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THE SAIEE CHALLENGE: THE WORLD IS CHANGING

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LIGHTNING

SAIEE THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | AUGUST 2018

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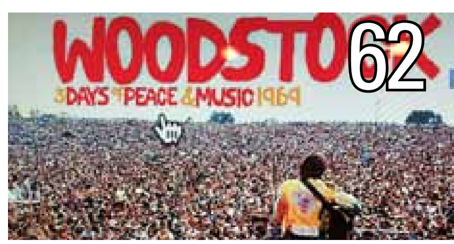

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ISSN: 1991-0452

2018 Q2 - 15 811

August is Women's Month, and all over people are celebrating women – our caregivers, nurturers, teachers – everyone a great story to tell. I wish all our female readers a fantastic Women's Month – and thank you for persevering in this industry.

August is the prelude to our Lightning season, and therefore I thought it apt to feature Lightning and Protection in this issue. According to NASA, Africa is the lightning capital of the world, with ± 24 million strokes of lightning per annum, which leads to ± 500 fatalities.

Our first feature article showcases the first high-speed video observations of lightning over Johannesburg, written by Drs Carina Schumann and Hugh Hunt. Read all about it on page 18.

Page 24 features an article written by Richard Evert, the National Director of the Earthing and Lightning Protection Association (ELPA) and he poses the question: "Are you, as an electrical engineer, doing your part to eliminate the lightning threat to save lives?"

SAIEE House is situated on the grounds of the SAASTA Johannesburg Observatory site. The ground flash lightning density in this area is 7.5 strikes/km^2/year according to the CSIR. This compares to lightning density in Cape Town of 0.3 strikes/km^2/year. Viv Crone wrote an article on the process of the implementation of the Lightning Protection System at SAIEE House. This can be found on page 30.

Then, of course, this issue would not be complete without a beautiful article from Dudley Basson – Balled Lightning, which has long been a matter of much speculation as well as scepticism. Its brief and unpredictable appearances have hampered a scientific study of this phenomenon. Turn to page 52 to read it.

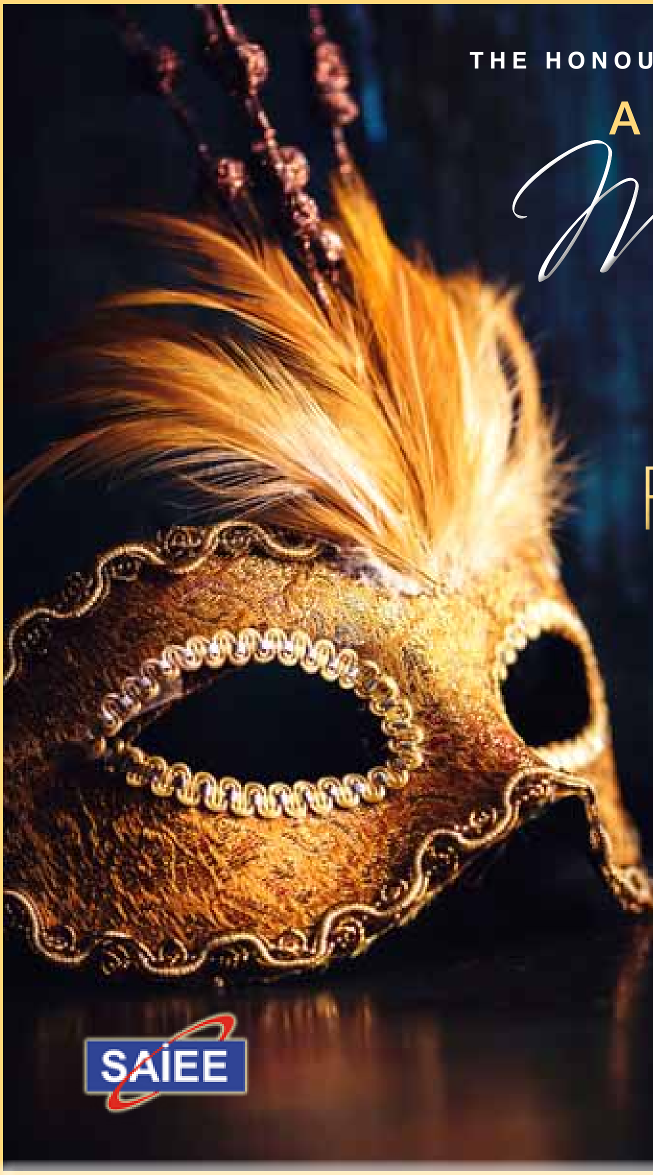
The SAIEE Banquet (see the next page for more info) is around the corner – book your tables now to avoid disappointment. It promises to be a night filled with excellent food, fun and laughter. Book now by sending an email to Gerda – geyerg@saiee.org.za.

Herewith the August issue, enjoy the read!

Minx

Earn CPD Credits

Visit www.saiee.org.za to answer the questions related to these articles to earn your CPD points.



THE HONOUR OF YOUR PRESENCE IS REQUESTED AT THE

ANNUAL SAIEE Masquerade Ball

FRIDAY 26 OCT 2018

VILLAGE HALL | MIDRAND CONFERENCE CENTRE

661 PENDULUM ROAD, HALFWAY HOUSE EXT 12, MIDRAND

TIME **18H00**

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DR HENDRI GELDENHUYS
2018 SAIEE PRESIDENT

As president of the SAIEE, I wish to bring accolades to our woman engineers. I have had the privilege to work with some amazing female colleagues who have delivered excellent work; it is such a pleasure to have worked with you. I wish I could publish a list here to allow others to appreciate the exceptional women we have in Electrical Engineering…

Women in Engineering

We have to recognise that we are coming from a background where women have not always been welcome in the engineering-midst. Speaking to my female colleagues, most of them have stories which do not reflect an engineering world of moonshine and roses and this needs our serious attention.

Diversity in teams is the critical success factor for any team effort. Most projects require not only technical inputs, but even more importantly, human-caring factors and community considerations. Diversity in teams is essential and makes the difference between great outcomes and minor success. Women have not only made their mark in the technical space, but they often bring much more to the table.

We are all different; and the full range of possible career opportunities that exist, from the back room - behind the scene work types through to sizeable organisational leadership positions are possible. Some engineers enjoy getting their hands dirty on site, others prefer fine-tuning design calculations behind a computer, and others still would choose to be decision makers and direction takers seated around a boardroom table.

SAIEE is committed to assisting every member through every step of their career as part of the greater "South African Engineering Team".

Career happiness is critical. Every person needs to understand her or himself better, what their strengths, weaknesses, preferences and goals are. The SAIEE will support members in sharpening their engineering skills and aid in their other skills needed to navigate the engineering profession.

The rapidly changing socio-economic society requires a rethink of the traditional family paradigm of women being the primary caregivers and men focusing on being breadwinners. Each family is different. It is the responsibility of fathers and mothers jointly, to ensure that the next generation is nurtured and given the best childhood development opportunities possible.

Let's support our female colleagues to grow their careers in this exciting discipline and let's also make space for fathers to play an increasing role in parenting. The challenge of support in this regard needs more discussion in our profession and workplace.

H Geldenhuys | SAIEE President 2018
FSAIEE

The month of Reflection...

STAN BRIDGENS
SAIEE CEO

Sixty-two years ago 20,000 brave women marched to Pretoria Union Buildings in protest of the repressive laws. We celebrate that day, the outcome of that action, and of course the change it brought about that we enjoy today.

On 09 August 2018, SAIEE also pauses to reflect on that day, so long ago that changed the game, and was brought about by women in South Africa.

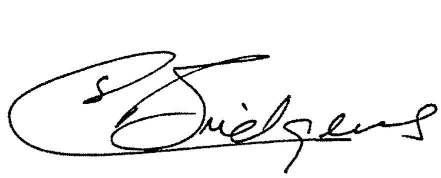
The SAIEE also chooses the same day to acknowledge and celebrate our female members and staff for the contribution that they make to electrical engineering in South Africa.

On behalf of the SAIEE Council, who have provided the leadership and commitment for proper gender equality, I thank:

- our Members - of which 500 female Members hugely contribute to the engineering industry
- Past Presidents - of which we have two esteemed ladies;
- Council Members - of which there are eight women;
- our many young female students; and lastly but not least,
- the wives/partners of our Members and Councillors who, without their support, would not be able to make the voluntary contribution of their expertise to our noble Institution.

So it is with much pride that we thank our ladies for their excellent contributions to our communities.

We salute our woman!



S Bridgens | SAIEE CEO
PR Eng | FSAIEE | Past President

EMPOWER A BILLION LIVES

An IEEE PELS Initiative

IEEE

Africa-Europe Regional Competition

Global Competition to Develop Scalable Solutions to Energy Poverty

The Issues

- 3 BILLION people live in energy poverty, including 1.1 Billion people without any access to electricity
- 95% of utilities in the Sub-Saharan Africa cannot recover their operational and capital costs
- 110 MILLION people have gained improved access using solar lanterns -however most of them don't even meet minimum Tier 1 requirements for electricity access
- ONLY 1.8 MILLION people have Tier 2 access (50 watts peak or 200 watt hours per day) that enables improved livelihood and productivity using off-grid electric services

More of the same may not be the answer – new strategies are required to scale deployment a ~1000-fold

Empower a Billion Lives (EBL) is a biennial global competition (starting 2018) organized by the IEEE Power Electronics Society to crowdsource regionally relevant innovation to accelerate deployment of energy access solutions around the world.

The Goal of the Competition

Foster interdisciplinary innovation in the global community to develop and demonstrate solutions to electricity access that are designed to scale, regionally relevant, holistic, and leverage 21st century technologies that feature exponentially declining prices.

What Are the Targeted Electricity Needs?

Tier 2 electricity access (200 Wh/day) and above including:

- Household uses: lighting and phone charging, telecommunication, entertainment, air circulation, refrigeration, water pumping, etc.
- Community uses: public lighting, water pumping & purification, etc.
- Productive uses: agricultural manufacturing, light manufacturing, commerce, etc.

Preliminary Design Criteria

The competition is agnostic to energy sources, technologies, business models, and will primarily evaluate potential impact and ability to rapidly and sustainably scale the solutions to a Billion customers.

- Holistic sustainable technology-based solutions that are designed to scale
- Accompanied by a viable business plan designed for the Base of the Pyramid
- Integrate communications, Pay/Go, Cybersecurity, microfinance as needed
- Enables electricity access from the bottom-up; without centralized planning
- Address challenge of managing a fleet of millions of devices
- Create new income generating opportunities for target customer group
- Additional value streams for external stakeholders
- Utilizes carbon neutral technologies

Register your intention to participate on the empowerabillionlives.org website.

IEEE POWER ELECTRONICS SOCIETY
Powering a Sustainable Future

Supporting organizations: World Bank, GOGLA, IEEE Smart Village, Georgia Tech CDE, TU Delft

www.empowerabillionlives.org

Alstom to build 100 next-generation very high speed trains

Avelia Horizon high speed train.

The Board of Directors of SNCF Mobilités has approved a firm order for 100 next-generation Avelia Horizon high-speed trains (TGV) at its meeting in July 2018.

This new generation of very high-speed trains addresses to ambitious goals in terms of competitiveness of the rail sector and profitability for SNCF, with a total acquisition cost 20% lower than that of the previous generation. The teams of experts working on this project for two years have risen to the challenge of specifying a new train at a reduced cost of €25 million per trainset, with an additional budget of €190 million for options and services .

Avelia Horizon will consist of two innovative power cars of reduced length, combining high performance and compactness, and articulated double-deck passenger cars. Their design allows for a 20% increase in passenger-dedicated areas, allowing the train to accommodate up to 740 passengers in the highest-capacity configuration chosen by SNCF.

Maintenance costs will be more than 30% lower than those currently recorded by SNCF. The train's maintainability is considered from the design stage, with a remote diagnostic system for predictive maintenance, which improves the trains' reliability and availability. Many of the components have an optimised design to simplify, reduce, and allow longer intervals between maintenance interventions.

Thanks to its aerodynamic design and a more efficient traction drive, the next-generation TGV will consume 20% less energy than existing TGVs.

"This order is the successful fruit of the collaborative work of SNCF and Alstom. Alstom's Avelia Horizon solution meets the technological, economic and competitiveness challenges of SNCF," said Henri Poupart-Lafarge, Chief Executive Officer of Alstom.

The Ultimate Tool Backpack for Maintenance Professionals

New, rugged backpack featuring more than 30 pockets and pouches to transport and protect a wide array of Fluke tools and accessories, hand tools, and tablets.

It can be very inefficient, not to mention frustrating, for maintenance professionals to have to go back and forth to the office stores, getting additional tools because one can't carry everything needed on-site. COMTEST is offering the new Fluke Pack30 Professional Tool Backpack that makes it easy to organize, transport, and access all the tools needed for the day. Designed specifically for an electrician; DMMs, clamps, tools, and accessories, the rugged backpack also protects tools even in the dirtiest of work sites. For digital users, the Fluke Pack30 offers a way to carry all the necessary tools while keeping "hands-free" to use cell phones and tablets.

The Fluke Pack30 features:

- More than 30 pockets and pouches designed to hold a broad array of Fluke tools and accessories, as well as screwdrivers, pliers, tape rolls, and other hand tools;
- Six main storage compartments for convenient organization;
- A special pocket for tablets and laptops 12 inches (30 cm) wide or smaller;
- Storage for safety glasses, earplugs, cell phones, valuables, and more;
- Rugged, waterproof molded bottom to protect tools and accessories from the elements;
- Molded base also holds backpack upright, keeping tools organized and within easy reach.

Contact COMTEST for more information on the Fluke Pack30 Professional Tool Backpack, or for upcoming seminars, demos or to locate the nearest dealer
010 595 1821 or sales@comtest.co.za

‘Let’s #MoveTheDate of Earth Overshoot Day’

Earth Overshoot Day marks the date in the year by when humanity will have consumed more from the planet, including food, fibres, timber, and absorption capacity for carbon dioxide from fossil fuel burning than the planet’s ecosystems can renew in the entire year.

Schneider Electric, the leader in digital transformation of energy management and automation, believes that adoption of energy efficient and renewable technologies such as its IoT -enabled EcoStruxure platform, could move the date back by 21 days through retrofitting of existing building, industry and datacenter infrastructure and upgrading electricity production alone.

To demonstrate how this can be done and to promote new approaches to sustainable business thinking, the company has partnered with Global Footprint Network, the international research organization that is changing how the world manages its natural resources and responds to climate change. Global Footprint Network’s Ecological Footprint accounts enable to calculate Earth Overshoot Day.

Schneider Electric believes this situation is reversible. The company has calculated that if 100% of existing building, industry and datacenter infrastructure was equipped with active energy efficiency technologies that are readily available and the electric grid was upgraded with renewable capacities, the world could move the date back by at least 21 days.

“Operating on a planet with finite resources requires creativity and innovation”, said Xavier Houot, Schneider Electric’s SVP Global Environment. *We team-up with our customers and partners to unlock the potential to retrofit existing infrastructure, adopting circular business models, and we measure how much this helps save resources and CO_2. We work to see our growth path through the lens of the growing need of living within the means of our one planet.”*

SA AND RUSSIA TO DEVELOP TWO NUCLEAR REACTORS IN FIGHT AGAINST CANCER

From left: Dmitry Shornikov, CEO, Rosatom Central and Southern Africa.
Mr. Phumzile Tshelane, CEO, NECSA
Dr. Kelvin Kemm, Chairperson of the Board, Necsa
Mr. Denis Cherednichenko, Director General, Rusatom Healthcare.

Russian state owned nuclear corporation Rusatom, and the South African Nuclear Energy Corporation (Necsa), have signed a coperative aggreement in nuclear medicine in the fight against cancer at in Johannesburg.

Necsa’s supplies close to 28% of the worlds medical isotopes, which is used in the detection of cancer. These locally produced isotopes have a short shelf life and allows for the detection of cancer down to the molecular level. Necsa has the ability to bring transport these life saving medicine to 60 countries around the world in 36 hours. Necsa brings in over R1.4 billion in revenue from nuclear medicine and is looking to expand its operation by developing two more small reactors in conjuction with the Rusatom. These reactors are for the production of nuclear medicine, not the generation of power.

With cancer rates increasing by close to 30% worldwide between 2006 and 2016 according to JAMA Oncology journal. The early detection of cancer allows for the costs for treatment to be brought down according to Phumzile Tshelane the CEO of Necsa.

ACTOM Protection & Control sets up prepayment meter manufacturing plant

ACTOM Protection & Control (P&C) has set up a prepayment meter factory at its Knights, Germiston, premises in line with the latest national regulations governing local content requirements for key industrial products.

Residential prepayment meters and smart meters are included among many categories of equipment recently designated by the Department of Trade & Industry (DTI) as requiring a minimum 70% and 50% local content respectively to be eligible for sale and supply to SOE's and other organs of state, including many municipalities.

The establishment of the local production facility, operating since March this year, enables the business unit to meet the DTI's local content conditions applying to prepayment meters.

"It positions us optimally to cater to the rapidly growing demand for state-of-the-art smart prepayment metering systems in the local market, especially among local authorities, which have increasingly adopted them as the most efficient and convenient method for controlling, monitoring and managing electricity consumption in the residential areas under their jurisdiction," commented Faisal Hoosen, P&C's General Manager.

P&C produces and assembles the equipment under licence to its technology partner Holley Technology, an international manufacturer and supplier of metering systems. The items produced in the new factory comprise prepayment meters, smart prepayment meters and customer interface units (CIU's). The manufacturing area of the new facility contains four dual multi-station assembly lines for both single- and three-phase meters, a withstand voltage test bench, two calibration benches, two configuration benches and two quality testing benches.

RAUBEX INFRA BRINGS FASTER CONNECTIONS TO BLOEMFONTEIN HOMES

As South Africa's consumers today demand faster and more reliable connectivity for a range of home and home-office uses, Raubex Infra is working with telecommunications operators to roll out the 'last-mile' optical fibre cabling to the household.

In a recent contract, Raubex Infra's telecommunications division – which provides a diversity of network infrastructure solutions – provided fibre links to 2,200 homes in the Universitas and Waverley neighbourhoods of Bloemfontein in the Free State province.

According to Danie Marias, operations director of the company's telecommunications division, the project required the deployment of specialised equipment as well as the careful management of teams of trained workers for the manual aspects of the job. He highlights the importance of working neatly, quietly and quickly in the suburban environment, creating as little disruption as possible to the residents.

The well-coordinated effort using a specialised trenching machine created a narrow slot some 20 to 30 cm deep in the roadway, into which the ducting was laid from a large reel. While this task could be best conducted using mechanised means, the shallow gulley for ducting to run from the road to the householder's fence had to be manually dug. A termination box was then located at the edge of each property for later connection to network.

Marais emphasises the importance of restoring the roadway to its previous condition of strength to avoid any ingress of water through weak points in the asphalt as this could reduce the lifespan of the road. The gravel removed by the trencher is therefore meticulously swept up and transported to a nearby site, where it is sieved and mixed with cement by a dedicated mixer to create a soilcrete mixture.

Once moistened, the soilcrete can be packed into the roadway slot on top of the ducting, and then compacted to the required density ensuring the road layers are returned to their previous strength. The filled slot is then sealed with bitumen paint before a final asphalt layer is applied and compacted with a pedestrian plate compactor.

Data Centres needs to be protected!

Data centres rely on the optimal performance of equipment, and surges can cripple operations. Data centre operators need to be able to effectively manage these energy spikes, as it can cost a significant amount of money to recover from the resultant downtime or hardware damage. Across the continent, DEHN AFRICA's expertise provides surge protection for data centres, against various potential causes.

NEWS

Julienne Puttkammer, who is part of the Technical Team at DEHN AFRICA, the local subsidiary of DEHN, a globally active electrotechnical company offering comprehensive services, products and solutions in the field of surge protection, lightning protection and safety equipment, says there are two main types of risk when it comes to data centres and electrical power surges. He clarifies, "The leading causes of power surges when it comes to data centres are: lightning strikes, both direct and indirect hits; and switching surges, which can be internal, potentially caused by the switching of a cooling system's inductive load or possibly generator switching over from utility supplier, or external, coming in from the utility itself.

