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CABLE

SAIEE

THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | **FEBRUARY 2017**

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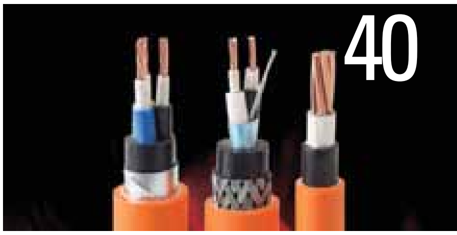

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Alas! It is February 2017... and what a dreadful start to the year.

Firstly, let me apologise for the lateness of this issue - but it was out of my hands.

The **watt**now magazine has suffered a great loss in January, with the passing of Ryan Spence, who was the booking agent for this magazine. It was very sudden and we are all still reeling from the shock. It was not easy putting this magazine together, knowing I will not hear his beautiful voice ever again, or getting a cheeky sms!
Barbara, our thoughts are with you – thank you for sharing Ryan with us - he was always a ray of sunshine!

The SAIEE has suffered another great loss with the untimely passing of the Centenary President, du Toit Grobler, on the 3rd of February. He was a stalwart in his own right and will be missed. Read his Obituary on page 16.

This issue focuses on Cables. Our first feature article is "The past, present and future of cable systems", on page 20, written by Thinus du Plessis.

After the history lesson, you will find an article discussing the importance of cables in wind power reliability (pg 24).

Page 30 sports an article that reviews the approaches to the design of submarine power cables.

Our last feature article, on page 40, discusses the need for improved fire resistant cables.

Thank you for your contributions to the success of this magazine, I appreciate it.

Herewith the February 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.

TC MADIKANE
2016 SAIEE PRESIDENT

This month's edition features the topic of cables! What an extensive subject for Electrical Practitioners. Cable applications vary from simple house wiring to Communications, Railway lines, Locomotives and coaches, Airfield runway lighting, runway series circuits, Power Equipment, and even Submersible cable applications, to mention but a few. I encourage you to read the various articles which cover applications of cables in this February edition.

Patterns in the month of February are interesting as per Wikipedia, "February has only 28 days in common years, and it is the only month of the year that can pass without a single full moon. This last happened in 1999 and will next happen in 2018. February is also the only month of the calendar that, once every six years, and twice every 11 years consecutively, either back into the past or forward into the future, will have four full 7-day weeks". It is also commonly known as the month of Love. Let us spread love and be kind to each other.

SAIEE's Task Team, which was commissioned by Executive Committee (EXCO) last year to deal with Engineering Council of South (ECSA) Roadshows, and any other related matters, met with the CEO of ECSA on 30 January 2017 to get an update from ECSA. The meeting went very well. The task team was advised that ECSA Council has reviewed, and approved a new committee structure for the Council to carry out its mandate. A list of Chairpersons and Vice Chairpersons of High Impact Committees (HICs) is available, and composition of HICs has been finalised. The first meetings for all the HICs will take place in February, and their recommendations will be sent to EXCO, which is scheduled to meet on 24 February. Thereafter, ECSA will communicate with all the Stakeholders regarding relevant decisions that will be of interest to Registered Individuals and Voluntary Associations. We are all eagerly awaiting the outputs of that process.

ECSA also reported that all the roadshows to nine provinces, was highly successful. The feedback received have been ibcluded in a report that will be tabled at the Strategic Transformation Committee; then to EXCO and to the Council of Built Engineering (CBE). The target date for publication of the VA recognition framework is June 2017.

SAIEE wrote a Congratulatory letter to the Acting Group Chief Executive of Eskom, Mr Matshela Koko, who has 22 years' experience working for Eskom. As a Generation Group Executive, he played pivotal role during the load shedding dilemma over 18 months ago. SAIEE has always have had a strong relationship with Eskom, partcularly as more than 35% of our members work for Eskom. We hope to continue our relationship with the new leadership, and are pleased that the Public Enterprises Minister Lynne Brown, approved the recommendation of the Eskom Board to appoint an engineer at the helm of Eskom.

