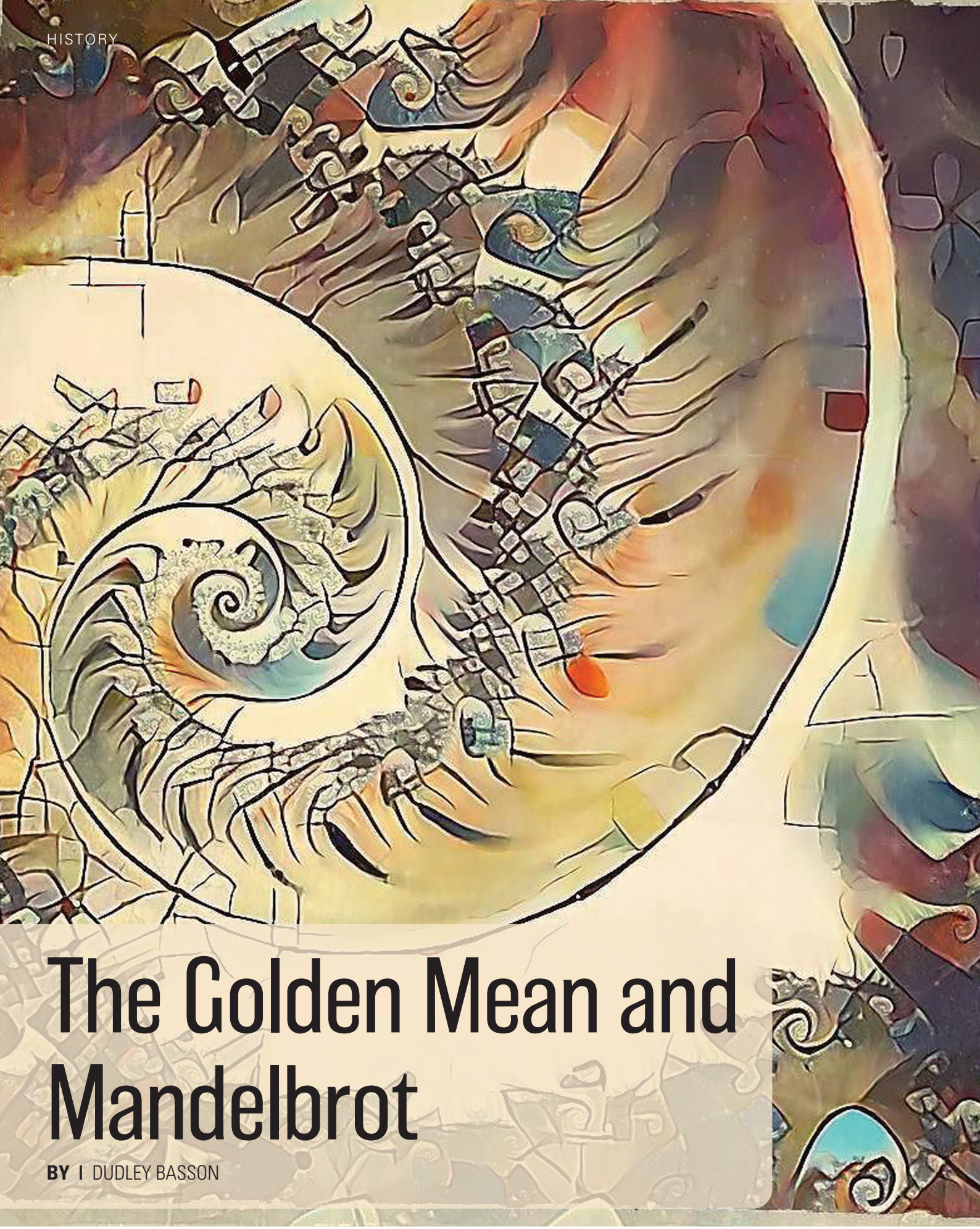
The modern approach to business is designed for convenience. One might ask – "convenience for who?" The benefit of quick self-help facilities disappears when one must wait in a long line to pay at when there are insufficient open cashiers. Same at the bank and many other stores in a mall. A Call Centre wait is filled with adverts and sales pitches and ends with "we are experiencing high call rates, and your call will be answered as soon as an agent is free".

Having to repeat verbally all the information entered digitally when an agent eventually responds is not convenient. While up-front, the conveniences of new technology appear to be beneficial become a frustration and delay. The question to ask – is on-line service the way for voluntary institutions to go? It is my experience that our members require personal interactive service. The few on-line facilities that could be provided should be confined and protected personal membership information and contact details.

The modern trend is to distance the client as far as possible from the engine room of the business detracts from a fundamental need for social interaction. Our members must never feel remote from their Institute. The SAIEE has always provided a direct person-to-person interaction.

While this interaction should remain, a limited provision could be made for those who prefer to work on-line electronically. My experience has been that members prefer to do business with the Institute directly with people. I believe it is a fundamental requirement of voluntary institutions – personal interaction is essential - and is the start of the networking that professionals need ongoing. There are good examples of commercial and financial businesses who are bucking the modern trend and thriving.

I hope that this article provides some cause for reflection and debate about what the Institute needs to do going forward. wn



# The Golden Mean and Mandelbrot

**BY |** DUDLEY BASSON

Three mathematicians separated in history by several centuries, shared a common passion – the "Golden Ratio". We add a fourth mathematician, Benoit Mandelbrot, to complete the picture.

The golden ratio is obtained by adding a rectangle to the side of a square such that the length to width ratio of the larger rectangle is the same as that of the added rectangle. This gives a simple quadratic equation with values of $(1 \pm \sqrt{5})/2$ giving 1,61803399… and 0,61803399… which are reciprocal to each other. The larger value is commonly denoted by $\phi$ and the smaller by $\varphi$. This gives: $\phi = \varphi + 1$ and $\phi = 1 / \varphi$

This ratio has fascinated philosophers, mathematicians, architects and artists throughout the ages. If adding a square to the long side of the rectangle is continued, a spiral can be drawn through opposite corners of the squares. This can be continued indefinitely by going larger as well as going smaller from the starting rectangle.