"In Africa, the foremost causes of surges to data centre systems largely depend on the area. For example, in regions with a stable power supply, power surges could most commonly be caused by lightning strikes, while in areas with an unstable supply we could see the most frequent cause being from on-off switching. Even a nearby lightning strike, and not necessarily a direct hit, can cause a surge to flow on conductors and electrical lines. So, the factors to look at are whether you are in a lightning-prone area, and the stability of your power grid."

Puttkammer says that because there can be catastrophic consequences for a direct lightning hit, it is common, in DEHN AFRICA's experience, for data centre designers to opt for lightning protection installation, regardless of whether the normal risk procedure requires it or not. He notes, *"Data centres contain sensitive operations, for which all kinds of back-up power need to be implemented to secure a constant*

stream of power, and no down-time. Even within the data centre itself, we can find on and off switching, for example the cooling system can cause switching surges, which are also a danger to the electronics. On and off switching is the main cause of non-lightning related surges."

Puttkammer says the main challenges in implementing surge protection measures involve coordinating how to implement all the aspects of lightning and surge protection from the beginning of the project. *"Ideally, the most comprehensive solution would include all the interlinking systems of lightning and surge protection from the design stage, to have all the components optimised. We need to think about issues such as cable routing or embedding bonding conductors in concrete – these need to be very well coordinated from the beginning of the planning and construction phases,"* he explains.

"To come in once a rollout has been completed or is already underway means that you need to find the space to install and implement surge protection systems, which then requires some sort of compromise in most cases. And while it is not impossible to still have a very good system installed afterwards, retrofitting is not ideal. At DEHN AFRICA we are, however, seeing an encouraging move towards including lightning and surge protection for data centres from the beginning of projects."

With regards to DEHN's products and solutions for data centres and surge protection, Puttkammer reiterates that it all starts with the planning phase. "We offer all the services required – a risk assessment, soil testing if necessary, a detailed design, an earth electrode design for AC system faults, an inspection and sign off on a lightning safety report. Thereafter we offer all the necessary tested products as well, including the lightning protection, earthing and bonding components as well as the electrical and electronic surge protection devices."

Puttkammer notes some unique challenges for data centre surge protection in Africa. *"We see some of the highest lightning flash density in central Africa, and some of the data centres we've worked on are very close to these high density areas. DEHN is seen as a lightning specialist, and so we start with the lightning protection side, but as it's all one solution, we bring in the surge risk management side as well. There are places on the continent where we need to safeguard against on and off switching on the grid itself.*

When it comes to grid reliability, we should note that South Africa, by and large, measures up very well here when we are not having to deal with load shedding issues," he concludes. **wn**

Energy Efficient Motor Keeps SA Economy Alive

Reducing energy consumption is a reality for all industries in South Africa, and the WEG W22 IE3 premium efficiency electric motor can rightfully claim to be the most efficient motor that is turning industry in the country.

Available from Zest WEG Group, the WEG W22 IE3 is available in models with a rated capacity up to 1,000 kW and has been engineered specifically to reduce energy consumption optimising on total cost of ownership in numerous applications.

The WEG W22 IE3 product line was engineered using the latest generation computational tools such as structural (finite element method) and fluid flow analysis as well as electric design optimisation software. This resulted in a robust product that offers reduced energy consumption and thermal efficiency as well as a reduction in noise and vibration levels.

Fanie Steyn, Manager responsible for rotating machines at Zest WEG Group, says that because a chain is only as strong as its weakest link, during design close attention was paid not only to the internal efficiencies of the working motor, but also to the elements constituting the external components of the designed motor.

FOCUS ON THE FRAME/HOUSING

The frame is a fundamental component in the design because, besides constituting the mechanical structure reference, it is the main conduit responsible for the heat dissipation generated inside the electric motor. *"In addition, the frame and the end shields ensure the enclosure of the electric components, protecting them against the environment where the motor is installed,"* Steyn says. *"The frame design ensures high thermal exchange and high reliability where mechanical strength is essential."* The terminal box is located at the front of the frame thereby increasing the heat dissipation area and providing a uniform air flow over the motor frame.

NEWS

500 kW foot mounted WEG motors are known as the work horse of the industry.

Reliability of the frame was also deemed important, so careful consideration of construction materials led to the selection of FC-200 cast iron which is produced in WEG's own facilities. Interestingly, this is the same material that is used in WEG's explosion-proof motors.

FAN AND FAN COVER

The main function of the fan, when assembled directly on the motor shaft, is to promote the air flow over the frame fins, thus dissipating the heat generated inside the motor.

The function of the fan cover is to protect the fan against external agents and to ensure continuous air flow over the motor fins regardless of the environmental conditions within which the motor is operating. As a natural consequence, when the cooling system is operating to promote heat dissipation, it generates acoustic noise and mechanical losses which can be caused by a combination of the friction of the fan blades through the air and ineffectual design of the fan cover's shape.

Good ventilation is key to reducing the mechanical losses, particularly for two-pole motors. Due to its high efficiency, an IE3 motor has inherently less demand for heating removal, so the ventilating system can be optimised to reduce mechanical losses and consequently acoustic noise.

WEG's design on the cooling system on these new motors was conceived using the most advanced simulation software and fluid flow analysis software, resulting in an innovative aerodynamic profile with reductions in both mechanical and acoustic noise.

TERMINAL BOX

Because the terminal box is the point of contact between the user and the motor, WEG first carried out a field survey amongst installation and maintenance experts to determine optimal design performance. This research resulted in a new terminal box concept that prioritises the interface with the user, providing easier access and handling of the power and accessory cables and ensuring more reliability and versatility in the motor installation.

The new terminal box allows improved cable housing, ensuring larger contact areas between the cables and the motor terminals and allowing correct tightening torque. The diagonal cut design of the terminal box base and the terminal box cover enables easier access to the electrical connection and gives a better view of the interior of the terminal box during installation procedures.

Using the same WEG exclusive BMC (polyester with 20% fibreglass) die-cast terminal blocks that are used for the terminal blocks of hazardous area motors ensures high electrical insulation resistance and durability. In addition, the accessory cable connections are made with quick coupling connectors.

"With a focus on designing for efficiency, coupled with the ability to understand and implement market needs, WEG W22 IE3 motors are a long-term solution to the ongoing need for energy usage reductions," Steyn concludes. wn

The first 'high speed' footage of lightning was originally captured in South Africa in 1926, using a two-lens streak camera named the Boys Camera and conducted by the Lightning Investigation Committee of the South African Institute of Electrical Engineers (Schonland, 1934). This allowed, for the first time, the microsecond development of a lightning flash to be viewed.

BY | DR CARINA SCHUMANN | DR HUGH HUNT

Since then, the technology has improved hugely, and even more can be learnt about lightning flashes. Modern high-speed camera technology (with frames per second [fps] in excess of 1,000 fps) now allow us to confirm those original observations, as well as bring newer and more detailed understanding of the lightning phenomenon. Studies have been taking place in the USA and Europe as well as in South America and Asia.

The First High Speed Video Observations of Lightning over Johannesburg, South Africa

Now, they have returned to Africa.

By understanding the physics and behaviour of lightning, we are better able to protect against it, both with regard to human lives and assets. High speed (high frame rate) videos of lightning have been an invaluable tool in the ongoing study of lightning physics. South Africa is a pioneer of such lightning research, using cameras since 1926 as well as direct current measurements on the CSIR tower (Erikkson, 1978). The University of the Witwatersrand has played an important role throughout the history of this research, and more recently the Lightning/EMC research group in the School of Electrical Engineering.

Video Observations

continues from page 19

Since January 2017, as part of collaboration with the U.S. researcher and high-speed photography expert, Tom A. Warner, three high-speed cameras have been recording lightning over Johannesburg, South Africa. The cameras are able to record up to 20,000 images per second and, using equipment provided by the Brazilian National Space Research Institute, electric field measurements are made and time-correlated with these filmed events. The collaboration also involves members of the South African Weather Service, Michelle Hartslief, Andrew van der Merwe and Morné Gijben, and their continued operation of the South African Lightning Detection Network (SALDN) (Gijben, 2012).

JOHANNESBURG AND LIGHTNING

Johannesburg is a notable city for many reasons. Not least, it's inland location and relatively high altitude. However, to those interested in lightning, the flash density in the region is probably the most interesting - about 10-15 flashes/km^2/year. This is another characteristic that makes Johannesburg unique - very few countries (even countries with much higher flash densities) have their main industry and economic centre located in an area of such high lightning activity.

Figure 1 shows a photograph of the Johannesburg skyline, taken from the north of the city and facing south. The two tall towers on either ends of the skyline are the Hillbrow (left) and Brixton (right) tower. Tall towers are always of interest when attempting to observe lightning, as they not only have a higher frequency of lightning events but also provide a known location where one is relatively certain lightning will strike. Also, unlike many tall towers in Europe and Canada, the cloud base during a storm in Johannesburg sits well above the top of the towers, making lightning events clearly visible. All these characteristics make Johannesburg a unique and relevant choice for lightning studies.

Figure 2 shows a map of Johannesburg with data obtained from the SALDN. The SALDN has been in operation since 2006 and records lightning stroke occurrences throughout South Africa (Gijben,2012). It then reports the time, location and peak current of each event. This data, recorded over a number of years, can then be used to make very accurate flash density assessments. The figure shows what is termed a 'Gaussian smoothed' flash density map and was developed using lightning data registered from 2007 to 2015 over Johannesburg city. The Gaussian smoothing allows for flash density maps independent of resolution to be created. The red colour indicates locations of higher incidence whereas green locations have less lightning. As can clearly be seen in the figure, the location of the Brixton and Hillbrow towers are clearly struck often.

WHAT CAN WE LEARN FROM HIGH SPEED VIDEO OF LIGHTNING?

The high frame rates achieved by modern high-speed cameras allow us to distinguish very particular aspects of a developing lightning event. A frame rate of 10,000 fps translates to 100 microseconds per frame. Given that the average lightning event lasts some hundreds of milliseconds, we can see how much detail is now possible. It is possible to determine whether the filmed lightning event in question was a cloud event - lightning between different charge centers within clouds - or a ground event

Figure 1 - The skyline of Johannesburg city, view from the north looking south through the city.

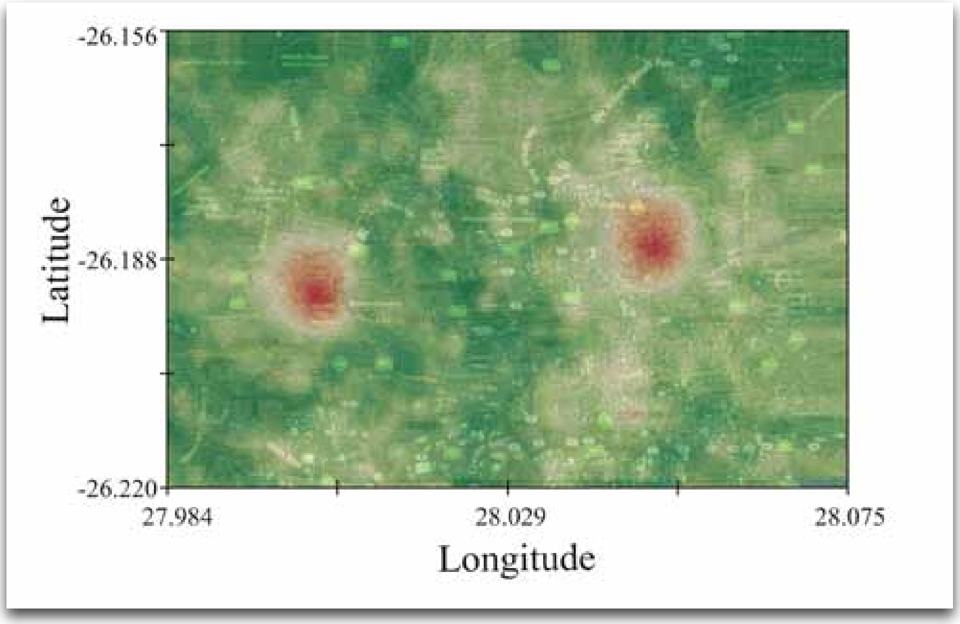


Figure 2 - Gaussian smoothed lightning density map based on SALDN data from 2007 - 2015. The Brixton and Hillbrow towers are indicated in the image and can be distinguished by the "hotspots".

- lightning between the clouds and the earth's surface. From this, it is then possible to see whether the lightning leader initiates from the cloud and travels to the ground or initiates from the ground (usually a tall structure: towers or skyscrapers) and travels into the cloud. This is known as downward and upward lightning respectively.

Figure 3 shows a sequence of frames taken from a high-speed video of a downward lightning event on February 06 at 12:14:24 GMT Time. A downward lightning event starts with a downward leader (as shown in the first 3 pictures of the sequence). The first leader of a flash is very branched. When this leader approaches the ground, an upward connecting leader from the ground (12:14:24.751 204) appears and one of the branches connects and creates a channel for the transfer of charge. The next step in the attachment process is what is known as the Return Stroke - 12:14:24.751 538. This is when the maximum transference of charge (in the order of kilo Amperes) in microseconds occurs. The current may keep transferring charges after this impulse (tens of milliseconds) and this process is called Continuous Current (CC). The continuous current is in the order of hundreds of amperes but is a longer process than the Return Stroke and is usually responsible for damage due to the heating that occurs.

During this process, some fluctuation of the current intensity may occur, and this is known as an M-Components - 12:14:24.778 463. After this current transfer ends, the flash may finish. However, after a no-current interval - 12:14:24.762 334, a subsequent downward leader may use the same channel (no branched leader - 12:14:24.776 397) to strike the same location. In Johannesburg, the team was able to see a lightning flash that hit the same location 26 times (on average, 3 times in the same flash). In some cases, the first channel dies and one of the branches from the first leader finds a new path to the ground and creates a new termination point (in Johannesburg the maximum number of termination points seen in the same flash was 3).

Within a downward or upward flash, a number of characteristics can be described and defined. For example, the duration of the initial return stroke as well as the duration of the continuing current phase. This is best described by a plot of luminosity against time, as shown in figure 4.

We can see that, as the initial return stroke occurs, the video's luminosity becomes much brighter. This is possible because the luminosity recorded in the video is proportional the current flowing in the lightning channel.

Most downward flashes are of negative polarity. The negative flashes are generally less intense than positive flashes however, negative flashes with intense return strokes have smaller durations. Positive flashes combine these two intense values - return strokes of hundreds of kilo Amperes and lasting for hundreds of milliseconds. On average, negative flashes in Johannesburg had continuous current duration lasted 28.3 milliseconds. The continuous current durations in positive flashes were about 10 times longer (230 milliseconds on average). The total average duration of a downward lightning event, for negative flashes, was 320 milliseconds.

As with downward flashes, upward flashes also have different polarities. The upward leader may start positive of negative and can initiate in two ways: self-initiation or

Video Observations

continues from page 21

Figure 3 - High speed video frames of a negative downward flash over Johannesburg.

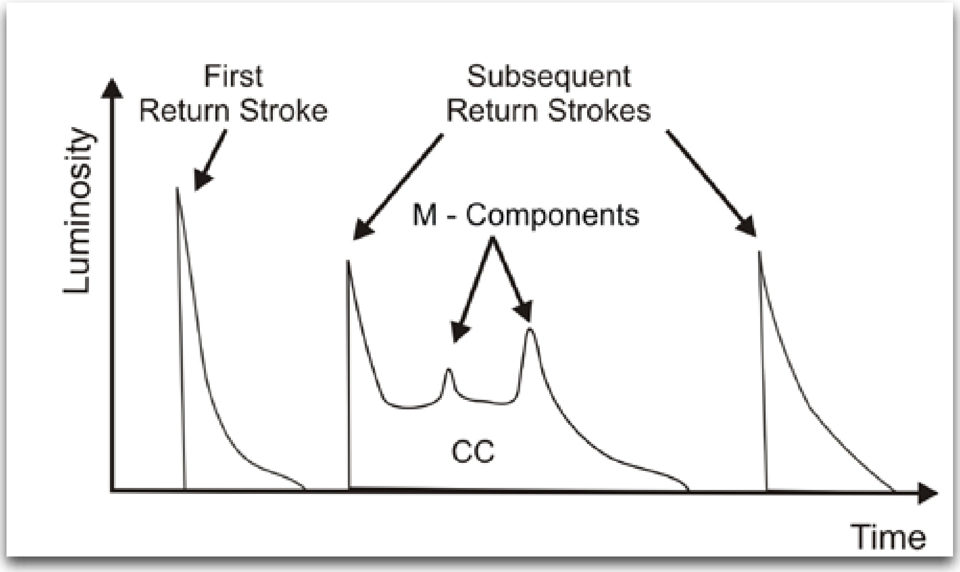


Figure 4 - Luminosity against time for a downward lightning flash.

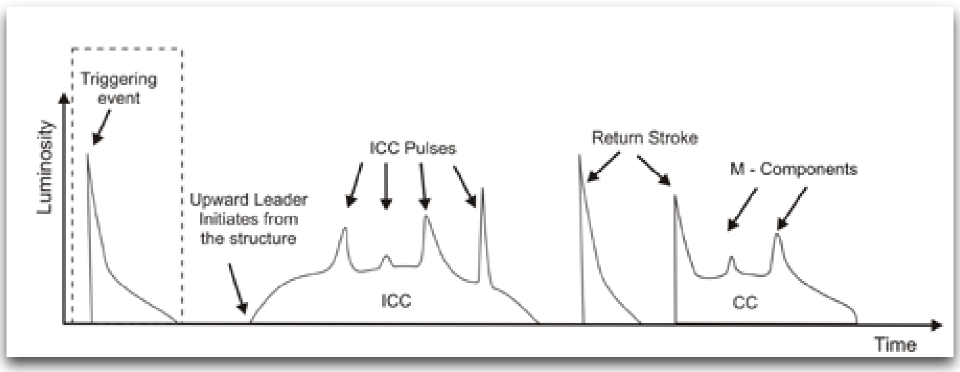


Figure 5 - Luminosity against time for an upward lightning flash.

triggered by a nearby discharge.

In Johannesburg, the team was able to observe both types. Upward leaders initiated from one of the towers (Brixton of Hillbrow) or from both towers simultaneously. In one event, even a tall building (Local TV broadcast building 125m tall) also initiated an upward leader along with the two towers.

Figure 5 shows the luminosity plot for an upward flash. Upward flashes initiate from the tower tip towards the cloud base. This initial phase is known as Initial Continuous Current (ICC) and is already transferring charge between the air and the tower. It is estimated that hundreds of Coulombs are transferred in this phase. The average duration is 405 milliseconds but can have maximum durations of 990 milliseconds (almost a second of charge transferring to the tower!). During this stage, some intense pulses may also occur, and these are designated as ICC pulses, superimposed on the ICC. After this stage the upward flash can end, or, after some tens of milliseconds, a downward leader can use the ionized channel to transfer charge to the ground (Return Stroke). These return strokes can then be followed by continuous current as in a downward flash.