I am pleased to announce that SAIEE's Past President Forum awarded a prestigious Past Presidents Scholarship to Mr Rifumo Progress Mzimba, who has achieved excellent grade 12 results. He has risen above a challenging school environment, and pulled himself up by his bootstraps. He will be studying Electrical Engineering at Wits University and will enjoy full support from the SAIEE. Indeed, this proves that the SAIEE is playing its role in the education sector by #ploughback and #makeithappen.

It is unbelievable that on 30 March 2017, we will have our Annual General Meeting (AGM), where SAIEE will inaugurate the new President. It is said that time flies when you are having fun! My experience and exposure as SAIEE President has been filled with so much enjoyment and fun. Please watch the space for details of that event, and diarise the date accordingly.

TC Madikane
Pr. Eng | FSAIEE | FSAAE

WATTSUP

Mines Must Choose PDS Carefully to Comply with Safety Law

PDS suppliers have the responsibility to deliver a reliable solution to their mining customers and this includes conducting ongoing product improvement.

While many mines consider proximity detection systems (PDS) a 'grudge purchase' to comply with the revised Mine Health and Safety Act (MHSA), there is still considerable legal onus on both users and suppliers to ensure that all equipment is fit-for-purpose.

Anton Lourens, Managing Director of leading PDS supplier Booyco Electronics, emphasises the importance of mines being very careful in their selection of equipment – to avoid falling foul of the law. *"We've seen a strong drive by the Department of Mineral Resources to enforce compliance with the new legislation,"* Lourens says. *"Some mining companies will opt for the cheapest equipment just so they can tick that box in the requirements, but this does create a risk further down the line – if an accident occurs and equipment is found to be not up to the task."*

He also highlights the responsibility of PDS suppliers to deliver a reliable solution to their mining customers, and pointed out that there are still suppliers in the market who do not fully understand their legal liabilities when selling PDS technology to mines.

"In terms of Section 21 of the MHSA, the equipment supplied by original equipment manufacturers (OEMs) must be fit-for-purpose," he says. *"If it is found that equipment does not comply, then the OEM can face both civil and criminal prosecution; as the PDS supplier to the OEM, we also bear responsibility."*

Lourens says the role of a competent supplier is to help educate customers about the importance of the drive towards zero-harm, which requires a commitment and passion rather than a tick-box approach.

Verbatim launches as Cross Africa Holdings

Data storage technology company, Verbatim Ltd. - a wholly-owned company has transferred its South African entity to CrossAfrica Holdings (Pty) Ltd, as a going concern, with effect from 1 October 2016. The restructure targets various benefits, amongst others, improved customer value and B-BBEE compliance.

Manny Cross, Group MD of CrossAfrica Holdings and former General Manager MEA (Middle East & Africa) for Verbatim, says the move allows the new operation to adapt more favourably to the changing markets across Africa.

The three trading entities positioned under CrossAfrica Holdings will operate independently. CrossAfrica Technologies (Pty) Ltd will be home to the Verbatim and Freecom brands providing storage, accessories and 3D printing material solutions. Water filtration products offering a unique technology bundle and positioned to target the growing need for quality drinking water in Africa, under the Cleansui brand, will be marketed through CrossAfrica Water Solutions (Pty) Ltd. Premium lighting solutions with a strong focus on LED, will be sold through CrossAfrica Lighting (Pty) Ltd.

Hidetaka Yabe, President of Verbatim EUMEA & Manny Cross Group MD of CrossAfrica Holdings and former General Manager MEA (Middle East & Africa) for Verbatim

DEHN Africa provides lightning protection components for thatched roofs

It's a reality that thatched roofs are extremely popular in South Africa, both within many rural communities and a number of upmarket developments. Constructed of soft material, such as straw, reed, grass or coconut leaves, a thatched roof is more susceptible to catching alight as a result of a lightning strike than any other roof type, according to the South African National Standard (SANS). Thatch is particularly prone to ignition because it becomes "fluffy" at the surface and, if moist, methane and other flammable gases can be formed.

If recommended protective measures are not considered, the effects of lightning can cause serious damage. However, prior to providing these protective measures, it is important to analyse the risk effects described in standards guide, such as SABS 0313: 1999, SABS IEC 61662-1: 1995 and IEC 62305-2.