The following video clip shows how the spiral continues indefinitely:
https://en.wikipedia.org/wiki/Golden_spiral#/media/File:GoldenSpiralLogarithmic_color_in.gif

The Golden Ratio is regarded as a pleasing shape. The shape of foolscap writing paper (13" x 8") was quite close to this ratio. Most copier paper is now in the ISO A series with a ratio of $1:\sqrt{2}$ as the next smaller size can be obtained by cutting the sheet in half without wastage.

## THEANO

Theano (c 546 BC), possibly the wife of Pythagoras, was a pupil and tutor of the Pythagorean School and is said to have run the school after the death of Pythagoras. She not only wrote on astronomy and mathematics, she also worked in areas of physics, medicine and child psychology. Her work *"Life of Pythagoras"* has been lost. Her most important work is said to have been an elucidation of the principle of the Golden Mean or Golden Ratio.

The Golden Mean was not simply a geometric curiosity; this implied a harmonious lifestyle of moderation where nothing must be taken to extremes of excess or deficiency. In battle this implied courage as a mean between recklessness and cowardice.

The Pythagorean School was organised as a private club rather than a public institution.

There were reportedly many individuals - both teachers and students - living communally at Pythagoras's school. Because all writings were published under Pythagoras's name, it is difficult to determine who was actually responsible for which work. However, given that Theano was a member of the Pythagorean academy, certain facts of her existence can be taken for granted.

There are no surviving written works by any of the Pythagoreans; all that is known of them comes from the writings of others, including Plato and Herodotus. Whenever one refers to the writings of Pythagoras or his students, one is in fact referencing a body of work that was done between approximately 585 B.C. and 400 B.C. The discoveries of the Pythagoreans were considered to be the common property of all members of the school.

A quotation by physicist Erwin Schrödinger (1887-1961) of wave equation fame:
*"We are told that such a number as the square root of 2 worried Pythagoras and his school almost to exhaustion. Being used to such queer numbers from early childhood, we must be careful not to form a low idea of the mathematical intuition of these ancient sages; their worry was highly credible".*

# The Golden Mean and Mandelbrot

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## HYPATIA

Hypatia of Alexandria (350/370-415) was a mathematician, astronomer, scientist, inventor and philosopher. She was best known as a teacher, eventually becoming the head of the Alexandrian neo-Platonic school.

She was taught by her father in the arts, literature, mathematics, science and philosophy.

At a young age, Hypatia surpassed her father's mathematical knowledge. He then sent her to Athens to begin studies in astronomy as well as mathematics. Her work in mathematics included writing commentaries on Apollonius, Diophantus, and Euclid. She was intrigued by Apollonius's conic sections and the new mathematics of the day - algebra.

She was known for her eloquence, beauty and modesty.

The great library of Alexandria had been destroyed before her time. This is considered to be the worst single loss of knowledge in recorded history. The more than half million books/scrolls of the library would have been of inestimable value to modern scholars and historians.

The best source of information about Hypatia and her achievements is Socrates Scholasticus, a Greek historian who lived in the same era as Hypatia.

In his major work The Historia Ecclesiastica, Socrates wrote:
*Hypatia of Alexandria, daughter of the philosopher Theon, made attainments in literature and science that far surpassed all the philosophers of her own time. Having*

*succeeded Theon as director of the school of Plato and Plotinus, she explained the principles of philosophy to her students, many of whom travelled far to receive her instructions.*

Hypatia used a planisphere and astrolabe for astronomical measurements which was perceived by the superstitious public as a sign that she was engaged in witchcraft. Hypatia developed her own unique calculation methods utilizing Babylonian sexagesimal (base 60) numbers and an abacus-like calculator. Like her father, Hypatia used Greek letters for numbers 1-59 and sexagesimals for higher numbers. Her methods of calculation allowed her to both improve upon, and offer criticism of Ptolemy's original work. The result of this, in addition to her revision of Ptolemy's text, was her own Astronomical Tables featuring new calculated values for celestial events such as planet conjunctions.

She devised a hydrometer for measuring liquid density and discovered that water could be purified by distillation. It is said that she was also known for her fascination with the Golden Mean or Golden Rectangle. Hypatia met a horrific end when she was set upon by a frenzied, bigoted mob. She was pulled from her carriage, dragged, beaten, dismembered and burned.

At the time of her death she was a lonely remnant of a philosophical school that had been heavily persecuted for over 25 years.

A most unusual meteoric pebble found in 2013 in south-west Egypt has been named the Hypatia stone. It is thought that this is a fragment of a much larger meteorite, possibly of several metres in diameter. This meteorite has been studied by researchers of the University of Johannesburg. The meteorite has a bizarre mineral matrix not found in any other meteorite and which contains an unusually high carbon content and little silicon. It also contains a high amount of polyaromatic hydrocarbons, which have been partly transformed into diamonds. The meteorite was also found to contain metallic aluminium which is never found naturally on Earth. Other unusual finds were iodine phosphide and silicon carbide. This most unusual meteorite has been appropriately named after the great scientist and mathematician of Alexandria.

## FIBONACCI

Leonardo Bonacci (c.1170-c.1250) became known as Fibonacci (son of Bonacci). He is considered to be the most talented mathematician of the Middle Ages.

He made a huge contribution to European mathematics by introducing the Indo-Arabic numerals which quickly replaced the Roman numbering system in use at the time. Indo-Arabic is a misnomer as Arabic numerals are quite different to European numerals. The Roman numerals used the symbols I, V, X, L, C, D, M for expressing numbers. It is thought that the numbers originated from a tally system used for counting sheep by cutting notches on a stick. Every fifth notch was a horizontal cut across the previous four, making it easier to count the groups of five.