IN SUMMARY

Negative downward flashes are the most common type cloud-to-ground lightning flashes. Even though they seem like single, flickering event to the naked eye, a single flash may consist of multiple strokes phases and phenomena - one of the negative flashes recorded in Johannesburg struck the ground 26 times in the same second. The duration on this type of flash is not so long, 28 milliseconds on average. Positive downward flashes are less common, but they last much longer - about 10 times more than the negative downward flashes (230 milliseconds). Upward flashes initiate from tall structures and have slightly differing physical characteristics - particularly the long lasting Initial Continuing Current (ICC). These types of flashes tend to occur on the wind turbines (due to the height) and the long continuing durations are often the cause of damage to the turbines and installed equipment. Understanding all these different characteristics and phases of a lightning event only becomes possible with the high frame rate provided by high speed video footage and studies. wn

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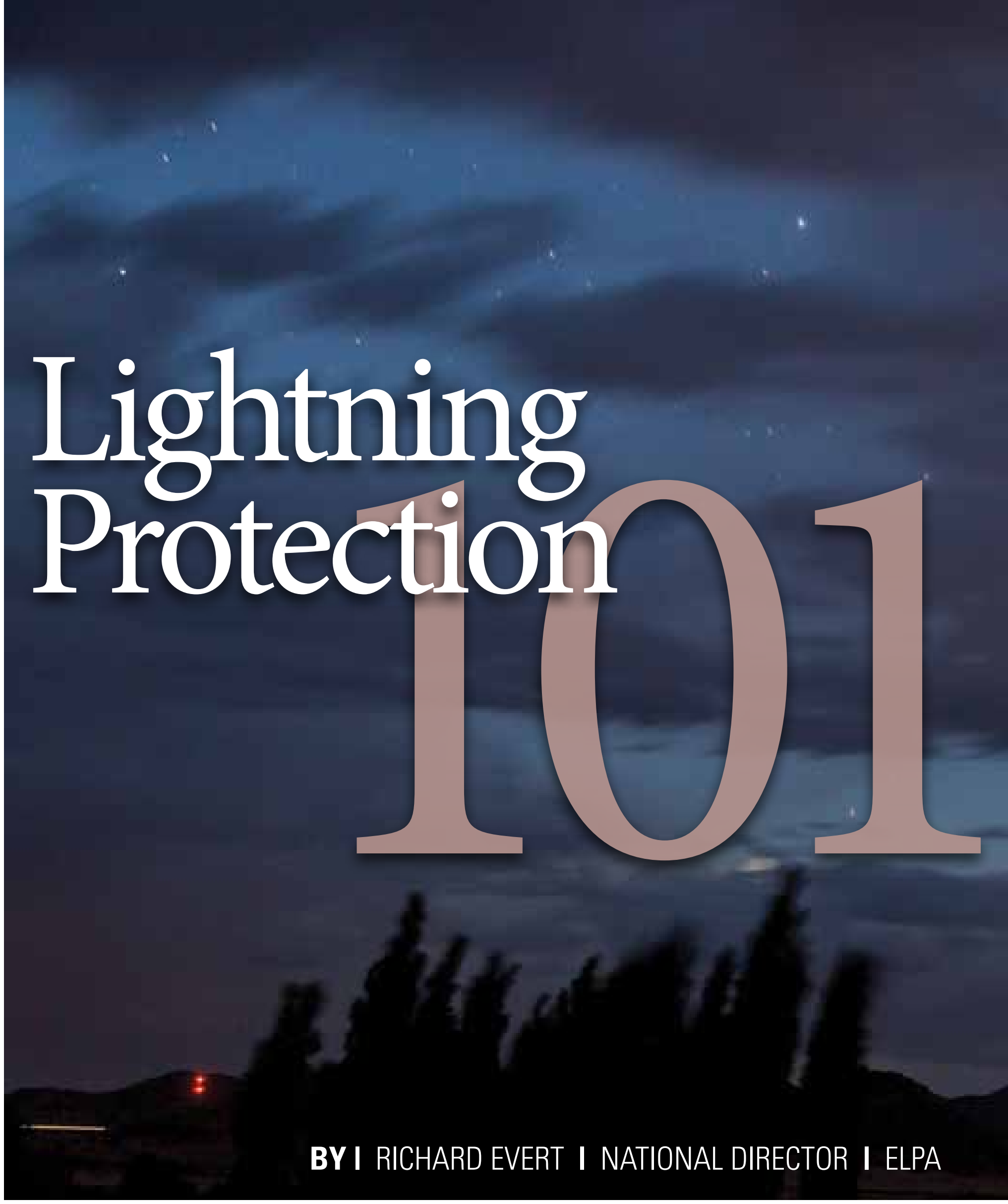
Earn CPD Credits



Lightning Protection 101

Are you, as an electrical engineer in South Africa, doing your part to eliminate the lightning threat to save lives and protect property and assets?

BY | RICHARD EVERT | NATIONAL DIRECTOR | ELPA

To protect our people, our property and our way of life, we have to be aware of our exposure to lightning.

As members of the Earthing and Lightning Protection Association (ELPA), we need all the help we can get to establish just how effective we are in South Africa. The new high-resolution ($4km^2$) updated lightning ground flash density (GFD) map was first officially released at the Earthing Africa 2017 symposium in Johannesburg in June 2017[1] in a joint submission from the South African Weather Service (SAWS) and Eskom.

The new map highlights significantly higher values in some parts of the country while the values of others remain unchanged from the old CSIR data.

The chart provides you, as an engineer in the SAIEE, with a better perspective, and empowers you to quantify the risk posed by lightning to your assets and the people using your facilities. You are obligated to quantify that risk through a "lightning risk assessment".

The SAWS owns and operates the Southern African Lightning Detection Network (SALDN), which obtains this data, and we as South Africans must hold them accountable to sustain this service so that South African electrical engineers can manage and track the effectiveness of our lightning protection systems to protect lives and property.

In the August 2017 edition of **watt**now, the SAIEE Past President, Jacob Machinjike,

mentioned the African effort to address the lightning threat.

At this early stage in my role as National Director of ELPA, I am hesitant to quote from the standards and regulations. Engineers and asset managers have their responsibilities and don't need somebody else reminding them of the clauses and paragraphs that are part of their business responsibilities.

I will therefore only tell you of the primary documents that hold you (as professional engineers) accountable for the people and property you affect, in the context of lightning:

- SANS 62305 (PROTECTION AGAINST LIGHTNING); and
- As a guide to what we expect and demand in our country: SANS 10313 concerning 62305.

As an introduction to the five parts of 62305:
"Lightning flashes too, or nearby, structures (or lines connected to the structures) are hazardous to people, to the structures themselves, their contents and installations as well as to lines.

This is why the application of lightning protection measures is essential."

Before you as an engineer, proceed with ignoring or implementing a lightning protection system, you must have a lightning risk assessment. It, therefore, stands to reason that there are many types of lightning risk assessments across the country and we need to register them.

The Certificate of Compliance (CoC) is a term many engineers, and electrical contractors understand as the affirmation that a structure is safe to use.

Together with the CoC comes a lightning protection system (LPS) installation safety report and a maintenance certificate. When are these required and how do we differentiate between those sites that need it and those that do not?

The lightning risk assessment is the tool that provides the legal basis for the need for an LPS. I am not sure that we have fully understood how simple the reasoning needs to be and just how complicated we humans have made the process.

Lightning Protection 101

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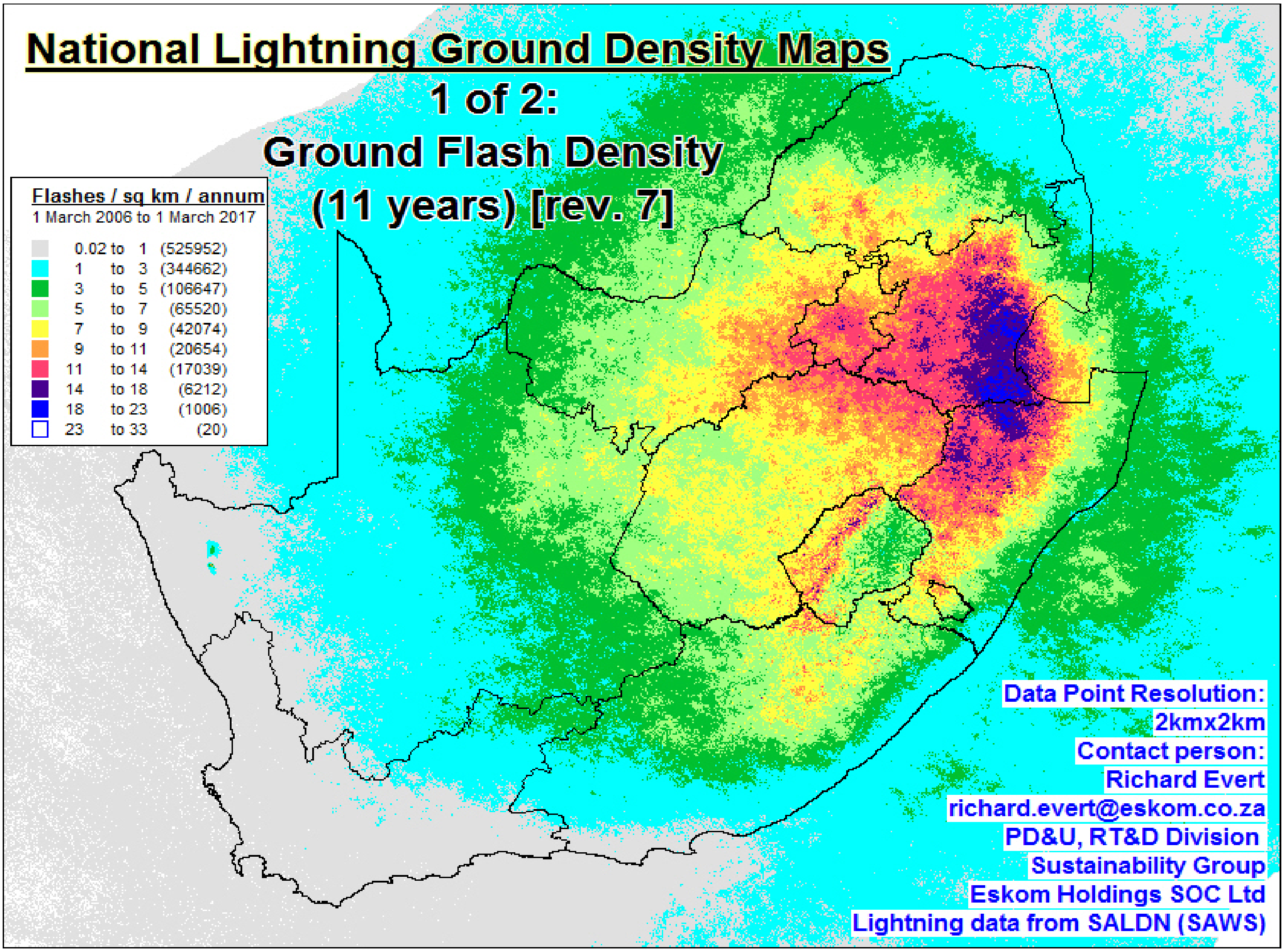


Lightning Ground Flash Density Map 2006 to 2017.

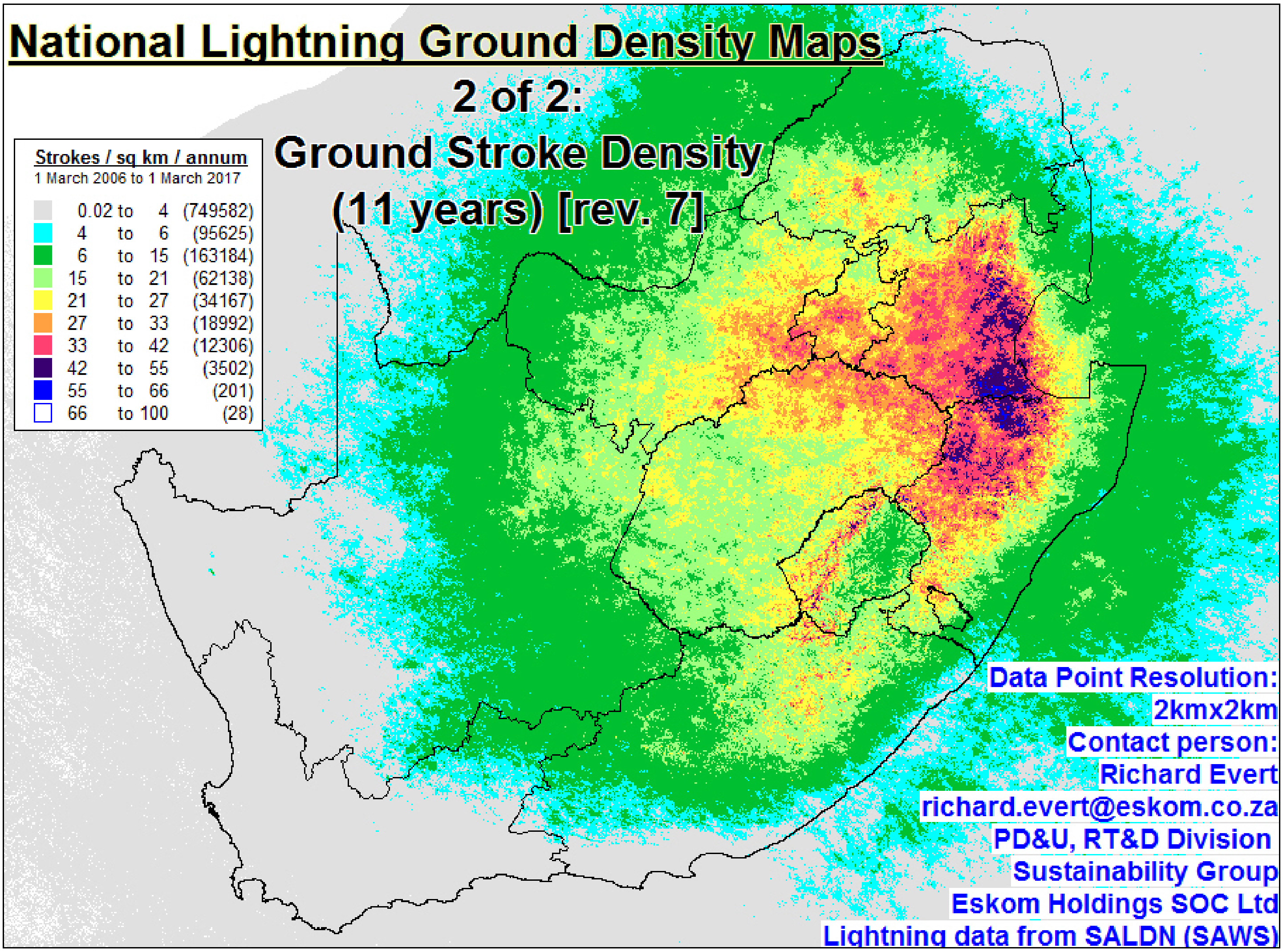
We elect to either create an "analysis paralysis" or simplify it into a "winging it" based on gut feel and available budget. At the end of the day, ignorance usually prevails:

- a rational, analytical, technical assessment with financial impact ignorance versus
- a sensible, systematic business assessment with technical impact ignorance.

Neither addresses the lives of the men and women who will use the premises nor does it discuss the long-term available life of the equipment and systems that will be used on those premises. Where our legislation and regulations may fail us right now is that we lack the clarity to apply measures required to protect human lives. Our directives frequently make use of softer words such as "may". When the lightning risk assessment indicates that there is a risk to human life the implementation has to be decisive. It is therefore imperative that the South African electrical industry take the initiative and find ways of defining and recording data so that the lightning risk throughout the country can be compared.

The record will need to:

- quantify the injuries and fatalities suffered by people across all walks of life, irrespective of whether this occurs in business or recreation; wealthy city suburbs or poor rural dwellings; mining, industry or agriculture; rail transport or pedestrians; active social



Lightning Ground Stroke Density Map 2006 to 2017.

media or isolated homesteads. We must start by recognising what we don't understand.

- quantify the condition of the lightning protection we currently available in use across South Africa. Not having any formalised lightning protection materials or any specific design only means that the protection could be minimal at best, and that protection is more an act of God than inspired by human intervention for protection.

Not having the lightning risk assessment in a country such as South Africa means that:

- you have any no engineering basis upon which to claim that the people using the premises will be 100 % safe in the event of a lightning strike at or near the premises.
- you can provide a zero per cent guarantee that any electrical and electronic systems on those premises will be safeguarded in the event of a lightning strike at or near the premises.

Simply put: without a lightning risk assessment you have nothing that will substantiate any claims that what you have done was needed to save the lives of people who would be affected if lightning should strike at or near the premises.

It, therefore, stands to reason that we need a lightning risk assessment for every premise in South Africa.

Is this expectation unreasonable? Yes, if we are going to make it difficult for engineers

Lightning Protection 101

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and electricians to deliver the outcomes and if we continue to refuse to allow the architect to influence the industry.

Annexe E of part 3 of 62305 is evident in section E.4.2.

E.4.2.1 Planning procedure: Before any detailed design work on the LPS is commenced, the lightning protection designer should where reasonably practicable, obtain necessary information regarding the function, general design, construction and location of the structure.

Where the LPS has not already been specified by the licensing authority, insurer or purchaser, the lightning protection designer should determine whether or not to protect the structure with an LPS by following the procedures for risk assessment given in IEC 62305-2.

E.4.2.2 Consultation: Regular consultations between the involved parties should result in an active LPS at the lowest possible cost.

E.4.2.2.2 The principal consulting parties:

1. *Architect;*
2. *Public Utilities;*
3. *Fire and safety authorities;*
4. *Electronic system and external antenna installers; and*
5. *Builder and installer.*

As electrical engineers in South Africa we can do our part to save lives and protect property and assets by merely insisting on a legitimate lightning risk assessment. This means the premises can be equipped with a suitable Lightning Protection System. Make it possible for others in the supply chain to implement an LPS by sharing their findings and design, thereby saving lives and assets.

For more info, visit www.elpasa.org.za.

ELPA is supported by various institutions such as Wits University, The South African Institute of Electrical Engineers (SAIEE) and the Electrical Contractors Association of South Africa (ECA) and the Department of Labour. wn

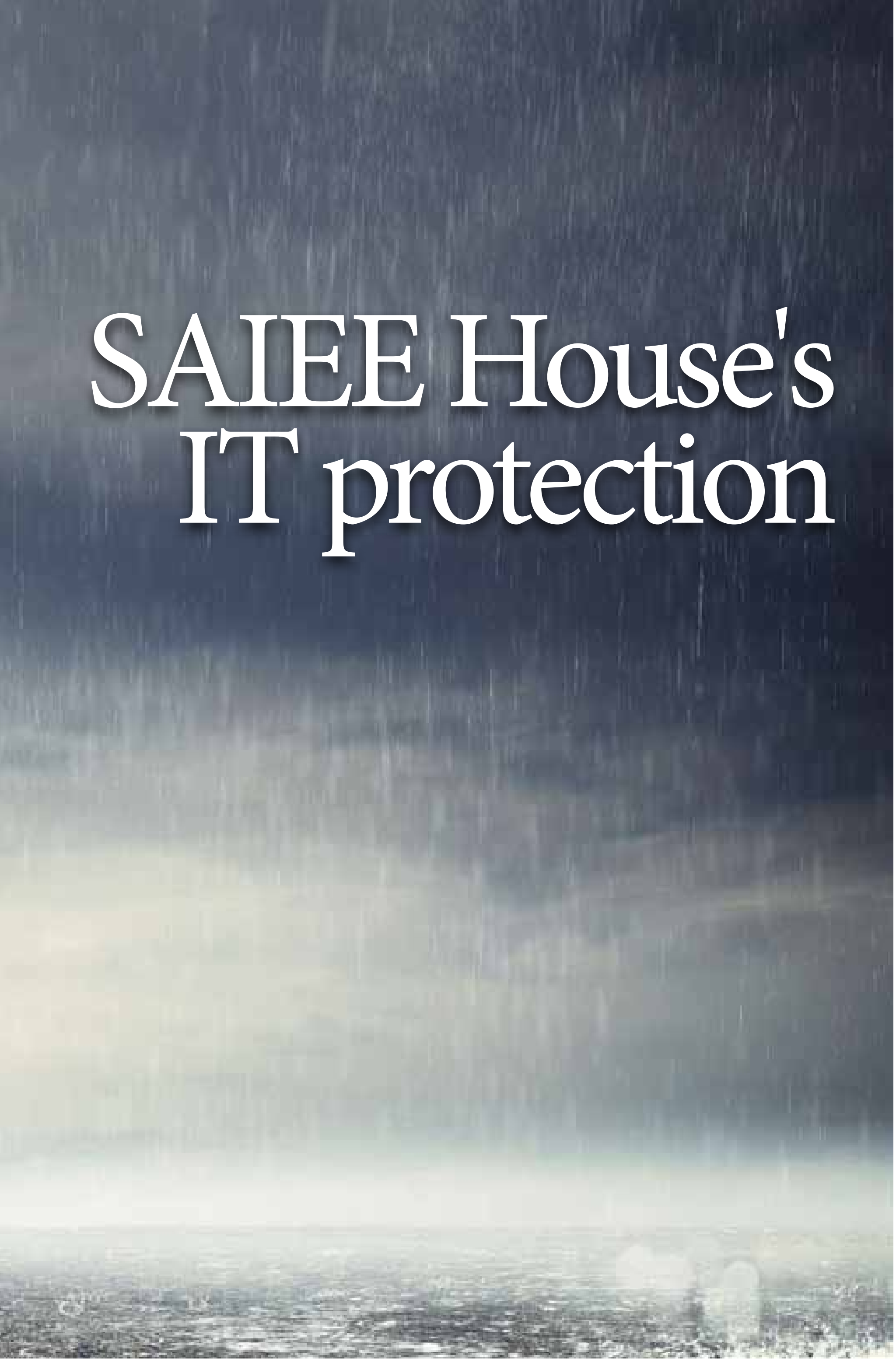
REFERENCE

1. Evert, CR; Gijben, M; *"Official South African Lightning Ground Flash Density Map 2006 to 2017"*; Earthing Africa 2017 Symposium, Johannesburg, June 2017.