When a thatch roof is constructed, wire mesh is used to reinforce and secure the bundles of thatch. Should lightning strike, then current flows through the wire mesh and the thermal effect (generated heat) may occur, and set the roof alight.

DEHN Africa, an expert in surge and lightning protection, can assist homeowners in avoiding lightning related disasters – and ultimately extend the life span of these structures - through the provision of lightning protection system (LPS) components for use specifically on thatched roofs.

More importantly, it can also provide the protection needed to avoid any injuries (or loss of life) related to a lightning strike for the people living and working in thatched roofed structures. DEHN Africa has recently introduced new methods of protecting thatched roofed structures in South Africa, and it is no longer necessary to have a ≥30 meter long mast installed. The latest preferred external protection system for installation on thatched buildings is the high-voltage-resistant insulated (HVI) lightning protection system that is compact, neat and approved by leading insurance companies and SANS.

For protection measures to be successful, air-termination conductors on thatched roofs must be installed as elevated traverses, for example: on isolating supports, with certain distances also to be kept for the eaves. LPSes should be designed to provide sufficient low impedance so that the lightning energy can follow in the required route. This requires an integrated design and effective use of material with enough low impedance. For protection measures to be successful, air-termination conductors on thatched roofs must be installed as elevated traverses, for example: on isolating supports, with certain distances also to be kept for the eaves.

Clamp CT's

Universal Technic France now offers more than 3 500 products for AC/DC current measurement from 1mA-15 000A.

The newest addition is the MX Series of "Hall" effect micro clamps which measure low current AC and DC up to 50 kHz in ratios of 20A/1V and 100A/1V.
For more information, visit:
www.denvertech.co.za

Control Cables with numbered cores for easier installations

Helukabel's JZ500 flexible control cables have numbered cores for easier installations.

Equipment and machinery installations using the latest cabling technologies from world-leading manufacturer, Helukabel, can contribute significantly to the ease of installation and overall success of a project.

A good example of this is the company's clever JZ500 flexible control cable, which is designed to be super-supple, yet strong enough to be used in the toughest industrial conditions where its oil and chemical resistance makes it ideal for toolroom controls, conveyor applications, production lines, air condition and steel production among others.

Another unique feature is its easy-to-read core identification to DIN VDE 0293 that has black cores with continuous white numbering (also available in other colours on request) for ease of installation, particularly where long runs are required or individual installers are working at different ends. The numbering, colours and other special requirements can also be ordered to suit different applications.

According to Hardus van Dyk of Helukabel, the cables are designed for flexible use for applications requiring medium mechanical stresses with free movement - without tensile stress or forced movements and can be used in either dry, moist or wet rooms. Selected PVC-compounds guarantee a good flexibility as well as an economic and fast installation.

The materials used in manufacture are cadmium-free and contain no silicone and are free from substances harmful to the wetting properties of lacquers. The cable also conforms will relevant national and international standards and requirements.

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

Leak-Detection In Coal-Fired Power Stations

Instrotech has designed and developed at the request of, and in consultation with, the South African Power Utility (where 93% of all electricity is currently generated using coal) an advanced acoustic leak detection system called Inspecta FFT. This was to detect boiler tube leaks in coal fired utilities as well as in oxygen plants and gasifiers.

This technology and equipment is now in use in power stations worldwide, where the early detection of tube leaks to reduce down time and prevent consequential damage is vital.

The Inspecta installed base includes power stations in South Africa, Germany, Australia, Turkey, India, Malaysia and China. Authorised distributors in these countries are on hand to provide all the services required to provide high levels of pre- and post-sales support as well as any spare parts required to keep the systems running efficiently.

Instrotech – local manufacturer and distributor of a range of process control instrumentation and specialised systems to the South African and international markets.

For more information on Inspecta FFT acoustic leak detection system, email sales@instrotech.co.za.

RNRG's SRA Systems Improve Power Prediction Accuracy by 14%

Kumenan PV plant Japan

When developing a utility-scale solar PV project, accurately projecting the site's power output is crucial. For its 33 MW Kumenan PV project in Japan, Pacifico Energy experimented with publically available data before seeking a more precise measurement solution. After implementing SRA Systems from Renewable NRG Systems (RNRG)—a leading designer and manufacturer of decision support tools for the global renewable energy industry—Pacifico Energy increased the accuracy of power output projections at the Kumenan PV project by up to 14%. The gain allowed the company to secure more competitive financing terms to build the PV plant.