The symbols have the values: I=1, V=5, X=10, L=50, C=100, D=500 and M=1000. The numbers could be simplified by using symbols subtractively: I before V or X, X before L or C, and C before D or M, so that IV=4, IX=9, XL=40 XC=90 etc. The value for 1984 would therefore appear as MCMLXXXIV. There was no symbol for zero. Using this system to do even the simplest arithmetic calculation must have been fiendishly cumbersome. The Roman numerals can still sometimes be seen on clock faces and used for dates in formal documents and monumental inscriptions. The ancient Egyptians had a well-developed decimal numbering system (without a zero) with which they were able to perform calculations. There is an interesting ancient example in the Moscow papyrus which shows how to calculate the volume of a pyramid using this numbering system. There were several other numbering systems used by the various ancient civilizations. The ancient Chinese I-Ching system of hexagrams is interesting in that it uses stacks of six horizontal lines which are either whole or split in two. This gives a six bit byte with 64 values.

Fibonacci made a significant addition to the Golden Ratio of the ancient Greeks with his introduction of the Fibonacci series. The series starts with a seed of two whole numbers, usually 0,1 or 1,1. Each successive number is the sum of the previous two giving:
0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377… Any of the numbers divided by the previous number gives a ratio which, as the numbers increase in value, converges on the Golden Ratio. The last two numbers of this list give a ratio of 1,618 025 75 which is already very close to the Golden Ratio $\phi$. This series cannot match the Golden Ratio exactly as the Golden Ratio is an irrational number which cannot be a quotient of two integers. Other numbers can also be used as a seed for the Fibonacci series but will take longer to converge. Fibonacci first came to his number series by considering the breeding pattern starting from a pair of rabbits. The breeding pattern of rabbits was

# The Golden Mean and Mandelbrot

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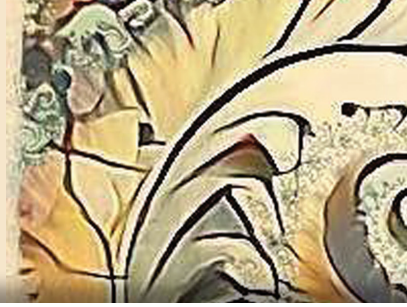


also studied by Mitchell Feigenbaum but his theory also included food availability and breeding fertility. This resulted in populations that could increase, stabilise or periodically diminish. Mitchell Jay Feigenbaum (1944-2019) was an American mathematical physicist whose pioneering studies in chaos theory led to the discovery of the Feigenbaum constants.

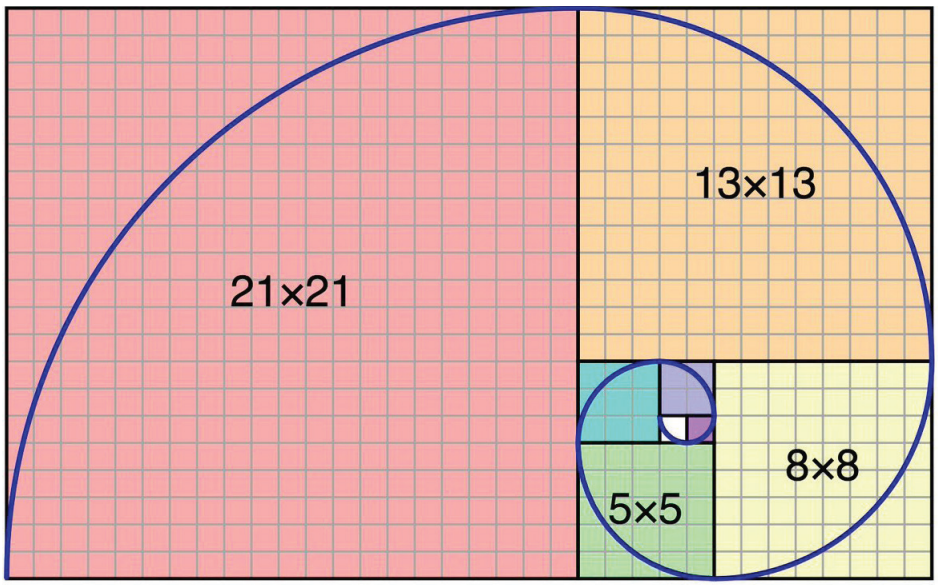
The Fibonacci series can also be used to make a pattern of tiles. Simply add a square of tiles to the long side of the previous rectangle. The number of tiles to a side of the squares will correspond to the Fibonacci series. A curve passing through diagonally opposite corners of all the squares will form a spiral. As the spiral increases in size it will closely approximate the spiral of the Golden Ratio.

The Fibonacci spiral differs from the Golden Ratio spiral in that it has a definite starting point whereas the Golden Ratio spiral extends indefinitely in both directions.

There are of course many other ways of generating a spiral. A logarithmic spiral, equiangular spiral or growth spiral is a self-similar spiral curve which often appears in nature. The logarithmic spiral was first described by Descartes and later extensively investigated by Jacob Bernoulli who called it Spira mirabilis, "the marvellous spiral". The logarithmic spiral also appears in the Mandelbrot fractal set.

See the following video of spirals in the Mandelbrot set:
https://www.youtube.com/watch?v=0UFnjgSW0tU

All of the bodies in the Solar System are moving in three dimensional tubular spiral paths as the Sun moves at great velocity about the galactic centre.




For some fascinating Fibonacci and toroflux mathematical disappearing tricks see:
https://www.youtube.com/watch?v=VK7XR-wlpAk

The toroflux bears an interesting resemblance to the skyrmion proposed in ball lightning theory. The toroflux appears to be of fundamental nature and may possibly have a link to string theory of particle physics.

For the electrical engineering relationship in signal processing between the Lainiotis filter and the golden section and Fibonacci sequence see:
http://hypatia.teiath.gr/xmlui/handle/11400/10826?locale-attribute=en

There are also interesting relationships between the Fibonacci series and Mandelbrot set with the Feigenbaum Function.

Pioneering computer scientist and cryptanalyst Alan Turing took a particular interest in the occurrence of the Fibonacci spiral in nature: the seed patterns of flowers, the branches of trees, snail shells, even in spiral galaxies. This is known as phyllotaxis. Turing died tragically before completing this work.

See the following video clip for the appearance of the Fibonacci numbers in a flower head:
https://www.youtube.com/watch?v=_GkxCIW46to

Fibonacci could never have imagined that his number series would appear in the Mandelbrot fractal set nearly eight centuries later.