However, the truth seemed to align more with the favourite trope, *"Cobbler's Children have no Shoes!"*, with which many of you are familiar with, and the surge related failures continued over several years without being adequately addressed.

At least one LAN data switch would fail along with several IP phone instruments per lightning season with the attendant disruption that this would cause. Some mitigation exercises were implemented including fitting surge protection plugs to equipment, using a local surge protection company to survey the site and replacing the metallic connection between SAIEE House and Innes House with an optical fibre connection.

Matters, however, were brought to a head when during an unseasonal winter thunderstorm in July 2016, over R200k of (insured) IT equipment was damaged.



SAIEE House's IT protection

After the completion of SAIEE House, lightning surges caused several IT system failures. One would have thought that this would be quickly corrected using the extensive experience and skills of our members.

BY | VIV CRONE | PR ENG | FSAIEE

THE BACKGROUND

SAIEE House is situated on the grounds of the South African Agency for Science and Technology Advancement (SAASTA) Johannesburg Observatory site.

The ground flash lightning density in this area is 7.5 strikes/km^2/year according to the CSIR. This compares to lightning density in Cape Town of 0.3 strikes/km^2/year. It is a fact that lightning regularly strikes the military communication tower above this site, and a significant effort was made to mitigate the effects of lightning during construction.

Thus, steps were taken to ensure that the earth bonding of SAIEE House was expertly done and the AC mains supply was protected with appropriate Surge

SAIEE House's IT Protection

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Figure 1: Example of earth bonding at SAIEE House.

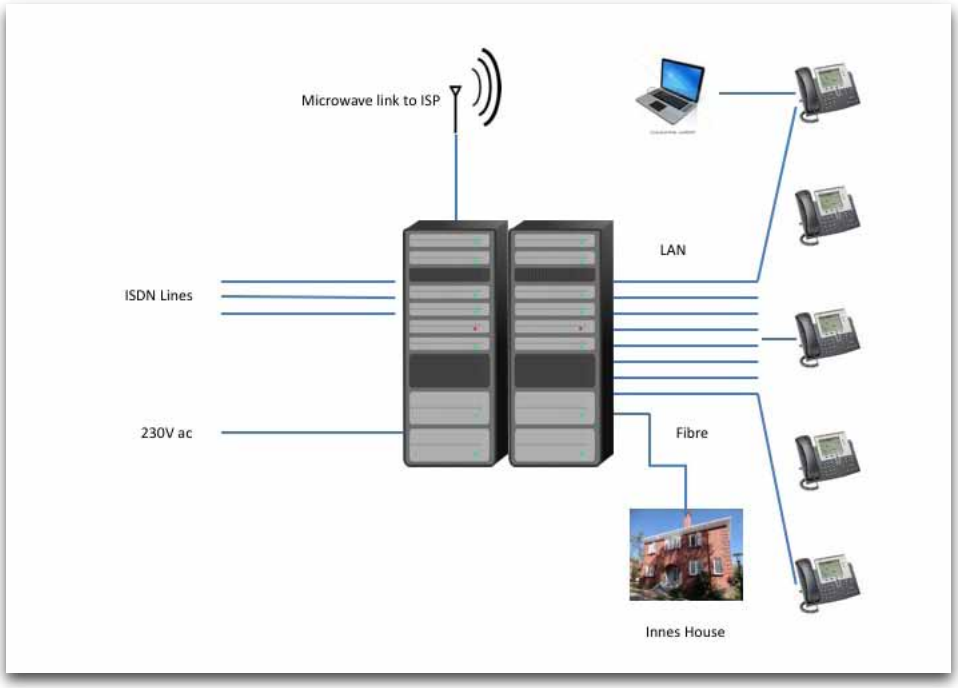

Figure 2: Diagram of SAIEE House IT Network.

Protection Devices (SPDs) fitted to the main building incoming distribution board.

SAIEE IT SYSTEM OVERVIEW

The SAIEE IT system is centralised in a dedicated room on the ground floor of the building. The servers and other CIT equipment are fitted into two 43U 19" racks.

A single physical Local Area Network (LAN) connects to staff workstations and WiFi access points in the SAIEE buildings. This single physical LAN is configured with several virtual LANs, each dedicated to a specific service. For example, the IP phone system, guest data network, private data network, etc.

Three rack-mounted, POE (Power Over Ethernet) 24 port data switches are used. Connections to the offices are via metallic cables (CAT 5 UTP) running in cable racks and the data cable channels of the power skirting of the building. The maximum length of these LAN links is limited to about 100m.

Workstations each have a POE IP phone connected to the LAN. Workstation computers are connected to the LAN via the built-in IP Phone data switch.

Connection to the internet is via a microwave radio link, with the antenna mounted on the outside of the building, and the telephone service is connected via 3 ISDN lines.

Figure 2 shows a diagrammatic overview of the system.

THE INVESTIGATION

An initial investigation was conducted, which covered several areas:

BUILDING BONDING

It was ascertained that the building metal roof and gutters were effectively bonded to earth at several points.

SERVER ROOM EQUIPMENT RACKS

The server-room equipment rack frames were neither connected to earth nor connected to each other which was a significant problem! Further, some of the equipment chassis were also not positively connected to the rack frames.

Typical of many small server room installations that have 'grown' over the years, the wiring was untidy and definitely

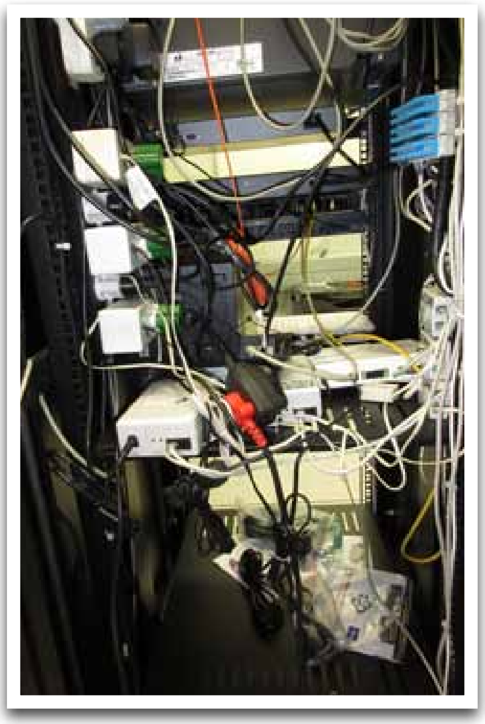

Figure 3: Showing unacceptable rack wiring.

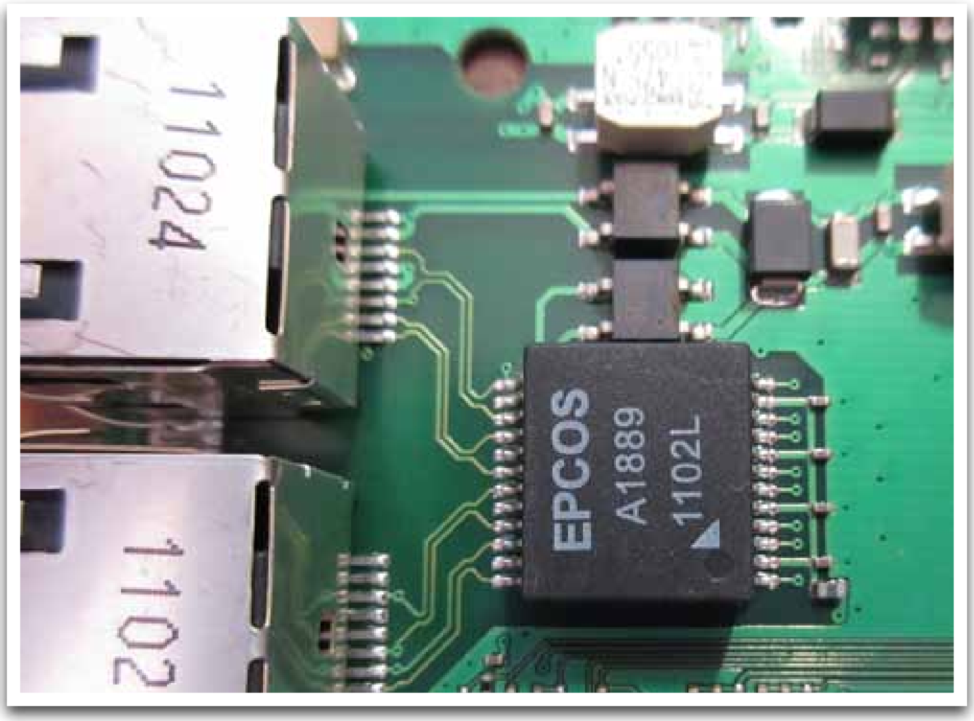

Figure 4: view showing IP Phone PCB area close to ethernet connections.

not to best practice industry standards.

Different metallic connections comprising old ADSL and analogue facsimile lines, ISDN lines and the microwave connection cable to the dish antenna all entered the server room at different locations and via different paths.

MAINS SUPPLY AND SURGE PROTECTION

Although SPDs are fitted to the main building distribution board, there were no SPDs fitted to the sub-board that feeds the server room.

Power to the IT equipment was via plug-in connections to the power skirting in the server room. Combination AC and data surge protection devices were fitted to the ISDN modems.

LAN CONNECTIONS

The LAN workstation and WiFI access point connections use CAT 5e cable connected from the data switches via patch panels, building cable-ways and the data cable channels of the building power skirting. There was no surge protection fitted to the LAN connections.

INNES HOUSE FIBRE CONNECTION

Several years ago, the metallic LAN connection to Innes House was replaced with an optical fibre link to improve surge resistance. However, a fault in this fibre link had resulted in the metallic

CAT5e cable connection being re-instated. Any advantage provided by the non-metallic fibre connection was therefore lost!

WORKSTATION CONNECTIONS

At each workstation, the LAN is connected to the IP Phone unit. The phone has a built-in data switch and provides a second port for a LAN connection to a computer.

Although several the IP phones had failed, no computer or laptop connected to the phone data switch had failed.

THE ANALYSIS

Once the survey of the site had been completed, the task was to assemble this and other information into a coherent view.

Talking to the system administrator and other staff members, the universal story of failures due to 'power surges' had emerged. However, on closer examination, an entirely different picture emerged!

SAIEE House's IT Protection

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By far, the absolute failures were the server room data switches and workstation IP telephones. Several of the faulty IP phone instruments and server-room data switches were analysed, stripped and examined for damage.

DATA SWITCHES

Five failed data switches, from two different manufacturers, were obtained for analysis from the SAIEE system administrator. There were no power related failures on any of the examined switches. i.e. all power supplies operated normally.

On powering up the switches, various failures were observed. These included a mix of indications, including FAULT, POE, PWR, etc. Importantly, no physical surge damage was observed inside the units.

IP PHONES

Four of the failed IP phones were also stripped and diagnosed to identify the failure mode.

The PCB was scrutinised with a jeweller's loupe. Again, no physical damage was observed in any of the phones.

RACK EQUIPMENT CONNECTED TO DATA SWITCHES

None of the IT systems connected to the server side of the data switches failed due to surges. These included servers, microwave link modem and the IP telephone system (PABX).

THE SUMMARY

The above observations were summarised as follows:

- there were no supply power equipment related failures in the failed equipment. (e.g. data switch power supplies)
- equipment failures were isolated to those parts of the equipment connected to the building LAN only.
- failures appeared on both sides of the building LAN connections. i.e. the data switch LAN ports and the IP telephone LAN data port.
- no physical damage would indicate high energy surges being present and no evidence that any breakdown to earth had occurred.

This led to the following conclusions:
The evidence suggested that longitudinal surges induced on the LAN wiring, from nearby lightning flashes, were the primary cause of failures.

These, in turn, would appear as transient surges directly across connected equipment, depending on the symmetry of the CAT5e cables.

Although these surges were large enough to cause electronic failures, they were large enough to result in any observable physical damage in the failed equipment.

Although the surge protection on the mains supply was considered by some not to be adequate, there was no evidence to support that power surges had caused any failures.

THE PLAN

Given the above evidence and observations, it was decided to address the problem by implementing primary surge mitigation as a start and then only apply fixes to the areas that had failed.

EQUIPMENT BONDING

A key target to mitigate the effects of surges is to create an equipotential structure that reduces the voltage stress across different pieces of equipment in the presence of a surge. This means electrically bonding all equipment chassis, rack frames and cableway racks together at several points.
The total structure would then be adequately bonded to the power earth to mitigate touch safety issues.

LAN SURGE PROTECTION

From the above, it was concluded that the damaging surges on the LAN cables manifested themselves as transverse voltage levels.

Internet research revealed that rack mounted Ethernet surge arrestor units compatible with POE were available. It was decided to fit these in the server room.

RACK WIRING

Rack wiring would generally be neatened up and old cables and services to be removed (e.g. ADSL and analogue facsimile connections) to reduce the number of metallic connections to the external environment.

INNES HOUSE FIBRE LINK

The optical fibre link between SAIEE House and Innes House would be restored to mitigate any surges originating from this link.

FURTHER AREAS

Several other areas were also identified for the second stage of improvements should the above actions proved to be inadequate. This included fitting surge protection to the IP phone side of the LAN connections, coordinating mains protection SPDs throughout SAIEE House and fitting surge protection to the microwave link antenna connection.

THE IMPLEMENTATION

A team comprising Stan Bridgens, Wayne Fisher, Calvin La Camera and the writer was put together. To avoid affecting the operations of the SAIEE the above plan was implemented on a Saturday. As activities were interspersed with general Engineering chats and pizzas, this exercise took most of the day but was completed by beer time!

THE RESULT AND CONCLUSION

The planned modifications and additions were implemented in September 2016, just before the beginning of the lightning season.

Since then, through two complete lightning seasons, there has not been a single surge-caused failure of any of the IT equipment.
The cost of this exercise was minimal. The only significant cost was the purchase of the LAN protection modules.

So, while realising that a future close lightning strike may still cause failures, the above illustrates that a sound engineering approach aimed at the basics has proven successful in reducing lightning induced failures. wn

Figure 5: SAIEE Server Room Equipment.

Earn CPD Credits

Manufacturing and Testing

Power stations are installed at a point of location generally hundreds or thousands of kilometres away from the consumers, hence a vast transmission line network between generating point and consumer load centre is needed. It has been seen in practice that generation voltages at the power stations are in the range of 10 to 15 kV. It is a fact that when power is transmitted through overhead lines, some of the power it carries dissipates in the line conductor as I^2R in the form of heat, where 'I' is the current drawn by the line conductor and 'R' is the line resistance.

It is not economical to try to reduce these losses by decreasing the conductor resistance, because this would require a substantial increase in the cross-sectional area of the conductor, resulting in huge expenses of copper material. It is precisely to reduce the power loss and the cost of line conductors that transformers are used. The transformer, while leaving the transmitted power unchanged, decreases the current by increasing the voltage and the loss which is proportional to the square of the current (I^2) is thus sharply reduced. For example, a ten-fold increase in supply voltage reduces the power by a factor of one hundred.

At the beginning of the power transmission line adjacent to the generating station, the line voltage is raised by a step-up transformer and at the end of the line the voltage is lowered by series of step-down transformers to a value convenient for the consumers (400 V or similiar).

A prime role in the present day power station is played by power transformers that are used to raise or lower the voltage in the power supply network which serve to transmit electric power over great distances and distribute it among consumers.

BY I ROBIN W COOMBS I PR.TECH.ENG. I MSAIEE

PRINCIPLE OF OPERATION

The transformer is an electromagnetic conversion device in which electrical energy received by the primary winding is first converted into magnetic energy which is reconverted back into a useful electrical energy in other circuits (secondary winding, tertiary winding, etc.).

According to Faraday's Laws of Electromagnetic Induction, if an alternating voltage is applied to one winding placed in a closed magnetic circuit, an alternating flux will generate in the magnetic loop.

If the magnetic circuit has more than one winding, each winding will link the flux and will generate an Electro Motive Force (EMF). The magnitude of

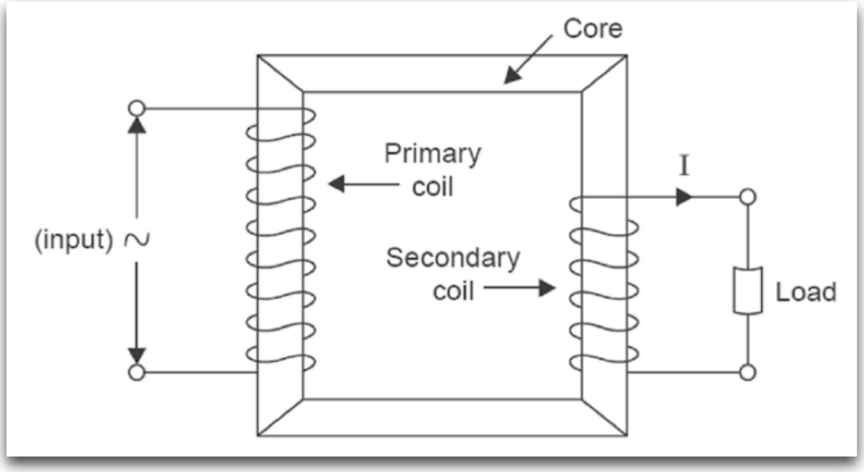

Fig. 1 - Primary coil is energized, secondary coil is loaded.

Transformer Testing

continues from page 37

Fig. 2 - Typical oil immersed transformer.

EMF depends upon the number of turns in each winding and amount of flux generated in the magnetic circuit. Since the flux around the windings is the same and the only variable is the number of turns in the windings, the induced EMF in the windings is directly proportional to their turns.

In a transformer action if the power is kept the same, the primary and secondary voltages and currents are inversely proportional. In other words, in the process of transformation, a voltage is decreased or increased with proportional increase and decrease of current respectively. The coil which receive voltage from source is called the primary coil and the other coil which is magnetically induced to generate EMF is called the secondary coil.

CONSTRUCTION SOLUTIONS

There are three principal constructions of power transformers which differ according to the insulation system type:

- Oil immersed transformer;
- Cast Resin Transformer (CRT); and
- Dry type transformer.

OIL IMMERSED TRANSFORMER

The insulating system of an oil immersed transformer is composed of oil and solid materials such as pressed cardboard and diamond dotted paper.

The oil immersed transformer system can be of hermetically sealed or expansion type (which defines oil transformers with conservator). In the first case the oil can never get in touch with the air, while in the second case the air passage in the conservator is through a moisture filter.

The core and windings are completely immersed in oil, which works as both main insulator and heat transfer fluid.

On this type of transformers protection accessories such as Buchholz relay, over-pressure valve, oil level indicator and oil temperature indicator can be installed.

The tank which contains the live parts of the transformer allows for both indoor and outdoor installation, without adopting special environmental protection for electrical components.

CAST RESIN TRANSFORMER

The insulating system of a cast resin transformer is completely different from the one previously described and is composed of solid material and air.

The high voltage winding is completely encapsulated in a cast epoxy resin cylinder that guarantees excellent electrical and mechanical strength, while air works as an insulating system and heat transfer medium.

Low voltage windings are made of pre-impregnated insulation materials which

Fig. 3 - Typical cast resin transformer.

harden during the heating process in an oven cement and guarantee a perfect withstand to short-circuit.

The winding connections of this transformer are directly accessible, for this reason it is essential to take precautions to avoid direct contact. These transformers are usually installed indoors or outdoors with the use of an enclosure that meets the required protection rating against dust and moisture ingress.

On this type of transformer probes are installed (typically Pt100 type) for temperature control and are connected to a digital temperature controller/display. No other particular monitoring accessories are required.