As the utility solar industry continues to grow, the need for solar resource assessment to facilitate more accurate power output forcasting is becoming increasingly important. The most critical parameter used to estimate power output is Global Horizontal Irradiance (GHI). Because of its direct impact on energy production estimates, miscalculations of GHI can cause critical financial risk for project owners and investors. When Pacifico Energy first set out to determine power output at the Kumenan PV project, they used publically available, long-term GHI data from New Energy and Industrial Technology Organization (NEDO). Such resources are common in Japan, but are not ideal for every project.

In Pacifico Energy's case, the weather stations used by NEDO to collect GHI data were located too far from the Kumenan PV project to provide accurate output projections. Instead, they selected an approach that aligns with the solar industry's GHI measurement best practices, integrating the high-quality irradiance data collected onsite with RNRG's ground-based SRA Systems with long-term satellite data.

According to Nate Franklin, who manages Pacifico Energy's activities in Japan, " *"Deploying finance-grade solar assement campaigns like this one is fairly new in Japan, but Pacifico Energy wants to lead the way towards a high-standard approach to PV project development in the country."*

Pacifico Energy opted for RNRG's solution because of its exemplary quality, reasonable cost, and its ease of installation and maintenance. The SRA Systems were installed at the Kumenan PV site in 2013 and collected real-time irradiance data for one year. The monitoring station was equipped with best-in-class meteorological sensors that integrated seamlessly with RNRG's much-lauded SymphoniePLUS3 data logger, providing measured data directly to Pacifico Energy's control room. The long-term satellite data were later corrected with the records collected by the SRA Systems, providing the most accurate irradiance input to energy production simulation model. *"The SRA System configuration that is used here is recommended for utility-scale resource assessment campaigns and solar monitoring applications when measurement accuracy is the top priority,"* said Dave Hurwitt, VP Marketing & Product Management at RNRG. *"Pairing RNRG's solution with satellite data ensures that deviations between predicted irradiance and actual site conditions are minimized, which is extremely beneficial for PV project developers."*

Once the solar assessement campaign reached completion, Pacifico Energy concluded that RNRG's SRA Systems helped improve the long-term GHI estimation by up to 14% when compared with the irradiance data collected by NEDO weather stations alone. The Kumenan PV plant has been in operation since early 2016 and power output has closely mirrored RNRG's predictions. The impressive resource assessment accuracy at the Kumenan PV project led Pacifico Energy to install RNRG's SRA Systems at six other projects in Japan. *"This way, we can ensure that all of our projections reflect reality,"* added Franklin.

BEKA Schréder shines a beacon of light to learners and the youth of Tembisa

BEKA Schréder (Pty) Ltd joined the Department of Science and Technology (DST) to hand over a computer research lab to Moipone Academy Science Center (MASC) in Tembisa.

In 2005, Mr Joseph Taetsane, in response to the lack of information and exposure available for school learners that persisted even after his hay days of schooling, realized the need to establish a science and information center in the township of Tembisa. Little did he know that this could one day turn into a reputable science center capable of alleviating even more social ills around his community. On the 29th of November, BEKA Schréder handed over an after-school computer research lab and became the first private entity to invest in the only science center in the East Rand. The lab will assist with access to information for school learners and much needed computer skills for unemployed youth in the community.

"The advance of technology involves a range of emotions from all walks of life. Some view technology as an evil that degrades our humanity while others see it as way to bring the world closer together in solving some of our challenges. Regardless of the contrasting views, there's always something good you can point at and say thank you to technology because our lives today revolve around it" said the Deputy Director General from DST Livhuwani Masevhe in attendance. His words were echoed by BEKA Schréder Managing Director Wimpie Ludwick when he stressed the need for access to network and connectivity in bettering our communities by becoming active citizens in the now global village. Mr Ludwick went on to pledge extra support for MASC's connectivity, terming it a "second phase" to the existing project - a gesture that sent the 60 strong crowd into ululations and applause.