Polish polymath Benoit Mandelbrot (1924-2210) introduced his sensational Mandelbrot set in 1980. His math and geometry-centred research career included contributions to such fields as information technology, computer graphics, economics, geology, medicine, physical cosmology, engineering, chaos theory, econophysics, metallurgy and the social sciences.

The Fibonacci sequence can be seen in the Mandelbrot fractal set at:
https://www.youtube.com/watch?v=4LQvjSf6SSwv

A convergence to π can be seen in the Mandelbrot set at:
https://www.youtube.com/watch?v=d0vY0CKYhPY

This is not a useful way to determine the value of π. Using other algorithms, π has been calculated to millions of significant digits.

The following video clip gives an astonishing view of the infinite complexity going down the ever decreasing fractal scale of the Mandelbrot set. This video is timed to correspond to the length of the first movement of Beethoven's piano sonata no. 14.

This *"Sonata quasi una Fantasia"* provides the perfect accompaniment to the mathematical geometric fantasy of fractals.

https://www.youtube.com/watch?v=aSg2Db3jF_4

Unlike quantum physics where there are definite boundaries as to how small physical phenomena can become, set by the Planck length (1,616229 x $10^{-35}$ m) and Planck time (5,391116 x $10^{-44}$ s), mathematics has no such boundaries and can continue with smaller dimensions indefinitely.

In December 2017, Giulio Prisco wrote a paper on *"Down in the fractal depths of quantum matter and space-time".*
*The smooth space-time fabric of reality seems to break down at very small scales, and become a fractal with infinite depth. New physics, with intriguing implications for metaphysics and theology, could be hidden in those fractal depths.*

*Smooth (continuous and differentiable) curves and surfaces become locally flat if you zoom-in deep enough, but fractals are always rough at all scales, and you can zoom-in a fractal forever.*

In his seminal book *"The Fractal Geometry of Nature"* Benoit Mandelbrot mentioned *"a new fractal wrinkle to the presentation of quantum mechanics".*

The Mandelbrot set does not imply the use of colour, but the display can be greatly enhanced by adding colours according to the iterations. Various colouring algorithms can be used with sensational effect. Zooming down the colour enhanced Mandelbrot set gives an appreciation of the humanly incomprehensible processing speed of modern supercomputers.

An interesting aspect of fractals is that they can have non-integer Hausdorff dimensions. In Euclidean geometry, a line has one dimension, an area two dimensions and a volume three dimensions. In fractal geometry, objects can have non-integer Hausdorff dimensions which are larger than the topological dimensions.

Here is an absolutely fabulous set of Mandelbrot zoom-ins with Mozart accompaniment:
https://www.youtube.com/watch?v=jca936_QKw4

Here is another Mandelbrot zoom to infinity:
https://www.youtube.com/watch?v=Yh8OY286HDc

Another super Mandelbrot zoom:
https://www.youtube.com/watch?v=u_P83LcI8Oc

Here is a video clip showing how a cardioid can appear in multiplication tables:
https://www.youtube.com/watch?v=qhbuKbxJsk8

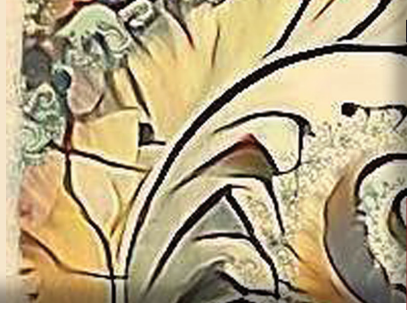
The cardioid is not unique to the Mandelbrot set. It is a basic form of the many variants of cycloids, epicycloids and hypocycloids. The cardioid is the path taken by a point on the circumference a circle when the circle is rolled around another circle of the same size. It is easy to draw a cardioid using a compass. Simply select a starting point on a circle and then draw numerous arcs from points all around the circle all passing through the starting point – this will produce a cardioid.

Epicycloids have been studied since the time of the ancient Greeks. Extending epicycloids to contain a large number of smaller rolling circles can produce an endless list of shapes in much the same way as the Fourier series can produce complex wave forms from waves of increasing frequency and decreasing amplitude. For a remarkable video of how multiple epicycloids can produce an outline of Homer Simpson see:
https://www.youtube.com/watch?v=qS4H6PEcCCA

This video also shows how a series of epicycloids can produce a Fourier series of waves producing a square wave.

See the following video for the origin of the Julia and Mandelbrot sets:
https://www.youtube.com/watch?v=56gzV0od6DU

# The Golden Mean and Mandelbrot



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Some quotations from Mandelbrot:

- The Mandelbrot set is the modern development of a theory developed independently in 1918 by Gaston Julia and Pierre Fatou. Julia wrote an enormous book - several hundred pages long - and was very hostile to his rival Fatou. That killed the subject for 60 years because nobody had a clue how to go beyond them. My uncle didn't know either, but he said it was the most beautiful problem imaginable and that it was a shame to neglect it. He insisted that it was important to learn Julia's work and he pushed me hard to understand how equations behave when you iterate them rather than solve them. At first, I couldn't find anything to say. But later, I decided a computer could take over where Julia had stopped 60 years previously.

- I conceived, developed and applied in many areas a new geometry of nature, which finds order in chaotic shapes and processes. It grew without a name until 1975, when I coined a new word to denote it, fractal geometry, from the Latin word for irregular and broken up, fractus. Today you might say that, until fractal geometry became organized, my life had followed a fractal orbit.

- A fractal is a mathematical set or concrete object that is irregular or fragmented at all scales...

- A fractal is by definition a set for which the Hausdorff-Besicovitch dimension strictly exceeds the topological dimension.

- Clouds are not spheres, mountains are not cones, coastlines are not circles, and bark is not smooth, nor does lightning travel in a straight line.

- I claim that many patterns of Nature are so irregular and fragmented, that, compared with Euclid - a term used in this work to denote all of standard geometry - Nature exhibits not simply a higher degree but an altogether different level of complexity… The existence of these patterns challenges us to study these forms that Euclid leaves aside as being "formless," to investigate the morphology of the "amorphous."