DRY TYPE TRANSFORMER

This type of solution is very similar to the previous one, as the insulating system is composed of solid materials and air.

Both windings are insulated with pre-impregnated materials or with materials

Fig. 4 - Typical dry type transformer.

Fig. 5 - View of the lamination of the core.

that will be subjected to impregnation.

As for the previous solution, these transformers are usually installed inside or outside with the use of appropriate enclosure protection.

Temperature probes are also typically installed on this type of transformers connected to a temperature controller/ display. No other particular monitoring accessories are required.

Nowadays, this type of transformer is mainly used for low voltage applications.

MAIN COMPONENTS

Power transformers are composed by three main components:

- Magnetic core;
- LV windings; and
- HV windings.

In this article we will have a look in detail at the components of the Cast Resin Transformer.

MAGNETIC CORE

The basic core material is electrical steel and is available in the form of thin laminated sheet, commercially known as Cold Rolled Grain Oriented (CRGO) Silicon Steel.

This material has an excellent magnetic property of high permeability and low hysteresis loss at reasonable operating flux density, which is 1.6 Tesla.

When a coil is placed in a closed magnetic circuit and is energized with an alternating voltage, a magnetic loss occurs in the core material which is commercially known as 'Core Loss'. Core loss has two components: Hysteresis Loss and Eddy Current Loss.

Hysteresis Loss depends upon the quality of the magnetic material at the operating flux density, frequency of the system and weight of core material.

Eddy Current Loss is inversely proportional to the thickness of the laminated sheet and that is why we have seen a mark improvement of the availability of thinner sheet, in the range of 0.18 mm, 0.23 mm, 0.27 mm, 0.30 mm, 0.35 mm. Each laminated sheet is insulated on either side by a thin oxide film, commonly known as 'Carlite film'.

The laminations available from mills are in the form of rolls of steel. After the steel is produced in the mill, it is annealed at a temperature of 800 to 900°C. This is done to get the magnetic grain uniform in line with the rolling direction.

To minimize the Eddy Current Loss, the core laminations are made thin. In order to build a stack core, it is assembled layer by layer in staggered manner.

During the process of assembly one has to take utmost care towards joints and ensure that the joints between lamination are free from air gap.

The magnetic properties of the steel determine the no-load losses, the no-load current and the noise produced by the core during the operation of the transformer.

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Fig. 6 - Typical cast resin low voltage winding.

Fig. 7 - Typical high Voltage Winding.

Once assembled, the core is covered with a special resin to guarantee an anti-corrosion protection.

LOW VOLTAGE WINDINGS

The low voltage windings can be made of aluminum or copper conductors and are characterized by high currents and great cross-section conductors.

A typical low voltage winding consists of two terminal bars welded to a foil conductor.

Each turn is insulated from the next one by interposition of class F insulating material.

At the end of the winding phase, coils are subjected to a heating process in order to allow the polymerization of the insulating material and guarantee high strength against forces produced by short circuit.

HIGH VOLTAGE WINDINGS

The high voltage windings can be made of aluminum or copper conductors and characterized by lower currents and smaller cross-section conductors compared to low voltage windings.

The high voltage winding consists of a number of series connected individual "pancake" windings. Each layer is a foil conductor winding separated by a single or double layer of class F insulating material.

The internal and external moulds are wrapped with a fiberglass mesh in order to guarantee high mechanical resistance.

VACUUM CASTING SYSTEM

The high voltage windings are cast with epoxy resin reinforced with fiberglass matting under vacuum.

The class F fire resistant resin is made in three parts:

- a bisphenol based epoxy resin with a suitable viscosity to ensure proper impregnation of the windings;
- an anhydride hardener with a flexible additive to prevent cracking;
- an active filler consisting of silica and trihydrate alumina is mixed with the resin and the hardener to reinforce the mechanical strength and heat dissipation.

The addition of trihydrate alumina guarantees the intrinsic fire resistance by three anti-fire effects:

- refracting shield of Alumina;
- barrier to water vapour; and
- temperature held below flash point.

The trihydrate alumina and the silica are vacuum dried and degassed to eliminate all traces of humidity and air.

Half of this is mixed with the resin and the other half with the hardener to produce

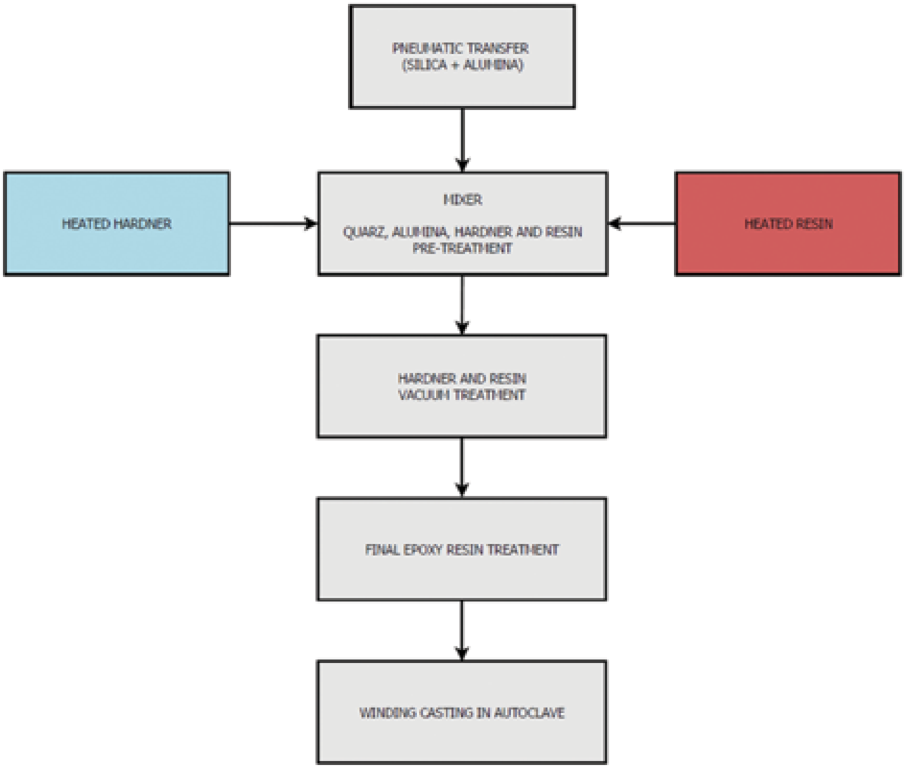

Fig. 8 - Casting system flow chart.

two homogenous premixes. A thin film degassing precedes the final mixing.

The windings are placed into a mould and then placed in an auto-clave and heated to 80°C. The mixed resin is then poured under vacuum into the casting.

During this process, if any unfilled spaces are seen at the top of the moulds through the window they are topped up whist still under vacuum. The polymerisation cycle begins with a gelification at 80°C and ends with a long polymerisation at 140°C.

These temperatures are close to the expected transformer temperatures in service and thus eliminate mechanical stresses which lead to the cracking of the coating.

Fig. 9 - Autoclave for high voltage coils.

Once the castings have cooled down the resin impregnated coils are removed from the moulds and taken to the assembly area. It is imperative that there are no voids in the casting as this will cause cracking and failure due to air and moisture expansion when heated. This will likely result in partial discharge occurring and subsequent failure of the coil.

TRANSFORMER ASSEMBLY

In order to proceed with the final mounting operation of the transformer, the operator proceeds with removing the superior yoke of the core.

The low voltage windings are placed over each column onto spacers, which fixes the air gap between core and coil, and is fixed to the core using insulating support slats.

This gap provides electrical clearance as well as a path for the air cooling flow.

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Fig. 10 - Magnetic core.

Fig. 11 - Low and high voltage windings mounted around the core.

Fig. 12 - Completed cast resin transformer ready for test.

The high voltage windings are placed over the secondary windings onto spacers leaving an air gap between them. This gap provides electrical clearance between the coils as well as space for air cooling flow.

At the end, the top core limb is mounted in order to close the magnetic circuit and the clamps and spacers are installed over the top core limb.

TRANSFORMER TESTING

Testing is a crucial process for a transformer, verifying that it meets its guaranteed performances and is ready to function under specified circumstances.

Power transformers belong to the class of equipment that is specifically designed and manufactured in accordance with the customers' technical specifications, which also invoke international standards.

Most contracts require an individual and very specific design study to be performed. Accordingly, the requirements of the customer must be validated by means of a comprehensive series of tests performed at the end of the manufacturing process and prior to shipment to site.

Testing serves to:

- validate the design;
- validate the manufacturing process;
- compare the measurements with the technical data specification; and
- establish a "finger print" of the transformer useful for comparison with future measurements made during the lifetime of the equipment (SFRA, capacitance, insulation resistance, etc.).

The test program is established in compliance with the contractual documents in order to demonstrate the ability of the transformer for operation and to confirm the technical aspects of the contractual terms.

The standards distinguish three types of tests:

- Routine Tests
  Tests to which each individual transformer is subjected.
- Type Tests (or design tests)
  Tests performed on one transformer which is representative for other transformers to demonstrate that these transformers comply with requirements not covered by routine tests.
- Special Tests (or other tests)
  Tests other than routine and type tests agreed between the manufacturer and the purchaser. Special tests are not necessarily standardized.

TESTS IN ACCORDANCE WITH IEC 60076-11 (SANS 60076-11)

ROUTINE TESTS AS PER IEC 60076-11

- Measurement of winding resistance
- Measurement of voltage ratio and check of phase displacement
- Measurement of short-circuit impedance and load loss
- Measurement of no-load loss and current
- Separate-source AC withstand voltage test
- Induced AC withstand voltage test
- Partial discharge measurement

TYPE TESTS

- Temperature-rise type test (IEC 60076-2)
- Lightning impulse test as (IEC 60076-3)

SPECIAL TESTS

- Partial discharge measurement (IEC 60076-11)
- Short circuit test (IEC 60076-5)
- Determination of sound level (IEC 60076-10)
- Environmental test (IEC 60076-11)
- Climatic test (incorporating thermal shock) (IEC 60076-11)
- Fire behaviour test (IEC 60076-11).

The two main type tests that are normally requested by customers are the lightning impulse test and the temperature rise test.

The full wave lightning impulse test is a type test for transformer with Um ≤ 72.5 kV and shall be carried out on the line terminals using a negative polarity impulse 1,2 ± 30 % / 50 ± 20 % µs.

The test sequence shall consist of:

- one reference impulse of a voltage between 50 % and 70 % of the full test voltage; and
- three subsequent impulses at full voltage.

The test is successful if there are no significant differences between voltage and current transients recorded from the reference impulse and those recorded at the full test voltage. Temperature rise is established by a simulated load method combining the short-circuited test (load loss) and the open circuit test (no-load loss).

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The winding short-circuited test shall be performed with rated current flowing in one winding and the other winding short-circuited and shall continue until the steady state condition of the windings and magnetic core are reached.

The winding temperature rise, $\Delta\theta_c$ shall be established by the rise in resistance method or by superposition.

The open-circuit test, at rated voltage and rated frequency, shall be continued until steady state condition of the winding and magnetic core is obtained, individual winding temperature rises, $\Delta\theta_e$ shall then be measured.

The total winding temperature rises are obtained combining these values and must be in accordance with IEC 60076-11.

	$U_m \leq$ 72,5 kV	72,5 kV $< U_m \leq$ 170 kV		$U_m >$ 170 kV
Insulation	Uniform	Uniform	Non-uniform	Uniform and non-uniform
Full wave lightning impulse test for the line terminals (LI)	Type	Routine	Routine	Not applicable (included in LIC)
Chopped wave lightning impulse test for the line terminals (LIC)	Special	Special	Special	Routine
Lightning impulse test for the neutral terminals (LIN)	Special	Special	Special	Special
Switching impulse test for the line terminal (SI)	Not applicable	Special	Special	Routine
Applied voltage test (AV)	Routine	Routine	Routine	Routine
Induced voltage withstand test (IVW)	Routine	Routine	Routine	Not applicable
Induced voltage test with PD measurement (IVPD)	Special[a]	Routine[a]	Routine[a]	Routine
Line terminal AC withstand voltage test (LTAC)	Not applicable	Special	Routine[b]	Special
Auxiliary wiring insulation test (AuxW)	Routine	Routine	Routine	Routine

[a] The requirements of the IVW test can be incorporated in the IVPD test so that only one test is required.

[b] The LTAC test for this category of transformers can be replaced by a switching impulse test by agreement between manufacturer and purchaser.

Fig. 13 - Dielectric tests for different categories of windings as per IEC 60076-3.

CLIMATIC, ENVIRONMENTAL AND FIRE BEHAVIOUR CLASSES

Two climatic classes are defined:

- Class C1: The transformer is suitable for operation at ambient temperature not below –5°C but may be exposed during transport and storage to ambient temperatures down to –25°C; and
- Class C2: The transformer is suitable for operation, transport and storage at ambient temperatures down to –25°C.

Environmental conditions for dry-type transformers are identified in terms of humidity, condensation, pollution and ambient temperature.

These are important not only during service but also during storage before installation. With regard to humidity, condensation and pollution, three different environmental classes are defined:

- Class E0: No condensation occurs on the transformers and pollution is negligible. This is commonly achieved in a clean, dry indoor installation.
- Class E1: Occasional condensation can occur on the transformer (for example, when the transformer is de-energized). Limited pollution is possible.
- Class E2: Frequent condensation or heavy pollution or combination of both.

Two fire behaviour classes are defined:

- Class F0: There is no special fire risk to consider. Except for the characteristics inherent in the design of the transformer, no special measures are taken to limit flammability. Nevertheless, the emission of toxic substances and opaque smoke shall be minimized.
- Class F1: Transformers subject to a fire hazard. Restricted flammability is required. The emission of toxic substances and opaque smokes shall be minimized.

Considering for example the class E2-C2-F1, the following test must be carried out. Environmental test E2, which includes a condensation test and a humidity penetration test.

For the condensation test, the transformer shall be placed in a test chamber in which temperature and humidity are kept under control in order to ensure condensation on the transformer.

The humidity in the chamber shall be maintained above 93 % and the conductivity of the water shall be in the range of 0.5 S/m to 1.5 S/m.

Transformer shall be energized at a voltage of 1,1 times the rated voltage for a period of 15 minutes, during the voltage application, no flashover shall occur and visual inspection shall not show any serious tracking.

Transformer type	Insulation system temperature, °C (thermal class in brackets)	Maximum value of temperature, °C	
		Copper	Aluminium
Oil-immersed	105 (A)	250	200
Dry	105 (A)	180	180
	120 (E)	250	200
	130 (B)	350	200
	155 (F)	350	200
	180 (H)	350	200
	200	350	200
	220	350	200
NOTE 1 In the case of windings made of high tensile strength aluminium alloys, higher maximum values of temperature, but not exceeding those relevant to copper, may be allowed by agreement between the manufacturer and the purchaser.			
NOTE 2 When insulation systems other than thermal class A are employed in oil-immersed transformers, different maximum values of temperature may be allowed by agreement between the manufacturer and the purchaser.			

Fig. 14 - Maximum permissible values of the average temperature of the winding after short circuit.

At the beginning of the humidity penetration test, the transformer shall be in a dry condition. It shall be installed in a de-energized condition and held in the climatic chamber for 144 hours.

The temperature of the climatic chamber shall be held at (50 ±3) °C and the relative humidity held at (90 ±5) %.

At the end of this period and after 3 hours in normal ambient conditions at the latest, the transformer shall be subjected to the separate-source AC withstand voltage test and the induced AC withstand voltage test, but at voltages reduced to 80 % of the standardized values.

There should be neither flashover nor breakdown during the dielectric tests and visual inspection shall not show any serious tracking.

Climatic test C2 includes a thermal shock test, the transformer shall be placed in the chamber, the temperature shall be gradually decreased to (–25 ± 3) °C in 8 hours and then maintained at this value for at least 12 hours until steady state condition has been reached.

A thermal shock shall then be performed by applying a current equal to twice the rated current to the winding under test (contained in solid insulation).

The current shall be maintained until the winding under test reaches a mean temperature corresponding to the average winding temperature rise plus 40 °C (maximum ambient temperature in normal service conditions). The mean temperature reached by the windings shall be determined by resistance variation. The thermal shock should be performed by applying one of the following methods.

After the thermal shock, the transformer shall be brought back to a temperature of (25 ± 10) °C.

At least 12 hours after the end of the thermal shock test, the transformer shall be submitted to the dielectric routine tests (separate-source and induced overvoltage withstand tests), in accordance with the insulation level of the windings, but at voltages reduced to 80 % of the standard values.

In addition, for transformers having windings contained within solid insulation, partial discharge measurements shall be carried out. The test voltage shall not exceed the test voltage of the reduced induced overvoltage withstand test (160 % of the rated value) and the measured values shall not exceed those prescribed for routine tests. When visually inspected, the windings shall show no visible abnormality, such as cracks or slits.

Fire behaviour test F1 includes a fire test, the test shall be carried out on one complete phase of a transformer comprising HV and LV coils, core leg and insulation components, without enclosure, if any.

The core leg may be replaced by material of approximately similar dimensions and thermal behaviour as the original core leg. The yoke shall not be considered and the LV terminal leads cut at upper and lower end coil level.

The test object shall be considered to have passed the test if it meets the following criteria:

a) The temperature rise above the ambient temperature of the gases in the measuring section in the chimney shall not exceed 420 ˚K throughout the test.
b) 5 min after the radiant panel is switched off (45 minutes after the beginning of the test), the temperature rise above the

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ambient temperature of the gases in the measuring section in the chimney shall not exceed 140 ˚K and it shall decrease when measured over time periods of 10 minutes.

c) The temperature rise of the gases in the measuring section in the chimney shall not exceed 80 ˚K after 60 minutes from the beginning of the test. These conditions are assumed to demonstrate that the fire had ceased to burn. A higher temperature rise may be allowed if the stored thermal energy prevents the temperature drop with natural airflow.

d) The arithmetic mean of the optical transmission factor of light in the measuring section, referred to an optical path through smoke of 1 m, between 20 minutes and 60 minutes after the beginning of the test shall be not less than 20 % (indicative).

SHORT-CIRCUIT TEST

(special test)

The short-circuit test includes two different test in order to evaluate the thermal and the dynamics withstand.

According to the standard, the thermal ability to withstand short circuit shall be demonstrated by calculating the maximum temperature reached at the end of the short circuit.

The maximum temperature must be in accordance with the following values:

- The ability to withstand the dynamic effects of short circuit shall be demonstrated by test or by calculation and design and manufacture considerations.

When a short-circuit test is selected, a short-circuit connection is mounted on the low voltage side and the test is performed suppling the high voltage side with a duration of 0.5 sec for transformer with power from 25 to 2 500 kVA and of 0.25 sec for transformer with power from 2 501 to 100 000 kVA.

Before the short-circuit testing, measurements and tests shall be carried out according to the standard and the gas-and-oil actuated relay (if any) inspected. These measurements and tests serve as references for the detection of faults.

During each test (including preliminary tests), oscillographic recordings shall be taken of applied voltage and currents.

After completion of the tests, the results of the short-circuit reactance measurements and the oscillograms taken during the different stages of the tests shall be examined for any indication of possible anomalies during the tests, especially any indications of change in the short-circuit reactance and a visual inspection must be done.

The short-circuit reactance values, in ohms, evaluated for each phase at the end of the tests, do not differ from the original values by more than:

- 2 % for transformers with circular concentric coils and sandwich non-circular coils. However, for transformers having metal foil as a conductor in the low-voltage winding and with rated power up to 10 000 kVA, higher values, not exceeding 4 %, are acceptable for transformers with a short-circuit impedance of 3 % or more. If the short-circuit impedance is less than 3 %, the above limit of 4 % is subject to agreement between the manufacturer and the purchaser;
- 7.5 % for transformers with non-circular concentric coils having a short-circuit impedance of 3 % or more. The value of 7.5 % may be reduced by agreement between the manufacturer and the purchaser, but not below 4 %.

DETERMINATION OF SOUND LEVEL

(special test)

One of many parameters considered for transformers is the sound level that they emit under service conditions.

There are two significant values for the noise: sound power and pressure level.