One cannot begin to comprehend the impact the computer lab will have on the members of the community especially for learners and unemployed youth. MASC will utilise the computer lab for after-school programmes like computer literacy and in-house activity programmes, such as Robotics, using CAD (Computer Aided Drafting) to design car models for the Jaguar Primary School competition.

It will also cater for school teachers where they will be taught modern ways of imparting knowledge, soft skills in office suite programs, creating data sheets and presentations. In closing the proceedings, the centre manager Mr. Taetsane alluded to how the donation by BEKA Schréder will go a long way in stimulating school learners to develop interest in pursuing ICT related careers such as IT and computer engineering.

Ms Nkele Sathekge (Ward Councillor) thanked BEKA Schréder for their outstanding support to the community of Tembisa.

Wireless DC Clamps improve measuring productivity in-field

New high current and 4-20 mA dc current clamps speed troubleshooting through collaboration, regardless of location

Fluke has on offer the dc current clamps to the Fluke Connect® system of wireless test tools: the Fluke a3003FC wireless DC current clamp and the a3004 FC Wireless DC 4-20 mA Current Clamp. Both fully-functional current clamps can wirelessly send measurements to Fluke Connect® enabled master units as well as the Fluke Connect® mobile app so users can view measurements from multiple devices simultaneously, review equipment history, and share measurements with other team members for faster troubleshooting.

The a3003FC wireless DC current clamp measures up to 2000 A dc making it ideal for very high dc current measurements typically found in utility and dc machine controller applications. It features a large jaw size (64 mm) for clamping around and measuring on large, high current conductors.

The a3004 FC Wireless DC 4-20mA Current Clamp measures 4 to 20 mA signals without breaking the loop so process control technicians can make accurate measurements without interrupting the workflow. It features a detachable clamp with extension cable for measurements in tight locations. For more info visit comtest.co.za

ZEST Energy Provides Mobile Power For Kamoa-Kakula Mine Development

The Zest Energy mobile substation in position on site, connected to the SNEL electrical network. The photograph shows preparations for hot commissioning and energising in progress.

The development of the world's largest high-grade copper deposit – the Kamoa-Kakula Copper Project in the Democratic Republic of Congo (DRC) – now is running on power from the DRC's national grid using a mobile substation recently commissioned by South Africa's Gauteng-based Zest Energy.

The 120/11 kV mobile substation will serve the construction of the planned initial mine at Kamoa-Kakula, a project whose existing mineral resource has been independently verified as Africa's largest copper find.

Kamoa-Kakula's principal owners are Ivanhoe Mines, Zijin Mining and the Government of the Democratic Republic of the Congo.

"Due to the high cost of running on diesel generators, the mine developers decided to purchase a mobile substation to interface with the network of the DRC power utility SNEL to provide power during the construction phase of the project," Alastair Gerrard, managing director at Zest Energy, says.

Although the substation will not be moved frequently, Gerrard says being mobile allowed for quick and hassle-free construction and commissioning, and gives the mine the added flexibility of deploying the substation to other areas of its operations when needed in the future.

Zest Energy – part of the Zest WEG Group – undertook the design, manufacture, supply, testing, delivery, installation and commissioning of the complete mobile substation, including the trailer, transformer and related electrical equipment. It also provided a protection system, earthing, site work (with full commissioning and testing) and site training.

The project began in February 2016, and the unit was commissioned and handed over to the mine developer in October 2016, in line with a challenging delivery deadline of nine months.

"Our strong network within the WEG Group, of which Zest WEG Group is part, allowed us to work with WEG Transmission and Distribution unit in Brazil on transformer design, manufacturing and factory testing," Gerrard says. *"We also involved WEG Transformers Africa – also a Zest WEG Group company – when it came to site assembly and testing of the mobile transformer."*

Skills transfer was facilitated by operator training conducted by Zest Energy to all selected mine personnel, ensuring that the substation was left in safe hands, with a strong after-sales service to respond to any further customer requirements.