- Being a language, mathematics may be used not only to inform but also, among other things, to seduce.

- Science would be ruined if (like sports) it were to put competition above everything else, and if it were to clarify the rules of competition by withdrawing entirely into narrowly defined specialties. The rare scholars who are nomads by choice are essential to the intellectual welfare of the subtle disciplines.

- For most of my life, one of the persons most baffled by my own work was myself.

- The first night I saw the set, it was just wild. The second night, I became used to it. After a few nights, I became familiar with it.

- There is nothing more to this than a simple iterative formula. It is so simple that most children can program their home computers to produce the Mandelbrot set… its astounding complication was completely out of proportion with what I was expecting. wn

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The cost of each page of advertorial will be R2000 and two books will be given free of charge, to each sponsoring company, for each group of four sponsored pages or part thereof. It is suggested that these books be placed in the company reception and CEO's office. The book will be advertised to the Institute's 6000 members and copies will be available at R350 each. The book is ideal to present to VIP visitors to this country who wish to learn about this country and what it has achieved.

We expect school and University libraries will value the book as an indication to students of what the profession of electrical engineering is all about. The new book will match the size of the first edition (240x320mm) and will consist of between 170 and 180 full colour high quality pages.

SAIEE

# Our Expert Answers

*Information provided by Zest WEG Group*

## QUESTION ONE

What is a mobile substation and where is it used?

## ANSWER ONE

A mobile substation is exactly what the name suggests - a substation on wheels. This system is used when temporary power supplies are needed. It provides an easy, fast and flexible solution. It is a specially built trailer engineered to mount a transformer, protection and metering panels, high and medium voltage circuit breakers and surge protection.

## QUESTION TWO

In which applications are mobile substations used?

## ANSWER TWO

A mobile substation is ideal where there are space constraints, restrictions or limitations preventing the construction of a traditional outdoor substation. They are mostly used to restore electrical services during an emergency outage caused by, for example, a storm or disaster. In many applications, mobile substations are used to provide temporary power services during construction of permanent facilities. In other instances, these are used as permanent substations installations. Mobile substations can also be used for alternate power services during regular maintenance of existing transformers or substations.

## QUESTION THREE

What are the benefits of mobile substations over conventional substations?

## ANSWER THREE

Mobile substations offer several benefits over conventional substations, and there are some examples below :

- No civil work required
- No need for dismantling and reassembly
- Easy connection to other electrical infrastructure
- Emergency power supply (reduction in response time to emergency/ maintenance)
- Maximum mobility and flexibility
- Promote electrical network availability including reduction in network downtime, commonly associated with maintenance activities or unexpected fault conditions
- Avoid the risk of making large investments in substations and other power sources where the site requiring power has a temporary lifetime
- Integrated compact solution to fit on sites with space constraints
- Increased and spare capacity readily available when, and where needed
- Reduced capital expenditure commonly associated with fixed or permanent power sources

## QUESTION FOUR

What should an engineer consider when designing a mobile substation?

## ANSWER FOUR

The two most important components of the mobile substation are the transformer and the trailer. The transformer is the main and largest, heaviest, and most expensive piece of equipment in a mobile substation.

The trailer is also a critical component as it is important to design a mobile transformer solution that it compliant with road and traffic legislation with regard to weight and equipment dimensions. The effects of trailer flex and movement on the integrity of the transformer design are also important considerations.

The most common transformers used are Oil Direct Air Forced (ODAF), Oil Forced Air Forced (OFAF) and Air Forced (ONAF).

## QUESTION FIVE

What is the proper location of the transformer and other equipment on the trailer?

## ANSWER FIVE

The proper location of the transformer is usually in the middle of the trailer with the high voltage section at the rear of the trailer. However, the design should comply with the road ordinance specifications including the dimensional and mass limitations as well as the other requirements for abnormal load vehicles (TRH11).

## QUESTION SIX

What is the use of the helper dolly on the mobile substation?

## ANSWER SIX

The helper dolly provides the link between a semi-trailer and the towing and is used to achieve gross axle unit mass limitations. The advantage of this type of coupling is for towing stability.

## QUESTION SEVEN

Apart from the transformer, what other equipment is included in a mobile substation?

The following could be components of a mobile substation, depending on the design and/or application:

- High voltage circuit breakers (mostly hybrid switchgear)
- Medium voltage breaker (mostly Metal Glad GIS)
- Neutral earthing compensator/neutral earthing resistor/auxiliary transformer
- Instrument transformers
- Lightning or surge protection
- Insulators, cables and conductors
- Low voltage panels including protection scheme metering units , control scheme ACDC and SCADA system
- Low bed trailer

## QUESTION SEVEN

What should be considered when preparing the mobile substation for transport?

## ANSWER SEVEN

General inspection of the mobile substation prior to transportation would include :

- Check and verify the oil level in all tanks
- Prepare transportation brackets and make sure that all bolts are adequately torqued
- Verify that the gas supply is adequate and that the cylinder is in the transport position
- Surge arresters should be secured in the transport position.
- Close all valves of the cooling system to decrease the possibility of oil leaks during transit
- Verify that a set of instruction manuals and control drawings are with the unit
- Lock and secure all cabinet doors for transit
- Protective covers should be secured for transit

## QUESTION EIGHT

What should be considered when placing the mobile substation in service?

## ANSWER EIGHT

Since mobile substations are designed for specific applications, these will vary depending on the Original Equipment Manufacturer (OEM). Irrespective of how supplies the mobile substation the following tests are suggested:

TRANSFORMER

- Transformer turns ratio
- Insulation, oil dielectric, and dissolved gas in oil tests

CIRCUIT-INTERRUPTING DEVICES

- High-potential dielectric tests on interrupting devices
- Insulation and dielectric tests

CURRENT TRANSFORMER

- Transformer turns ratio
- Insulation tests

RELAYS

- Operational test - primary and secondary current injection test.