The core is the main source of transformer noise, this noise is a buzzing and it caused by the phenomenon that is called magnetostriction.

Magnetostriction causes the grain of the material to change their shape or dimensions during the process of magnetization of the core.

Load noise is caused by vibrations in magnetic shields, and transformer windings due to the electromagnetic forces resulting from leakage fields produced by load currents.

Generally the sound power of the winding noise is only a small contribution to the total noise of the transformer. Furthermore cooling system devices usually contribute more to the total noise of transformer than load noise.

The standard reference for the sound level measurement is IEC 60076-10. Sound level measurements have been developed to quantify pressure variation in air that a human ear can detect.

The smallest pressure variation that a human ear can detect is 20µ Pascal. This was set as the reference level to which all other levels are compared, it was fixed as zero level for the A-weighting dB unit. The standard provides complex explanations of the sound pressure and power levels.

Let's simplify them:
SOUND PRESSURE LEVEL: is a pressure disturbance in the atmosphere whose intensity is influenced not only by the strength of the source, but also by the surroundings and the distance from the source to the receiver. Sound pressure is what our ears hear, what sound level meters measure.

SOUND POWER LEVEL: is the acoustical energy emitted by the sound source. It is not affected by the environment and independent of distance to the receiver.

Let's consider this example:
The speaker represents the source of sound and has its own sound power, 75 dB(A). The farther I move from the speaker, the less sound pressure my ear receive.

In order to correctly compare two sources of sound, only the sound power should be considered.

MEASUREMENT PROCEDURE
(point-by-point as per IEC 60076-10)

For the point-by-point procedure, the microphone positions shall be on the prescribed contour, equally spaced and not more than 1 metre apart, which is the dimension D.

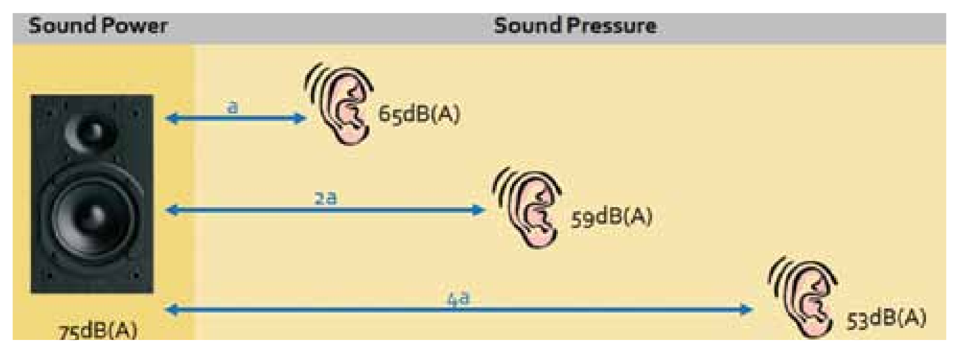

Fig. 15 - Sound pressure and sound power variation.

There shall be a minimum of 8 microphone positions and measuring duration shall be a minimum of 3 seconds for each position.

The distances between the measuring points and transformer are: 1 metre for cast resin transformers and 0.3 metres for oil transformers.

The measured values are adjusted considering the background noise with de-energized transformer and used to calculate an average value of sound power and sound pressure.

The permissible combinations are:
a) transformer at no-load excitation without cooling device(s);
b) transformer at no-load excitation with cooling device(s);
c) transformer at load current in short-circuit condition without cooling device(s);
d) transformer at load current in short-circuit condition with cooling device(s); or
e) cooling device(s) only.

The typical configuration, without any special request, is the option A.

Considering a sound pressure range from rustling leaves to a jet engine during takeoff operation, a transformer is placed in a central position, between 50 and 75 dBA.

PARTIAL DISCHARGE MEASUREMENT
(routine and special test)
Due to its construction, the dielectric material is not void free, and contains air especially between the paper layers. This can permit partial discharges activity, starting from a voltage of about 1.3-1.5 per unit of the rated voltage.

Depending upon their inception levels, partial discharges can cause an erosion process throughout the insulation lifetime, probably initiated by an over voltage event or some mechanical damage. The process can be very slow but continuously increasing in intensity.

However, the by-products of the erosion process remain trapped in the solid dielectric, and the problem remains localized for a long time, whilst the bulk of the dielectric remains in satisfactory condition.

Partial discharge measurements shall be

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performed on all dry-type transformer windings having Um ≥ 3.6 kV. A basic measuring circuit for the partial discharge test is shown in Fig. 18.

In the Figures, a partial discharge-free high voltage capacitor, C of suitable voltage rating (having a capacitance value large in comparison with the calibration generator capacitance, C_0) in series with a detection impedance, Z_m, is connected to each of the high-voltage winding terminals.

The partial discharge measurement shall be carried out after all dielectric tests are completed. The low-voltage winding shall be supplied from a three-phase or single-phase source, depending on whether the transformer itself is three-phase or single-phase. The voltage shall be as near as possible of sine-wave form and of a frequency suitably increased above the rated frequency to avoid excessive excitation current during the test. A phase-to-phase pre-stress voltage of 1.8 U_r shall be induced for 30 seconds where U_r is the rated voltage, followed without interruption by a phase-to-phase voltage of 1.3 U_r for 3 minutes, during which the partial discharge shall be measured. The maximum level of partial discharges shall be 10 pC.

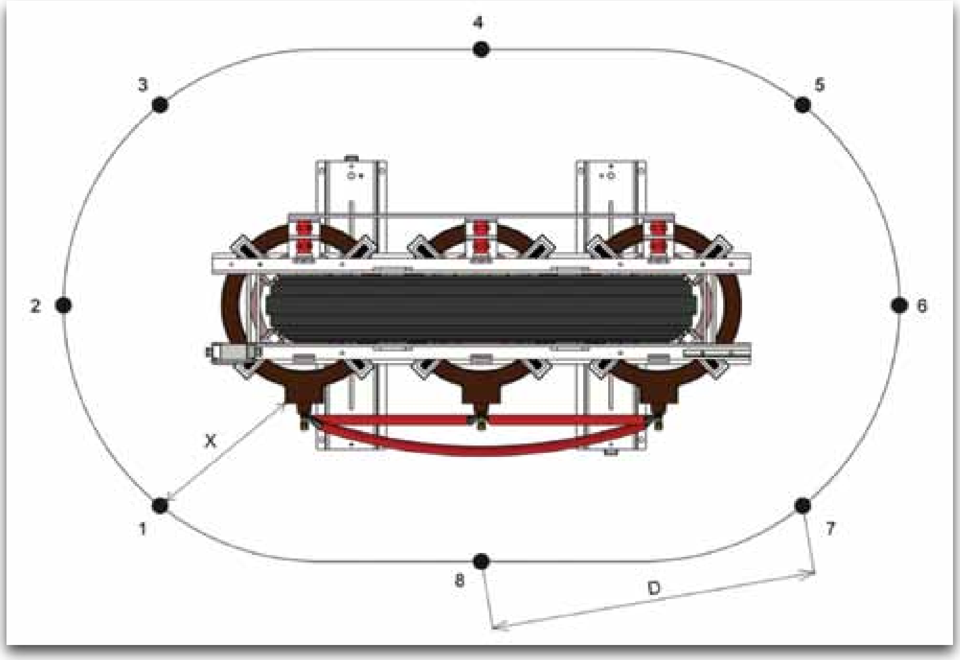

Fig. 16 - Microphone positions for point-by-point measurement.

Lp dB(A)	Noise level	Example
0	Healthy hearing threshold	-
20	Extremely low noise	Rustling leaves
40	Very low noise	Computer hum
From 50 to 75	Moderate noisy	Transformer hum
80	Very noisy	City traffic
100	Extremely noisy	Symphony orchestra or a tractor
140	Threshold of perceptibility	Jet engine at takeoff

Fig. 17 - Example of sound pressure values produced by different sources.

<u>MEASUREMENT OF DISSIPATION FACTOR</u>(tan δ)

The condition of the insulation is essential for secure and reliable operation of the transformer. Measuring capacitance and dissipation/power factor helps to determine the insulation condition in bushings or between windings. Changes in capacitance can, for example, indicate mechanical displacements of windings or partial breakdown in bushings. Aging and degradation of the insulation, coupled with the ingress of water, increase the amount of energy that is converted to heat in the insulation. The rate of these losses is measured as dissipation factor.

Insulation power factor is the ratio of the power dissipated in the insulation (in watts) to the product of the effective voltage and current (in voltamperes) when tested under a sinusoidal voltage.

The dissipation factor (tan δ) , corrected to 20°C, are usually less than or equal to 0.5%. The cleanliness of bushings and surface or the moisture level may influence the results.

COOLING CONSIDERATION

Transformers are typically designed to operate at a maximum ambient temperature of 40°C with a maximum temperature rise of the windings at full

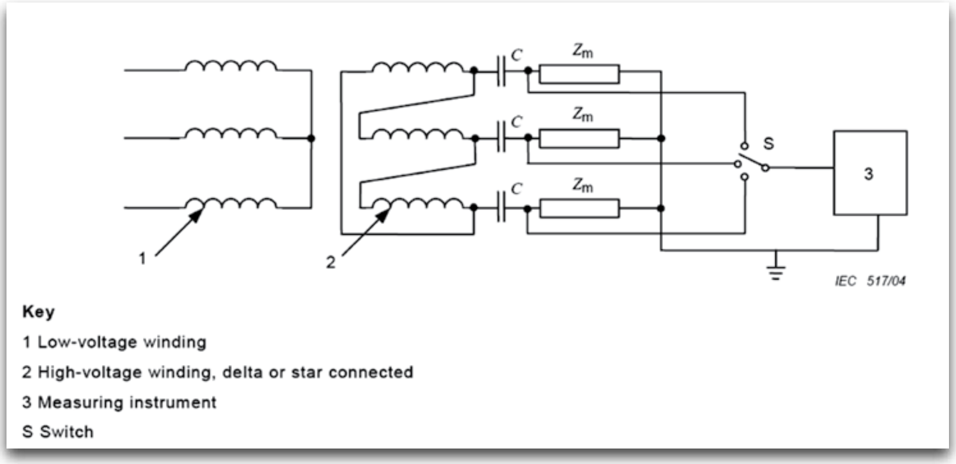

Fig. 18 - Basic measuring circuit for the partial discharge test for a three-phase transformer

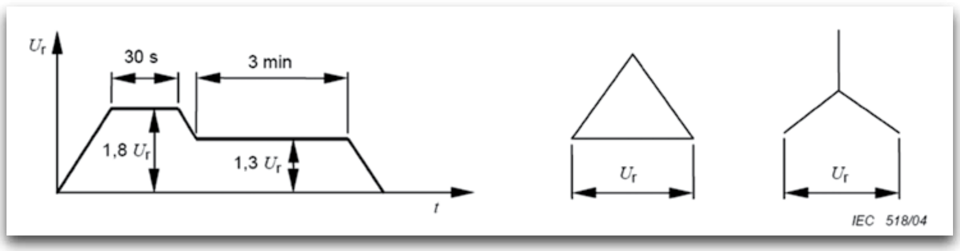

Fig. 19 - Voltage application for routine partial discharge test.

load of 100˚C (insulation system class F). These values can be adjusted in the design stage of the transformer to meet specific requirements or for operation at higher ambient temperature.

The cast resin transformers in particular are prone to increased risk of failure if there is insufficient cooling. The installation must take into consideration a proper air flow and an operating ambient temperature that does not exceed the maximum design temperature. Due to convection, cooling air enters the transformer from the bottom, passes through the gaps between the core and the LV/MV windings and exits out from the top. When a transformer is installed in an enclosure or directly into a room, sufficient ventilation must be provided with air inlet/s positioned at the bottom of the room.

The air outlet must be at the highest point of the room or enclosure, it must be greater in cross section area than the inlet vent by 10 % and should be situated on the opposite wall to the inlet.

It is imperative to avoid hot air accumulation, for natural convection ventilation the opening cross section can be calculated as follows:

$$S = \frac{0.18\ x\ P}{\sqrt{H}}$$

$$S_1 = 1.1\ x\ S$$

Where:

- P = Sum of no-load losses and load losses at 120°C (kW);
- S = Net inlet surface (m^2);
- S1 = Net outlet surface (m^2);
- H = Height between the two openings (m).

If the natural cooling cannot be realized, a forced ventilation must be installed with a suggested air flow of 3 – 4 m^3 / minute for every kW of total losses.

This air flow can be supplied from one or more fans and controlled by a thermostat or by the digital temperature controller. Usually the cast resin transformer is provided with PT100 temperature sensors inside each phase of the low voltage windings. They are typically in tubes to facilitate replacement if necessary. These sensors are connected directly to the digital temperature controller that gives alarm and trip signals according to the set thresholds. In order to prevent overheating, the type of load to be supplied, the maximum actual ambient temperatures, the presence of harmonics and overloads must be considered during the design stage.

CAST RESIN VS OIL IMMERSED TRANSFORMER

The cast resin transformer is not flammable and is made of self-extinguished materials in accordance to the standard and the F1 certification. While the oil immersed transformer is not.

In fact the oil immersed transformers are particularly flammable due to the presence of mineral oil, so special civil works such as: barriers, containment tanks and fire extinguishing system are necessary.

Furthermore, the mineral oil contained in tank makes oil immersed transformers a risk to the environment in case of leakage. However, transformers with high power and voltage levels can only be manufactured using insulating oil.

Thanks to the better heat transfer

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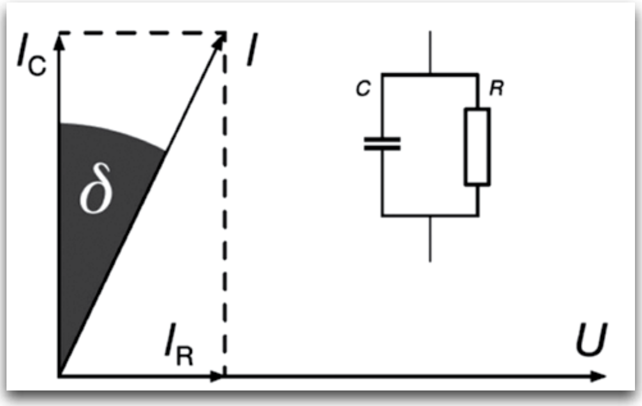

Fig. 20 - Tan δ angle diagram.

characteristics, oil immersed transformers are more suitable to withstand short-term overloads than cast resin transformers.

Thanks to the presence of the oil and the tank, the noise produced by the live parts is attenuated. This makes oil immersed transformers quieter than cast resin transformers.

However, oil transformers require more frequent maintenance to check the absence of leakages, the status of the gaskets and the correct functioning of the protection devices.

Oil immersed transformers can easily be installed outdoor, while cast resin transformers require special enclosures to protect the live parts from rain and dust.

Moreover, oil transformers are more suitable to be installed in critical areas, for example: in environments with high level of corrosion or areas with explosive atmosphere (ATEX). However, thanks to the absence of flammable and polluting oil, cast resin transformers are suitable for the installation in vulnerable areas such as: hospitals, data centers, hotels, mines and public buildings.

Finally, thanks to the more efficient cooling and insulating system, oil immersed transformers are more compact than cast resin transformers. wn

OIL IMMERSED vs CAST RESIN		
Made of self-extinguishing materials	NO	YES
Civil engineering (barriers and oil containment system) and fire extinguishing system	YES	NO
Environmental pollution production	YES	NO
Suitable for high power and high voltage levels	YES	NO
Attitude to withstand short-term overload	YES	NO
Reduced noise emissions	YES	NO
Regular maintenance required	YES	NO
Suitable for outdoor installation	YES	NO
Suitable for installation in hazardous areas	YES	NO
Flexible installation	NO	YES
Reduced installation dimensions	YES	NO

Fig. 21 - Comparative table.

Earn CPD Credits

Ball Lightning

Ball lightning has long been a matter of much speculation as well as scepticism. Scientific study of this phenomenon has been hampered by its brief and unpredictable appearances.

BY | DUDLEY BASSON

Sightings of ball lightning have been recorded since the time of the ancient Greeks.

Spectrographic analysis of the phenomenon would be invaluable but is almost impossible to obtain due to its unpredictability.

From the thousands of sightings of ball lightning, the following characteristics have emerged:

- they usually occur immediately after a lightning strike to earth;
- they are fuzzy spherical with a size of 1 cm to100 cm but are usually reported to be from orange-size to football-size;
- they can be of a variety of colours and are bright enough to be visible in daylight;
- they can exist from less than a second to more than a minute;
- they usually move slowly horizontally but can also move erratically or vertically;
- they sometimes have an affinity for metal objects, moving along wires or fences;
- they are sometimes seen to move through closed doors or windows and have even been seen to enter and leave a metal aircraft;
- they have also been seen to enter and leave houses through chimneys, presumably moved by air currents. They have even been seen to emerge from electric wall sockets and from banks of submarine storage batteries;
- when it is time for their disappearance this can either be a fizzle or a violent explosion, sometimes accompanied by odours of ozone, burning sulphur or nitrogen oxides.

Pioneering work on lightning flashes was undertaken by the famous South African scientist Basil Schonland.

Basil Ferdinand Jamieson Schönland (1896-1972) was born in Grahamstown to Selmar Schönland and Flora MacOwan. In 1910 he matriculated at the age of 14 from St Andrew's College as the top pupil in the Cape Province. He went on to Rhodes University and then to Gonville and Caius College, Cambridge, in the years 1914-15 and 1919-20. During the war years 1916-18 he served with the Signals Services of the Royal Engineers in France. He was wounded at Arras, northern France mentioned in despatches and awarded the Order of the British Empire.

In 1923 Schönland married Isabel Craib (known as Ismay) who bore him a son and two daughters.

Schönland was initially sceptical of the existence of ball lightning, until 1928, while spending a scolarship year at the Cavendish Laboratory of Cambridge, he encountered Pyotr Kapitza (1894-1984), who was an acknowledged expert on the interactions between plasmas and electromagnetic fields. Kapitza is also known for his work on superfluidity and the Kapitza pendulum – an upside-down pendulum which illustrates dynamic stabilization.

Although Schönland was not convinced by Kapitza's theory of ball lightning, the large number of reports of the phenomenon convinced Schonland of its existence. Most people however do not even know of someone who has witnessed ball lightning. To a gathering in Manchester, he put

Ball Lightning

continues from page 53

A 1901 illustration depicts ball lightning.

forward an explanation for the 'luminous soap bubble' that had been observed, more than once, in areas of dry, weathered rock.

It is possible to explain these reports if the luminous ball was, in fact, a slowly burning bubble of reactive gas, such as hydrogen, nitrous oxide, active nitrogen, oxygen or methane. Combustion for a few seconds may have been maintained by catalysts of hot pulverised material, carbon or rock dust, created by the same agency as the gases. This agency could only be the exceptionally heavy current of the return stroke flowing some distance along the earth in wet fissures in the ground selected for its path in preference to resistive rock. Such a selective flow of the heavy ground current is well established and some stream beds retain evidence of it in the magnetism of their rocky sides.

It would be many years before another theory of ball lightning would be proposed.

During the exciting period between 1937 and 1939 Schönland pursued the study of lightning at the University of the Witwatersrand, where he was also the founding director of the Bernard Price Institute of Geophysics. The high incidence of lightning on the Highveld provided ample material for his research which saw him chasing storms, photographing lightning and measuring the electrical fields under thunderclouds.

His work was internationally regarded as the greatest advance in the field since Benjamin Franklin's work in the late 18th century. In 1938 Schönland was appointed as a Fellow of the Royal Society.

In 1939, with war in Europe imminent, Schonland assembled his design team to commence work on producing South Africa's own Radar. The team members were: G R Bozzoli of Wits, W E Phillips of Natal University and N H Roberts of the University of Cape Town. This research and development was of major significance to the war effort. This has been described in some detail in the November 2014 issue of **watt**now.

In 1945, with the war at an end, and the United Nations Charter finalized, South African Prime Minister Smuts laid down his responsibilities in Britain. Seeing the need for a scientific research institute in South Africa, he sent a secret telegram to J H Hofmeyr, who acted as deputy Prime Minister and also took particular responsibility for scientific research in South Africa. In his telegram Smuts wrote: *"I think I have found our future director of scientific research . . . Brigadier Schönland who is in charge of all scientific work at the War Office. Both as administrator and as scientist he is held in highest esteem here, and risk is that unless we appoint him in time he may be offered post-war appointment by War Office. Do you approve my approaching him for post-war appointment as Director?"*

Schönland accepted the appointment as founding director of the South African Council of Scientific and Industrial Research (CSIR) but also stipulated that he wished to resume his directorship of the Bernard Price Institute.