PPE In-house 50kW Solar Photovoltaic Array

PPE Technologies recently took to designing and installing a rooftop, on-grid, 50kWac solar array at their head office in Nelspruit. Not only is it a statement about our concerns for the environment and promotion of renewable, eco-friendly energy sources, it is also a smart investment. Based on a typical 25 year lifespan of a solar array and including annual de-rating of solar module efficiencies, the company stands to make a conservative estimated saving of 65% on electricity bills.

The nature of solar modules dictates that they progressively de-rate and a 25-year lifespan is typically attributed to them; after which the progressive efficiency de-rating results in the array no longer being a viable investment and the system is decommissioned. The solar array was mounted on a pre-existing helipad which had fairly extensive rust damage. Based on the 25-year life-span, the roof was completely restored by sand blasting and an anti-rust coating layered on. With this restoration work, we can be confident that the roof and structures will be in good condition by the time the array is to be decommissioned.

The company carried out an extensive cost model in order to validate the fairly high initial cost of a solar project against the cost savings in the solar array's life span. The pay-back period for the initial investment is estimated to be around the 8-year mark.

The wide-spread concern of the initial cost of a solar array is being debunked as the long term investment benefits far outweigh initial expenses. Moreover, the cost of equipment is decreasing as demand for solar arrays is ever increasing, making it an ideal time to invest in solar power.

The company made use of 168 Jinko Solar modules split into 12 strings of 14 modules. These were tied into 2 ABB TRIO 27kW inverters operating in parallel which supplies 400VAC 3-phase supply to our existing main distribution board.

These intelligent inverters automatically synchronize to the source available whether it is municipal or generator supplied power. All powder-coated mounting structures were manufactured in-house; a comprehensive lightning risk assessment and lightning protection design was carried out in-house with design approval conducted by our channel partners, DEHN Africa. Additionally the complete design and installation was carried out in-house with input from both ABB and DEHN in reference to their specialized equipment.

All monitoring and safety precautions have been incorporated into our "smart building" automation system. This system constantly monitors and logs the kWh supplied by the solar array, all information from the solar inverter from dc power, efficiency, fuse blow statuses and more.

The system also prevents back-feeding of any kind into the grid and can automatically isolate the solar system in the event of an emergency such as a fire. Automating a safety system such as this was also carried out in-house and is far more reliable than relying on a human operator.

PPE Technologies has a complete solar solution for any industrial sized installation desired and phase 2 of our solar project will commence in October where our attention will shift to our Pretoria offices for a 10kWac solution.

African Utility Week to host launch of YEPP for young power pros and graduates wishing to solve Africa's energy challenges

"Youth unemployment on the continent is a major epidemic and internship opportunities are an amazing solution to help maximize human capital development on the continent" says Daniel Antwi, co-founder of the Africa Internship Academy (AIA) that will launch its Young Energy and Power Professionals (YEPP) at this year's African Utility Week in Cape Town in May.

Says Daniel: *"quite a number of employers have argued that skills constraint has been a major contributing factor to youth unemployment. Again, many young graduates find it very difficult to move out and become job makers in the market. Therefore, Africa Internship Academy stands to facilitate successful transition from academia to industry by ensuring that the skills of youth are honed early enough to match the labour market demands."*

Africa Internship Academy has already begun its monthly gatherings in Ghana and is looking to roll out more offices in many African cities by end of the first half of 2017. *"So far, all our fellows have secured amazing internship opportunities from great organisations in Africa,"* Daniel states, *"and Ecobank Ghana requested to have all fellows in Ghana to intern with them, if possible."*

He adds: *"also, together with the organisers of African Utility Week, we will be launching the Young Energy and Power Professionals Network (YEPP) which will be a network of ambitious graduates who wish to contribute to solving African's power and energy issues."*

YOUNG PEOPLE IN THE UTILITY SECTOR

YEPP will bring together graduates who want to learn from each other, access thought leadership, conduct research to broaden their understanding of power and energy issues, raise funding for future solutions and further their career ambitions. *"There is a lot of room for young people in the utility sector as long as they get the right skills to navigate"* says AIA's Daniel.