# November in History

November is the eleventh month of the year in the Julian and Gregorian Calendars, the fourth and last of four months to have a length of 30 days and the fifth and last of five months to have a length of less than 31 days. November was the ninth month of the calendar of Romulus c. 750 BC

**COMPILED BY |**
JANE BUISSON-STREET
FSAIEE | PMIITPSA | FMIITSPA

## 1 NOVEMBER

1931 E.I. DuPont announced to the world that they have come up with a new substance that is a Synthetic rubber called DuPrene. Made from Acetylene, salt and rubber, this combination would eventually be renamed NeoPrine in 1937.

## 2 NOVEMBER

1959 The first 72-mile (115 km) stretch of England's first intercity Motorway, the M1, was opened by Transport Minister Ernest Marples. It was built at a rate of about a mile every 8 days, and cost £16 million.

## 3 NOVEMBER

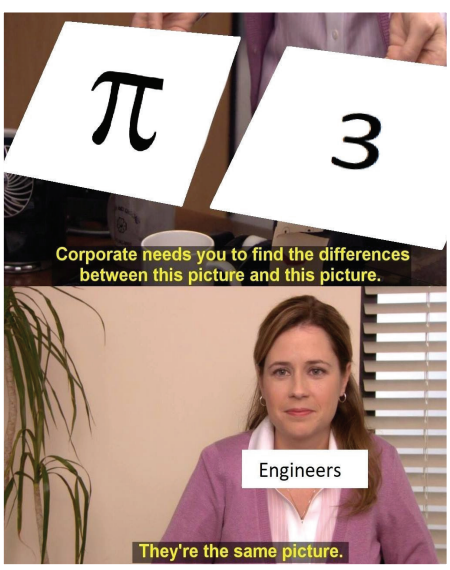
1957 The Soviet Union launched Sputnik 2, the second spacecraft launched into Earth orbit; and the first spacecraft to carry a living creature into orbit - Laika, a Siberian Husky dog.

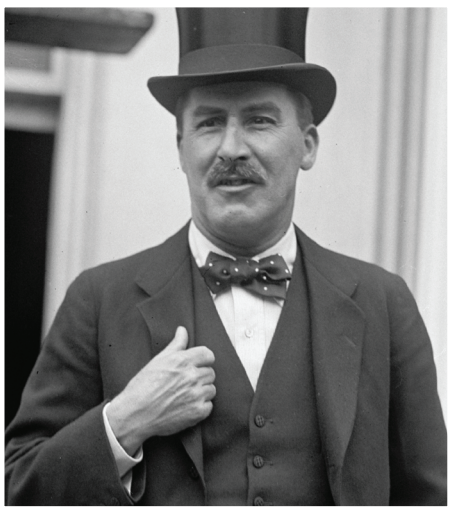
## 4 NOVEMBER

1879 African-American Thomas Elkins patented a refrigerating apparatus designed for chilling or cooling food, or even, according to the patent, human corpses. It consisted of a porous chilling box enveloped in fabric resting on a grated floor. Cool air was circulated which assisted with the evaporation of water supplied from a trough to the fabric.

## 5 NOVEMBER

1922 After the first step to a tomb had been discovered the day before, Howard Carter excavated a further 11 steps and exposed a large part of a plastered and sealed doorway in the Valley of the Kings near Luxor, Egypt. At the time, Carter recognized seal-impressions suggesting that the tomb belonged to somebody of high standing but did not yet know that it was occupied by Tutankhamun.



## 6 NOVEMBER

1981 The rediscovery of the black-footed ferret (previously thought extinct in 1979), was reported by the U.S. Fish and Wildlife Service. One had been captured in Wyoming and fitted with a radio transmitter. Historically it was a predator of prairie dogs on North America's arid, shortgrass prairies. Farming's destruction of the habitat and wide-scale poisoning to eradicate prairie dogs as pests, resulted in the disappearance of their specialized predator, the ferret. It now survives in a program of captive breeding and reintroduction sites.

## 7 NOVEMBER

1992 The first robot-assisted human hip replacement was performed on a 64-year-old man with osteoarthritis. The Robodoc device was used at Sutter General Hospital, Sacramento, California, under an investigational device exemption (IDE) which had approved by the US's Food and Drug Administration on the 9th October 1992. Ten more Robodoc assisted hip replacements followed. This ground-breaking orthopaedic surgical device was created for hip and knee replacement surgeries.

## 8 NOVEMBER

1602 The Bodleian Library, the main research library of the University of Oxford, and one of the oldest libraries in Europe, was established. With over 12 million items, it is the second-largest library in Britain after the British Library. It operates principally as a reference library and, in general, documents may not be removed from the reading rooms.

## 9 NOVEMBER

1991 In Culham, England, nuclear fusion was first harnessed to produce a significant amount of power. Though lasting for only two seconds, about 1.7 megawatts of electric power was produced. The experiment, by an international team of scientists at the Joint European Torus (JET), was the first to produce controlled fusion power.

## 10 NOVEMBER

1983 U.S. student Fred Cohen presented, to a security seminar, the results of his test - the first documented virus, created as an experiment in computer security. Cohen created this first virus when studying for a PhD at the University of Southern California.

## 11 NOVEMBER

1975 Angola achieved independence from Portugal.

## 12 NOVEMBER

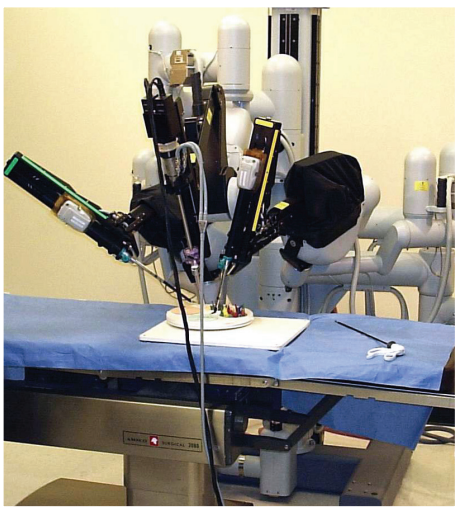
1980 The NASA space probe Voyager I made its closest approach to Saturn and took the first images of its rings.