An officer who served under him in the AORG (Army Operational Research Group) commented: *I think the first difficulty for posterity will be to get as good a man as the Brigadier to be in charge. He*

must be a good research scientist but not one whose interest is solely in his own line of research, he must be young in mind and active, he must suffer fools gladly, he must get on well with army officers, and above all he must be entirely outside political and departmental intrigues (though it is an advantage for him to be conversant with the elementary principles of these arts). The Brigadier had all these qualities but it will be damned difficult to find them combined in one man again for the next war.

Schönland became Director (1958-1961) of the UK's atomic energy research establishment at Harwell. He was knighted by Queen Elizabeth II in 1960 for his services to British science.

A most significant honour came to Schönland in 1962 when the Institution of Electrical Engineers in London awarded him the prestigious Faraday Medal, for the outstanding part he played in the development of electrical science and engineering, in particular in the field of nuclear power.

Schönland used the occasion to pay tribute to his many colleagues at Harwell who had worked alongside him in securing for Britain its pre-eminent position in the fields of nuclear power. He singled out one man to whom he owed so much: Bernard Price, *"a great Englishman and a great engineer who helped to finance the institute for geophysical research, which bears his name, at a time when such things were rare"*. The Nuclear Physics Research Unit of the University of the Witwatersrand, Johannesburg, founded in 1956 by Friedel Sellschop, mentee of Prof Schönland, was renamed the Schönland Research Centre in 1984.

Sir Basil Schönland

Brigadier Sir Basil Schönland died on 24 November 1972 in Winchester, United Kingdom.

In 1999 Schönland was nominated in South Africa as Scientist of the Century.

Scientist John Lowke of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) has proposed a theory which focuses on how ball lightning occurs in houses and aircraft – and how it can pass through glass. His theory also proposes that ball lightning is caused when leftover ions, which are very dense, are swept to the ground following a lightning strike. Lowke commented: *"A crucial proof of any theory of ball lightning would be if the theory could be used to make ball lightning. This is the first paper which gives a mathematical solution explaining the initiation of ball lighting."*

Lowke proposed that ball lightning occurs in houses and aircraft when a stream of ions accumulates on the outside of a glass window and the resulting electric field on the other side excites air molecules to form a ball discharge. The discharge requires a driving electric field of about a million volts.

In 1996 Spanish scientists Dr Antonio Ranada and Dr Jose Trueba of Universidad Complutense de Madrid (established in 1293), building on Dr Kapitsa's theory, built a theory by combining the Navier-Stokes equation describing the motions of fluids, with the Maxwell equation for magnetic fields. This theory suggested that after an ordinary lightning strike, the lines of magnetic force created by a huge current of electricity sometimes link with each other as an electromagnetic mathematical knot, strong enough to confine a ball of glowing plasma - hence a lightning ball. Dr Martin Uman, a lightning expert at the University of Florida raised an objection to this theory saying that a plasma of 30 000 K would appear as a dazzling white light which is not what is observed, and that such a hot plasma would rise vertically and not move horizontally as is often observed.

Dr Y. H. Ohtsuki, a physicist at Waseda University in Tokyo, devised an apparatus to test Dr Kapitsa's theory, and in 1991 he and an associate reported in Nature that they had created plasma fireballs. These balls "exhibited certain properties that match eyewitness accounts of ball lightning, such as motion against the wind and ability to pass through a wall intact." The balls were created in a metal chamber into which an intense microwave beam was ducted. The scientists created floating fireballs of various colours that persisted for up to several minutes, sometimes splitting into two balls.

Ball Lightning

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At the 10th International Symposium on Ball Lightning (ISBL-8), 7-12 July 2008, Kaliningrad Russia, it was shown that multi-layer toroidal magnetic surfaces containing the plasma in a tokamak could transform to a crescent and eventually a sphere.

A theory, proposed in the 1990s, suggests that ball lightning is a plasma held together by magnetic fields arranged in rings that link together into a mathematical knot. *"Because it's linked up in this tight way, it can't really fall apart,"* says physicist David Hall of Amherst College in Massachusetts. *"That could provide a reason why ball lightning survives as long as it does."*

A magnetic field does not have an existence of its own. It is always another view of the charged particle current that produces it, or by an oscillating electric field as in electromagnetic radiation. When describing magnetic fields as threads this implies current vortex filaments. Quantum particles with spin can also behave like magnets.

Pioneering work on mathematical knots was done by Scottish scientist Peter Guthrie Tait (1831-1901), a lifelong friend of Maxwell and who collaborated with Lord Kelvin in his Atomic Vortex Theory. The threads of mathematical knots are always closed loops which cannot be untied, but can fall apart when viewed from higher dimensions. Knot theory and Kelvin's vortex atoms (which have revived as superstrings) have been described in the November 2016 issue of **watt**now. Knotted rings can be illustrated by Borromean rings – three rings linked together. When any one of the rings is removed, the other two fall apart.

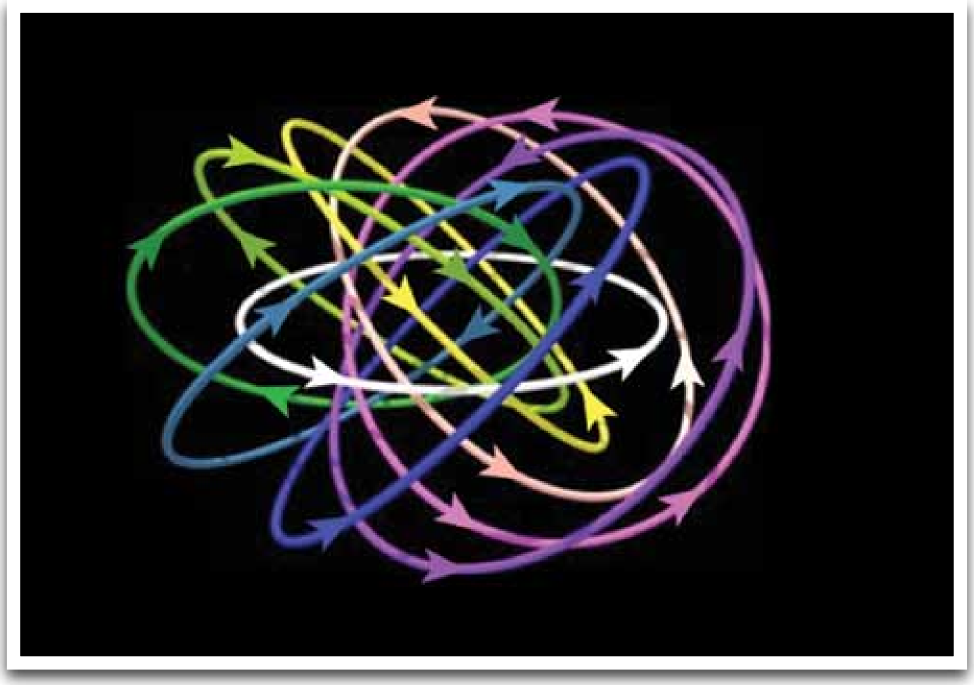
Physicist David Hall and colleagues from Amherst College in Massachusetts have created an analogue of the linked magnetic rings of ball lightning in a knotted structure known as a skyrmion.

Simulated magnetic fields produced by a 3D skyrmion are arranged into linked rings. The arrangement matches that of the magnetic fields proposed to explain ball lightning.

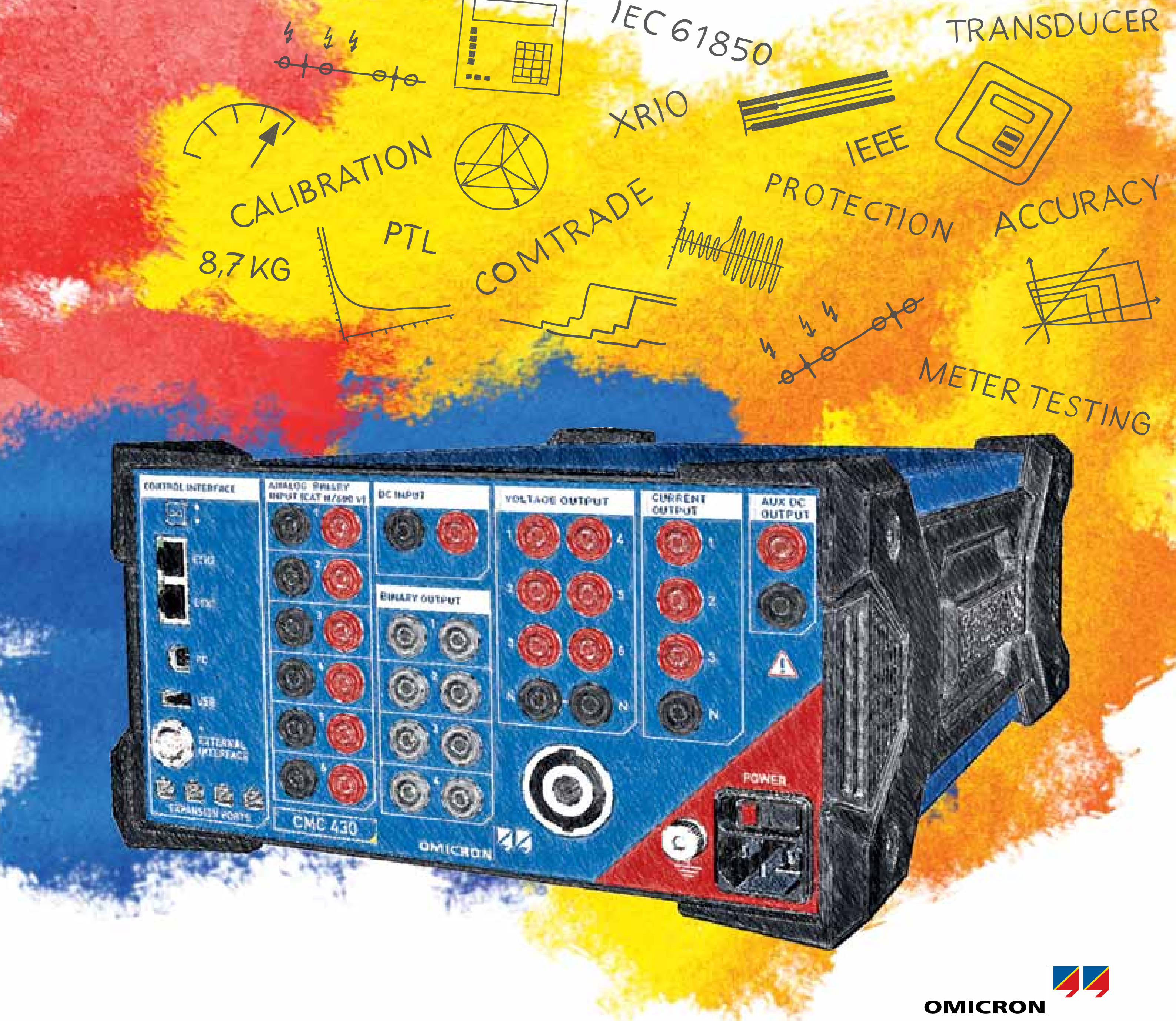
These can be found in a variety of quantum materials such as thin film magnetic materials and liquid crystals. Skyrmions are like disturbances within matter which can move like independent particles. These are mathematical knots which cannot be untied giving stable structures. The skyrmion was created in a state of matter known as a Bose-Einstein condensate. The atoms which make up the condensate each have a quantum property called spin, which makes them behave like tiny magnets.

When the scientists switched on a specially designed magnetic field, the spins arranged themselves into a twisting structure of loops, knotting up into a configuration known as a Shankar skyrmion. That arrangement was predicted theoretically about 40 years ago, but not seen in the real world until now. While skyrmions found in thin magnetic materials are two-dimensional whirls, the new Shankar skyrmion is 3-dimensional. Condensed matter research physicist Ramamurti Shankar is the John Randolph Huffman Professor of Physics at Yale University in New Haven.

A calculation of the energy value of skyrmion strings has given an astonishing result. It was found numerically that the value of vortex minimum energy per unit length for a twisted Skyrmion string is 20,37 x 10^{60} eV/m. Converting the energy from eV to kg, this gives 3,63 x 10^{25} kg/m. This seems astonishing to the point of absurdity.



Simulated magnetic fields produced by a 3D skyrmion are arranged into linked rings. The arrangement matches that of the magnetic fields proposed to explain ball lightning.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DC INPUT
VOLTAGE OUTPUT
CURRENT OUTPUT
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BINARY OUTPUT
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EXPANSION PORTS
CMC 430
OMICRON
POWER

Ball Lightning

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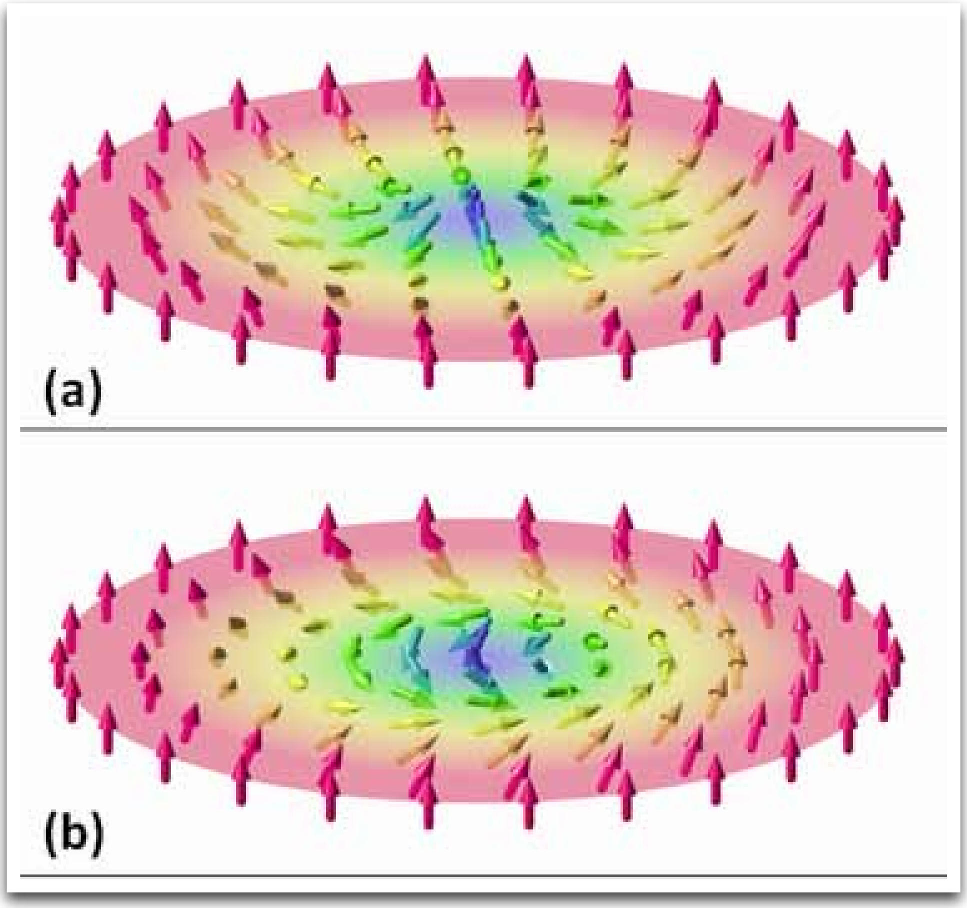


The vector field of two, two-dimensional magnetic skyrmions: a) a hedgehog skyrmion and b) a spiral syrmion.

Another seemingly absurd value is that of the pressure on the quarks within the proton - estimated at 10^{35} pascal – about 10 times greater than the pressure within a neutron star.

In Particle Theory the skyrmion is a topologically stable field in a certain class of models. It was originally proposed as a model of the nucleon by Tony Hilton Royle Skyrme (1922-1987) in 1962. It has found application in solid state physics as well as having ties to certain areas of string theory. In mathematics and physics, a soliton is a self-reinforcing solitary wave packet that maintains its shape while it propagates at a constant velocity. Solitons are caused by a cancellation of nonlinear and dispersive effects in the medium. A simplified description can be given by:

- they are of permanent form;
- they are localized within a region; and
- they can interact with other solitons, and emerge from the collision unchanged, except for a phase shift.

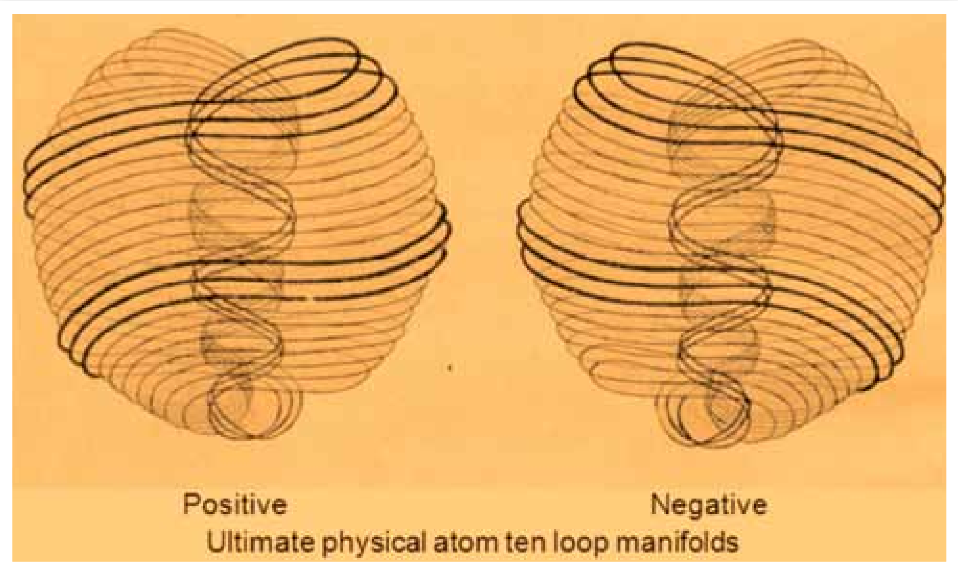
The soliton phenomenon was first described in 1834 by John Scott Russell (1808–1882) who observed a solitary wave in the Union Canal in Scotland.

Russell described the discovery of his 'wave of translation' as follows: *"I was observing the motion of a boat which was rapidly drawn along a narrow channel by a pair of horses, when the boat suddenly stopped – not so the mass of water in the channel which it had put in motion; it accumulated round the prow of the vessel in a state of violent agitation, then suddenly leaving it behind, rolled forward with great velocity, assuming the form of a large solitary elevation, a rounded, smooth and well-defined heap of water, which continued its course along the channel apparently without change of form or diminution of speed. I followed it on horseback, and overtook it still rolling on at a rate of some eight or nine miles an hour, preserving its original figure some thirty feet long and a foot to a foot and a half in height. Its height gradually diminished, and after a chase of one or two miles I lost it in the windings of the channel. Such, in the month of August 1834, was my first chance interview with that singular and beautiful phenomenon which I have called the 'Wave of Translation'."*

In addition to skyrmions, a new member of the soliton family, the "chiral magnetic bobber" was announced in "DailyScience" on 28 June 2018 by Dr. Nikolai Kiselev of the Jülich Peter Grünberg Institute. The bobbers are three dimensional chiral magnetic structures that appear near the surface of certain alloys.

Skyrmions and the newly-discovered chiral bobbers are very small, with diameters of typically only a few tens of nanometers.