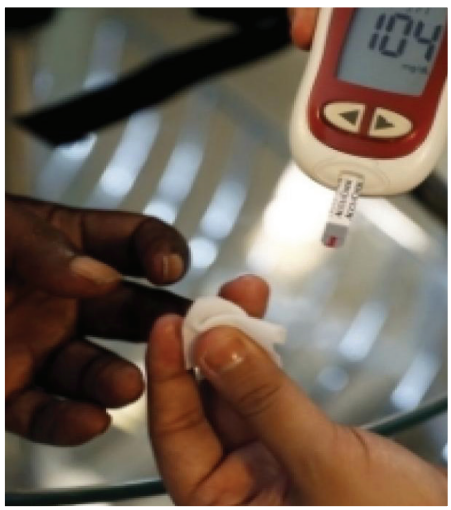
## 13 NOVEMBER

1855 A proposal for a tunnel under the English Channel was reported in the New York Daily Times, which, according to French engineer M. Loèpold Favre, would in five years connect Boulogne to Dover. The 18½ mile (30 km) tunnel under the Channel would also need about 1½ mile (2-km) under the shores for each approach at the ends. Excavated at no less than 82-ft (25-m) below the seabed, the tunnel would be lined with a double arch: one of granite and impermeable cement and an inner arch of thin, iron plates with perforations to reveal even slight leakage.

## 14 NOVEMBER

1991 World Diabetes Day was created by the International Diabetes Federation (ISF) and the World Health Organization to increase awareness of the health threat caused by diabetes.





# November in History

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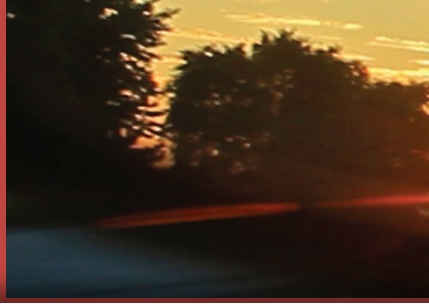


## 15 NOVEMBER

1883 Thomas Edison received a patent for his two-element vacuum tube, the forerunner of the vacuum tube rectifier.

## 16 NOVEMBER

1855 David Livingstone became the first European to see the Victoria Falls in what is now Zambia-Zimbabwe.

## 17 NOVEMBER

1810 Sweden declared war on its ally the United Kingdom to begin the Anglo-Swedish War, although no fighting ever takes place. During the Napoleonic Wars until 1810, Sweden and the United Kingdom were allies in the war against Napoleon. As a result of Sweden's defeat in the Finnish War and the Pomeranian War, Sweden declared war on the United Kingdom. The bloodless war, however, existed only on paper, and Britain was still not hindered in stationing ships at the Swedish island of Hanö and trade with the Baltic states.

## 18 NOVEMBER

1970 Microsoft Corporation co-founder and CEO, Bill Gates, got his start in computer programming at the Lakeside School in Seattle, USA. The school owned some early computers that Gates and his friends spent a good deal of their time pushing these machines to their limits.

## 19 NOVEMBER

2006 Nintendo's first video game console with motion control, the Wii, was released.

## 20 NOVEMBER

1985 A successful heart transplant to a 4-day-old infant, Eddie Anguiano known then as Baby Moses, was performed by Dr. Leonard Lee Bailey of the Loma Linda University Medical Centre. Eddie had been born with the fatal heart defect hypoplastic left heart syndrome, and had only days to live. His was the third such transplant attempted and is still alive today.

## 21 NOVEMBER

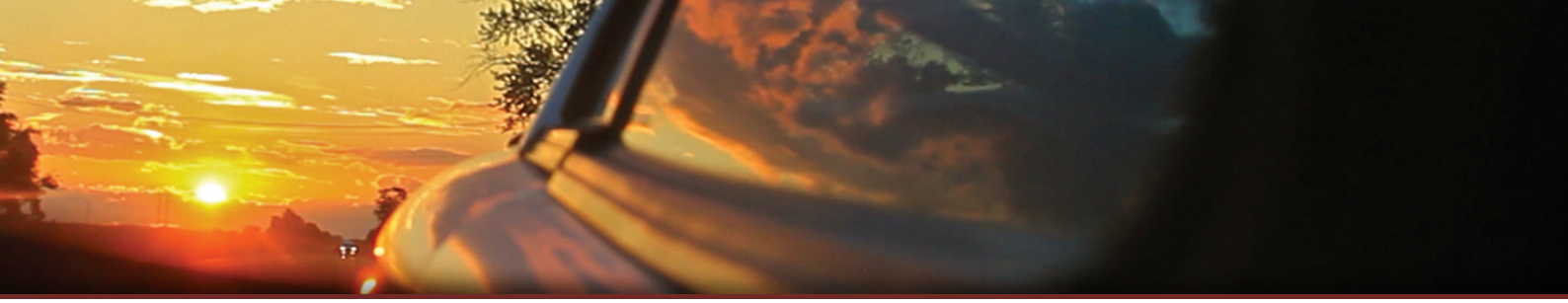
1863 English Engineer, Samuel Hall, inventor of the surface condenser for steam boilers (patented 1834), died. His invention was an important milestone of its era, because it was possible to recirculate fresh water instead of using corrosive salt water in the boilers of ocean-going steam ships. By keeping the boilers free of salt, a considerable saving of fuel was realized, and repair expenses were reduced.

## 22 NOVEMBER

1976 Angola was awarded full membership of the United Nations.

## 23 NOVEMBER

1889 The first jukebox was installed when an entrepreneur named Louis Glass and his business associate, William S. Arnold, placed a coin-operated Edison cylinder phonograph in the Palais Royale Saloon in San Francisco, USA.



## 24 NOVEMBER

1909 The Wright brothers formed a million-dollar corporation (The Wright Company) for the commercial manufacture of airplanes. The brothers found themselves immersed in business affairs, manufacturing and selling planes, arranging flying exhibitions and training pilots.

## 25 NOVEMBER

1997 Pixar Animation Studio released their second feature-length animated film, A Bug's Life. It tells the tale of a rag-tag group of bugs who band together to defeat a group of invading grasshoppers.

## 26 NOVEMBER

1922 Archaeologist Howard Carter pierced the second of two doorways closing the tomb of King Tutankhamun. Carter made archaeological history by unearthing the first Egyptian pharaonic tomb that still contained most of its treasures.

## 27 NOVEMBER

1995 Microsoft Corporation started to ship Internet Explorer 2.0, starting a browser war with the popular Netscape Navigator.

## 28 NOVEMBER

1948 The Polaroid Land Camera first went on sale, at a Boston department store. The 40 series, model 95 roll film camera went on sale for $89.75. This first model was sold through 1953, and was the first commercially successful self-developing camera system. A sepia-coloured photograph took about one minute to produce. Edwin H. Land had previously demonstrated his invention of instant photography at a meeting of the Optical Society of America on 2 Feb 1947. His first commercial success came in 1939 with his invention of Polaroid filters for lenses in products such as ski goggles, sunglasses and slip-on sunglasses for optical glasses.

## 29 NOVEMBER

1972 Pong, one of the earliest arcade video games, was launched. It is a table tennis sports game featuring simple two-dimensional graphics. The game was originally manufactured by Atari, which released it in 1972. Allan Alcorn created Pong as a training exercise assigned to him by Atari co-founder Nolan Bushnell. Bushnell and Atari co-founder, Ted Dabney, were surprised by the quality of Alcorn's work and decided to manufacture the game. Pong was the first commercially successful video game, which helped to establish the video game industry

## 30 NOVEMBER

1956 CBS became the first-ever network to broadcast from videotape. It was a rebroadcast to the West Coast of the 15-minute Douglas Edwards and the News program. It had been recorded earlier on 2-inch tape with an Ampex Mark IV machine. wn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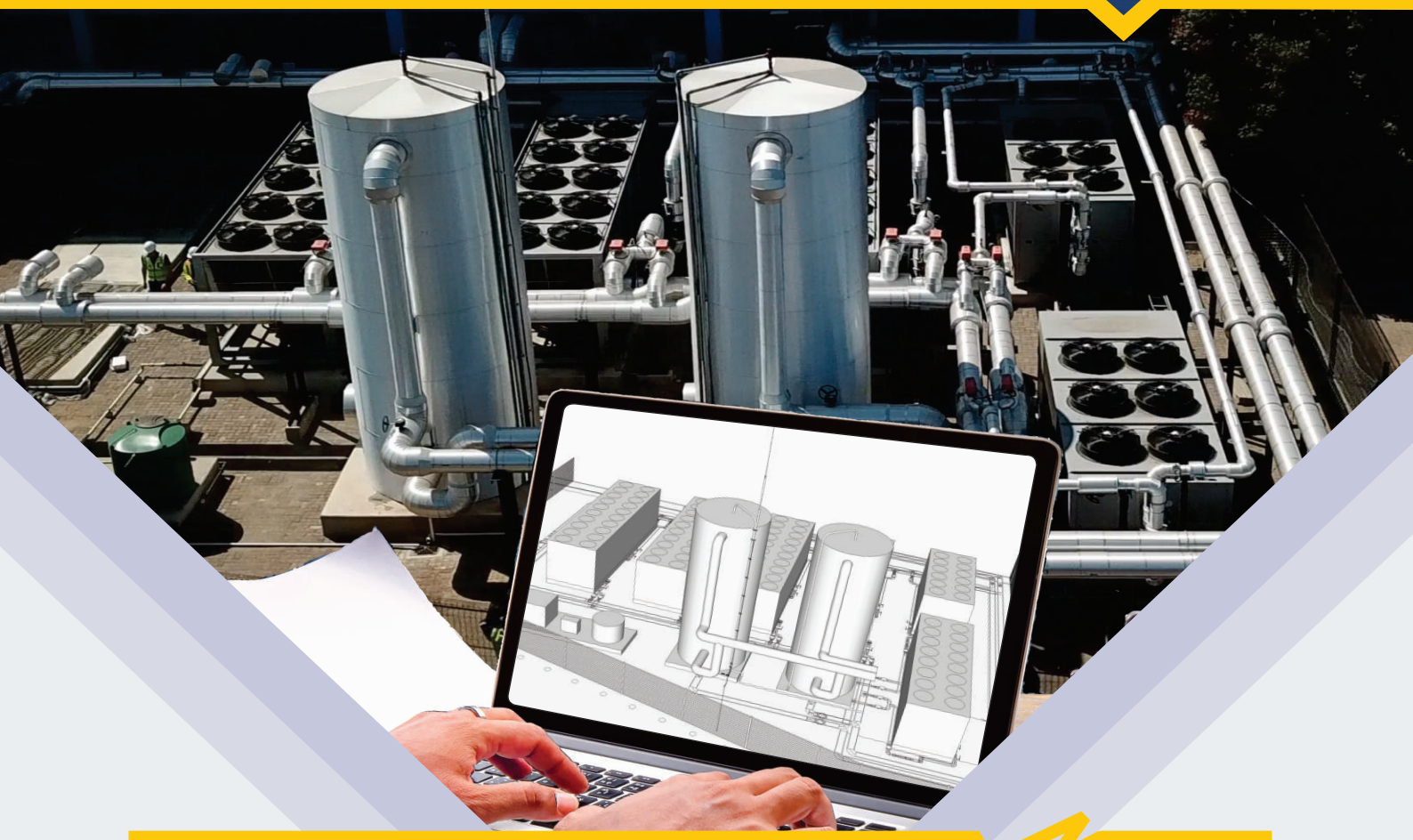

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The use of 3D modelling in our lightning protection design process provides extremely accurate and effective lightning protection design and execution.

This design accuracy and insight is unique to LPC. Our proven track record as earthing & lightning protection consultants ensures the most effective protection of people, property and operating systems.

**LPC`s consultancy services include:**

- Lightning Protection Risk Assessments
- Lightning Protection System Design
- Soil Resistivity Appraisal and Analysis
- Earth Termination System Design
- 50Hz Grid Potential Rise (GPR) Analysis
- Step & Touch Potential Analysis
- Site Assessments & Fault Finding

**Call Lpc Now**
for Effective, Innovative and Compliant Protection Solutions

LPC

LIGHTNING PROTECTION CONCEPTS

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