There is an important reason why magnetic solitons such as skyrmions and chiral bobbers are so promising for applications. In contrast to data bits in hard disk drives, skyrmions and bobbers are movable objects. Their motion along a guiding track in a chip can be induced



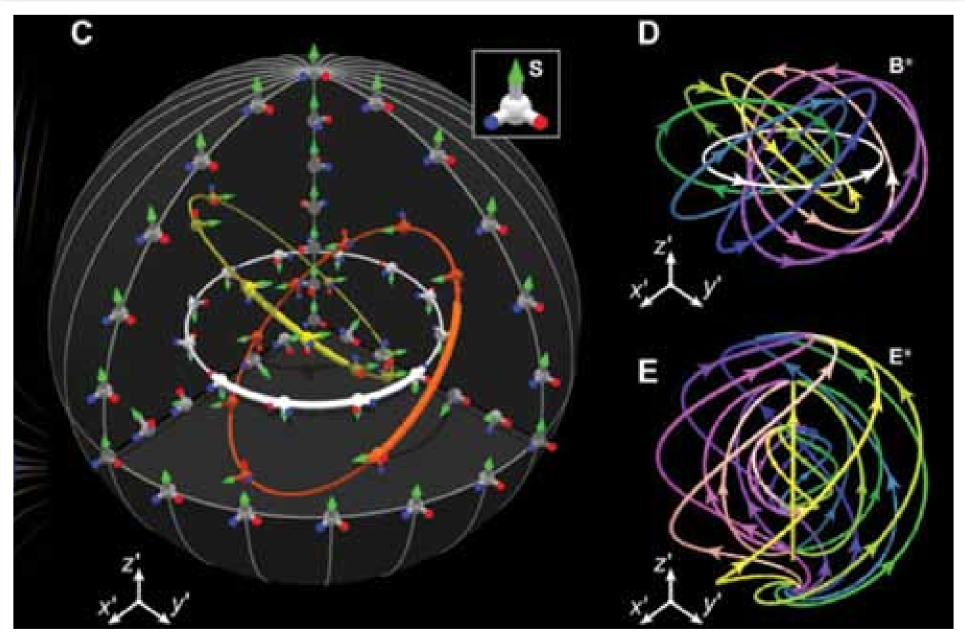
by a very weak pulse of electrical current. (No need to follow them on horseback). This property provides new opportunities for the development of a completely new concept of magnetic solid-state memory - the so-called skyrmion racetrack memory. The mobility of skyrmions allows data to move from write to read elements without the need for any movable mechanical parts such as read and write heads and spinning hard disks. The data can be encoded using skyrmions for '1' and bobbers for '0'.

Scientists have created a knotted structure known as a Shankar skyrmion that mimics the magnetic fields described in a proposed theory of ball lightning.

We now need to take a look at a bizarre investigation into the structure of the hydrogen atom undertaken in 1895. This was a psychic look at atomic structure at a time when the 'plum pudding' atomic model was still current.

The study revealed a positive nucleus surrounded by an envelope which was much later identified as an electron orbital. The proton nucleus was seen to contain three entities, two positive and one negative, which were decades later identified as quarks in 1964. The quarks were each seen to contain three stringy objects consisting of ten string loops twisted together, two positive and one negative, presumably conforming to the topological manifolds of string theory known as superstrings, and the electric charge depending on chirality. The ultimate nature of the string loops was recorded as multiple helixed vortex filaments. These stringy objects were described using their ancient Sanskrit name 'aahnoo'. The three-string quarks enveloped in a gamma-wavelength orbital have no correspondence in modern particle theory.

The topological knotted loop similarity between the Shankar skyrmion and the aahnoo superstring is astonishing to say the least. Curiously, both the skyrmion and the superstring have Sanskrit names. There is no suggestion here of a link between three dimensional skyrmions and the eleven dimensional space-time manifolds of superstrings, but the similar mathematical knot topology does suggest that this may be the natural way that radiant energy is constrained to existence as a discrete particle. Pursuing this matter further may well provide ripe scientific fruit ready for the picking. wn



The mathematical knot topology of the Shankar skyrmion.

WATT? is a forum related specifically to the industrial and commercial electrical sector.

Do you have any burning questions, topical issues or points of interest about the electrical industry, from the perspective of a contractor, supplier or professional service provider? Submit your comments, thoughts, ideas, suggestions or questions for the attention of our industry experts, and these will be addressed in a future issue of the magazine. This is your forum, and we would like to hear from you!

WATT? is an opportunity for people on the ground to engage with each other and related professionals in an informative and friendly manner. This is a platform for you to discuss anything related to your particular sector, to highlight anything new, or to ask a specific question related to a technical topic or to engage in general industry issues. . Please note that we will not be considering anything related to the domestic sector, such as residential wiring.

Send your burning questions to minx@saiee.org.za - subject 'WATT?'.

Q&A

QUESTION ONE

What are the main criteria for selecting an engine for a genset which will operate in a standby power application?

ANSWER ONE

The primary application for gensets in South Africa is standby power and gensets in these applications operate for a limited duration during power outages. Typically, engines used in gensets engineered for standby power application are sized for a maximum of 80% average load factor with an estimated run time of 250 hours per year.

The key criteria when selecting an engine for a standby genset should be reliability, presales and post-sales support and, of course, price. Given the anticipated low run time of an engine in this type of application, it is certainly not advisable to purchase a top-of-the-range engine which would not only cost a premium but would also be over-specified for the application. This would be a complete waste of money.

Another very important factor that must be considered is that the genset manufacturer and not the engine supplier will carry the warranty for the engine. This underscores the need to deal with a reputable genset manufacturer to ensure a reliable standby power solution.

It is essential that during the design stages the genset manufacturer supplies appropriate and accurate advice in terms of engine emission compliance requirements. Customers should also verify that the genset manufacturer has technically qualified service teams that can provide support 24/7 and that it carries a parts stockholding to support the engine brand and model proposed.

QUESTION TWO

Should engines produced in Asian countries be considered for standby genset applications?

ANSWER TWO

The engine manufacturing market has changed significantly in the last five years, and it is now possible to source a high quality engine at a far more affordable price.

Majority of the leading global engine Original Equipment Manufacturers (OEMs) have either sourced factories or are working with Eastern engine OEMs to produce lower cost units based on the same R&D principles and quality as the OEM specification.

These engines being produced in the Asian countries are now largely supported by locally based South African representatives or agents. This has led to more competitive pricing on both engines as well as parts, facilitating lower total cost of ownership.

QUESTION THREE

What other items need to be accurately specified, either in a tender or when requesting a quotation, for a standby genset?

There has been an increasing demand for generators in standby applications, and if customers understand the operational requirements for a genset it is a simpler process to select a fit-for purpose solution.

WATT?

Information provided by Zest WEG Group

ANSWER THREE

There are several items which must be correctly specified to ensure that these are the requisite quality and meet the application specification and/or compliance.

NOISE ATTENUATION REQUIREMENTS

Compliance with noise level requirements will differ from site to site, and also vary between residential, commercial and industrial applications.

Should this not be correctly specified upfront, the customer may end up with the lowest cost option which could have a negative impact on the installation itself, and potentially result in a sub-standard installation.

The solution offered by the genset manufacturer needs to comply with the exact specification requirements for the individual application and must be supported by sound verifiable data to avoid on-site issues once the generator has been installed.

MATERIALS OF CONSTRUCTION

Materials of construction refers specifically to the materials used for the canopy and exhaust on the genset. When specifying this, it is critical that the environment where the genset will be operational is considered.

Factors such as high corrosive environments must be considered. If the material selected is not appropriate to the on-site conditions damage will occur and will compromise the installation.

CHANGEOVER REQUIREMENTS

If not specified upfront this could result in additional expenses for the customer or an installation that does not meet the requirement. A single line diagram clearly indicating what is required on site will ensure the correct changeover for the application.

REDUNDANCY AND OUTDATED SPECIFICATION

Many items previously used in gensets are now redundant yet are still requested in tender specifications.

The danger with this is that reputable genset OEMs who typically quote according to the requested specification could lose out due to pricing during tender adjudication.

Examples of such items include duplex base frames, double bearing alternators, selector switches, bypass switches and additional gauges.

It is advisable to consult with a reputable genset OEM when drawing up tender specifications to ensure that outdated technology is replaced, and redundant items are removed.

QUESTION FOUR

Do newer technology genset controllers add value or should conventional genset controllers be used?

ANSWER FOUR

The obvious answer to this question is that newer technology genset controllers will offer major benefits to the end-user, and many are now available at a lower cost when compared to the traditional controllers.

The most important characteristic of any genset controller is that it be simple to operate and user-friendly. This is critical as many people do not have the necessary confidence to operate a genset, resulting in the installation not being regularly checked. This can lead to unnecessary callouts for maintenance purposes which increases the operating costs of the genset.

The genset controller should also offer the latest technology such as standard Automatic Mains Failure (AMF) functionality. This will facilitate integration into any changeover system allowing it to control automatic changeover or to receive a start/stop signal. It should also offer the option of built-in monitoring via text messages as well as the ability to view the genset alarms and fuel levels via a web-based platform. The benefit of this last functionality is obvious and being able to monitor the genset in this manner provides peace of mind.

August

Movers, shakers and history makers

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

1 AUGUST

1967 The US Navy recalled Captain Grace Murray Hopper to active duty to help develop the COmmon Business Oriented Language (COBOL) programming language.

2 AUGUST

1965 The Trimline Telephone was made available to all customers living in the Michigan Bell Telephone area for an optional $1 extra per month. The company had designed a telephone that had the dial and a hang-up button integrated into the handset.

3 AUGUST

1874 Henry Woodward and Mathew Evans, from Canada, were awarded a patent for an "Electric Light" (Lumière électrique). When the invention was patented in the United States (4 Jan 1875), it predated the patents of Thomas Edison and Joseph Wilson Swan.

4 AUGUST

1948 Hungary's Olga Gyarmati wins the first ever Olympic women's long jump competition at the London Games.

5 AUGUST

1864 Giovanni Batista Donati (1827-73) observed the first spectroscopic of a comet tail (from the small comet, Tempel, 1864 II). At a distance from the Sun the spectrum of a comet is identical to that of the Sun, and its visibility is due only to reflected sunlight.

6 AUGUST

1856 James Nasmyth presented a paper entitled *"On the Form of Lightning"* on the opening day of the 26th Meeting of the British Association at Cheltenham. He said that he wanted to call attention to the fact that Nature has never showed a zig-zag dovetail shape of lightning as often portrayed by painters and in other works of art. The true natural form is irregular curved lines, single or branched.

7 AUGUST

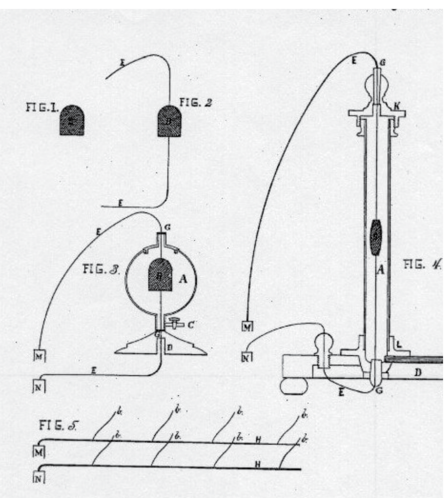
1935 London, England was plagued by flying ants, even stopping a tennis tournament. Swarms of the noxious insects invaded pantries and piled up on doorsteps. Authorities claimed that this was the worst attack of pestilence in a quarter of a century (at the time).

8 AUGUST

2007 Scientists announced that a rare type of dolphin, the Baijis, were functionally extinct. The Yangtze River, the Baijis' natural habitat, had been surveyed several times and none of these mammals showed up. The extinction of the Yangtze River dolphin would become the first extinction of the kind in nearly fifty years.

9 AUGUST

1941 Sometimes stocking up on scarce commodities doesn't pay, as Mrs. E. Petero of Prospect Park, USA found out. She had bought seven pairs of silk stockings, put them in her car and then went to the



chemist. By by the time she got back to her car, her hosiery had been heisted.

10 AUGUST

2003 The United Kingdom records its first ever temperature over 38˚C. At Brogdale in Kent a temperature of 38.5˚C was recorded the highest ever recorded temperature in the country since records began in 1875. Sound familiar?

11 AUGUST

1896 Harvey Hubbell, an American inventor, patented the electric light bulb socket with a pull chain.

12 AUGUST

2006 Norwich, UK piloted a project, making it the first in the country, to provide free Wi-Fi access in three quarters of the city. The scheme involved erecting more than 200 antennas (at the time) installed around the city, mainly on lampposts, with more being added all the time to provide blanket wi-fi coverage.

13 AUGUST

1973 The Institute for the Certification of Computing Professionals (ICCP), was founded by 8 professional computer societies. The purpose of ICCP is to promote certification and professionalism in the industry.

14 AUGUST

1882 This marks the anniversary of the meeting of Cetewayo, Zulu King 1872 - 1879, and Queen Victoria, who received him at Osborne, the Isle of Wight. After his defeat he was exiled to London in 1882, returning to Africa a year later where he died in 1884.

15 AUGUST

1994 Windows 95 programmer Benjamin Slivka sent an e-mail to his co-workers in which he suggested that a World Wide Web browser be included as a feature of Windows 95. Microsoft has since faced several legal challenges for the way Internet Explorer was bundled.

16 AUGUST

1988 IBM introduced software for artificial intelligence.

17 AUGUST

1969 This was officially the final day of the Woodstock Music Festival billed as three days of peace and music near Bethel, New York, USA. The following day, 18th August, the concert continued with eleven artist.

18 AUGUST

1960 The first oral contraceptive went on sale in the USA, and was marketed by the Searle Drug Company.

19 AUGUST

2003 In France a 40˚C heat wave killed approximately 5,000 people who perished from dehydration and complications of heat related illnesses.

20 AUGUST

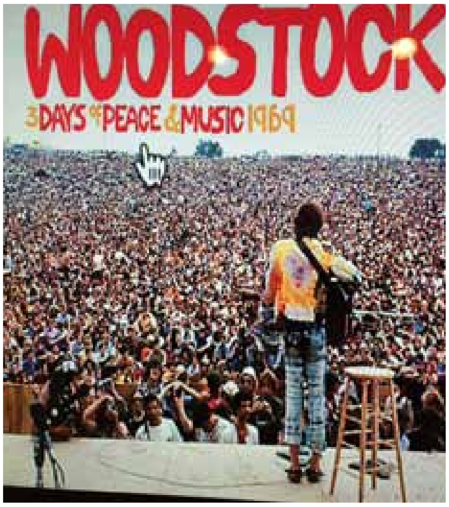
1940 After 3 months of the Battle Of Britain in the skies over the South Coast, the British Prime Minister Winston Churchill paid tribute to the British Royal Air Force, saying, *"Never in the field of human conflict was so much owed by so many to so few."*

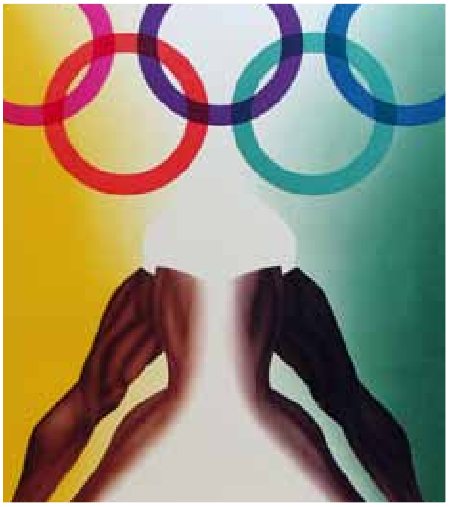
21 AUGUST

1989 The U.S. space probe Voyager 2 fired its thrusters to bring it closer to Neptune's mysterious moon Triton. A later photograph shows a false-colour image of Triton, taken two days before closest approach. At 2 700 km diameter, Triton is Neptune's largest satellite.

22 AUGUST

1972 Due to its racial policies, Rhodesia was asked to withdraw from the 20th Olympic Summer Games.





August

continues from page 63

23 AUGUST

1955 Betty Jameson wins LPGA White Mountain Golf Open.

24 AUGUST

1997 Gordon Spence discovered the largest known prime number, 2^2976221 - 1, the 36th known Mersenne prime number. It took his PC fifteen days to prove it. At 895,932 digits in length, if printed out the number would stretch for 2 253.0816 km.

25 AUGUST

1609 Italian astronomer and philosopher Galilei Galileo showed Venetian merchants his new creation, a telescope – the instrument that was to bring him scientific immortality.

26 AUGUST

2012 15 year-old New Zealand golfer, Lydia Ko, becomes the youngest LPGA Tour event winner and the first amateur winner since 1969.

27 AUGUST

1955 The first edition of The Guinness Book of Records was published and there were 50 000 printed copies in its first year. By Christmas 1955 the book had become a bestseller in the United Kingdom.

28 AUGUST

2017 Kenya brings in world's toughest ban on plastic bags with possible US$38,000 fine and four years in jail.

29 AUGUST

2017 Hurricane Harvey sets rainfall record (51.88 inches [1317 mm] in Cedar Bayou) from a tropical cyclone in continental US, according to US National Weather Service.

30 AUGUST

2017 Late author Terry Pratchett' unfinished works destroyed by steamroller as per his instructions.

31 AUGUST

2001 Delegates from more than 160 countries attend the weeklong third United Nations-sponsored World Conference Against Racism in Durban, South Africa. The summit is marred by disputes about slavery reparations, the Israeli-Palestinian conflict and a U.S. walkout.

Happy Women's Month to all our readers.

= Earn CPD Credits

calendar

AUGUST I SEPTEMBER I OCTOBER 2018

AUGUST 2018

6 - 7	2018 Advances in Big Data, Computing & Data Communication Systems	Durban, RSA	www.icabcd.org
6 - 8	2018 IEEE Symposium on Safety, Security, and Rescue Robotics (SSRR)	Pennsylvania, USA	www.ssrr2018.org
7	SAIEE - Photovoltaic Solar Systems	Johannesburg	roberto@saiee.org.za
10 - 12	2nd Industrial Engineering & Technology Management Conf.	New York, USA	www.icietm.com
13 - 15	2018 Industrial and Commercial Use of Energy (ICUE) Conference	Cape Town, RSA	www.energyuse.org.za
15 - 16	Optical Fibres, Cables and Systems Fundamentals	Johannesburg	roberto@saiee.org.za
20 - 22	2018 Power Science & Engineering Conference	Vienna, Austria	www.icpse.org
23	Fundamentals of Long-Term Evolution (LTE) Mobile Communications	Johannesburg	roberto@saiee.org.za
27 - 30	2018 International Conference on Radar (RADAR)	Brisbane, Australia	www.radar2018.org
28 - 31	Managing Projects Effectively	Johannesburg	roberto@saiee.org.za
30 - 31	Arc Flash Workshop	Johannesburg	roberto@saiee.org.za

SEPTEMBER 2018

4 - 5	Transformer Design, Protection, Testing And Maintenance	Johannesburg	roberto@saiee.org.za
6	Road To Registration For Engineering Candidates	Johannesburg	roberto@saiee.org.za
11 - 12	Optical Fibre Technology And Networks (OFTN)	Johannesburg	roberto@saiee.org.za
12 - 13	Incident Investigation And Management (Incl. Root Cause Analysis)	Johannesburg	roberto@saiee.org.za
17 - 19	Fundamentals Of Medium Voltage Protection	Johannesburg	roberto@saiee.org.za
17 - 20	SAIEE Bernard Price Memorial Lectures	Nationwide	geyerg@saiee.org.za
18 - 21	Advanced Microprocessor Based Power System Protection	Johannesburg	roberto@saiee.org.za
27 - 28	Design of Economical Earthing Systems for Utility Electrical Installations	Johannesburg	roberto@saiee.org.za
19	Incident Investigation & Management	Cape Town	khuvutli@saiee.org.za

OCTOBER 2018

2 - 4	Africa Smartgrid Conference	Rwanda	www.afsec-africa.org
9	Substation Design and Construction	Cape Town	khuvutli@saiee.org.za
10 - 11	Photovoltaic Solar Systems	Johannesburg	roberto@saiee.org.za
17 - 19	Operating Regulations for High Voltage Systems for Authorised Persons	Johannesburg	roberto@saiee.org.za
24 - 25	Fundamentals Of Power Distribution	Johannesburg	roberto@saiee.org.za
23 - 24	SA Energy Storage & Smartgrid Conference	Johannesburg	www.energystorage.co.za
24 - 25	Writing Electrical Specifications	Johannesburg	roberto@saiee.org.za
26	Annual SAIEE Banquet	Midrand Conference Centre	geyerg@saiee.org.za
31 - 1	High Voltage Testing And Measurement	Johannesburg	roberto@saiee.org.za

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