According to Daniel, internships are a win-win for all involved: *"when HR is able to recognise potential early enough and eventually bring them on board, the recruitment process is easier and the intern would definitely feel valuable. The long-term benefits are more for the employer because staff who are former interns at a company are most likely to stay on with that employer hence building the reputation on the organization as 'Employer of Choice'."* He also quotes Stuart Lander of Internships.com who says that *"you have a 7 in 10 chance of being hired by the company you interned with."*

At African Utility Week, 30 top power and energy students/graduates across Africa will have the opportunity to be invited to the event, have complimentary access to the strategic conference and will be invited to a networking function co-hosted with Africa Internship Academy. A selection of recruiters, VIP guests and sponsoring companies will also be invited to this function.

LEADING ENERGY PLATFORM ON THE CONTINENT

The 17th annual African Utility Week is the leading conference and trade exhibition for African power, energy and water professionals and takes place from 16-18 May 2017 at the CTICC in Cape Town. The event will gather over 7000 decision makers from more than 40 countries to source the latest solutions and meet over 300 suppliers. Along with multiple side events and numerous networking functions the event also boasts a seven track conference with over 300 expert speakers.

The conference programme will once again address the latest challenges, developments and opportunities in the power and water sectors: ranging from generation, T&D, metering, technology and water.

Energy Revolution Africa, a new platform for community scale projects, will provide a unique forum for solution providers to meet with the new energy purchasers such as metros and municipalities, IPPs, rural electrification project developers and large power users, including mines, commercial property developers and industrial manufacturers. The latest innovations and projects in the sectors of renewables, future technology, energy efficiency, micro/off-grid and energy storage will be showcased.

African Utility Week and Energy Revolution Africa are organised by Spintelligent, leading Cape Town-based trade exhibition and conference organiser, and the African office of Clarion Events Ltd, based in the UK. Other flagship events in Spintelligent's power portfolio are East African Power Industry Convention (EAPIC), West African Power Industry Convention (WAPIC), iPAD Rwanda Power & Mining Investment Forum and iPAD Cameroon Energy & Infrastructure Forum.

DATES FOR AFRICAN UTILITY WEEK AND ENERGY REVOLUTION AFRICA:

CONFERENCE AND EXPO:
16-18 MAY 2017
AWARDS GALA DINNER:
17 MAY 2017
SITE VISITS:
19 MAY 2017
LOCATION:
CTICC, CAPE TOWN, SOUTH AFRICA

IN MEMORIAM

du Toit Grobler

It is with deep regret that we report that SAIEE Past President and Council member, du Toit Grobler, passed away on 3 February 2017.

COMPILED BY I MINX AVRABOS

1948 - 2017

du Toit Grobler was born on 7 October 1948 in Grootfontein, South West Africa, now Namibia. He attended Buhrmansdrift Laerskool and matriculated from Hoërskool Vereeniging where he was Head Boy. During 1967 he was trained at the SA Air Force Gymnasiumfrom where he graduated and was awarded Telecommunication Mechanic of the Year. In 1971 he completed a BSc (Electrotechnical Engineering) at the University of Pretoria, having studied as an Iscor Bursar.

In 1972 he was appointed Assistant Project Engineer at the 3rd Iscor Integrated Steel Works in Newcastle. During 1973, he underwent 9 months formal and in-service training in the USA, as a Graduate Installation and Service Engineer, with General Electric USA. In 1978 he was appointed as Assistant Resident Engineer: Project & Planning at Iscor's Durban Navigation Collieries, Durnacol.

In 1991 he joined SAPPI Ltd's SA Region Technical Division Head Office as Project Manager. He was responsible for many multi-discipline (Electrical, Electronic, Mechanical, Chemical and Civil engineering) expansion and refurbishing projects, including the successful millennium roll-over of all process control and plant equipment at the 11 Saw, Pulp and Paper Mills in SA. In 2001 he was appointed as Senior Regional Electrical Engineer, providing consulting electrical engineering and project services to the SA region. In 2002 he designed a new Technical Graduate Diploma Training Programme for the Region.

In 2011 he retired having reached SAPPI's retirement age. In 2012 he received a Silver Award in the SAPPI African Awards Programme for his contribution to the successful Tugela River Pump Upgrade Project. A month after he retired, he joined Read, Swatman and Voight (Pty) Ltd, Consulting Engineers by invitation as Project Manager: Proposals.

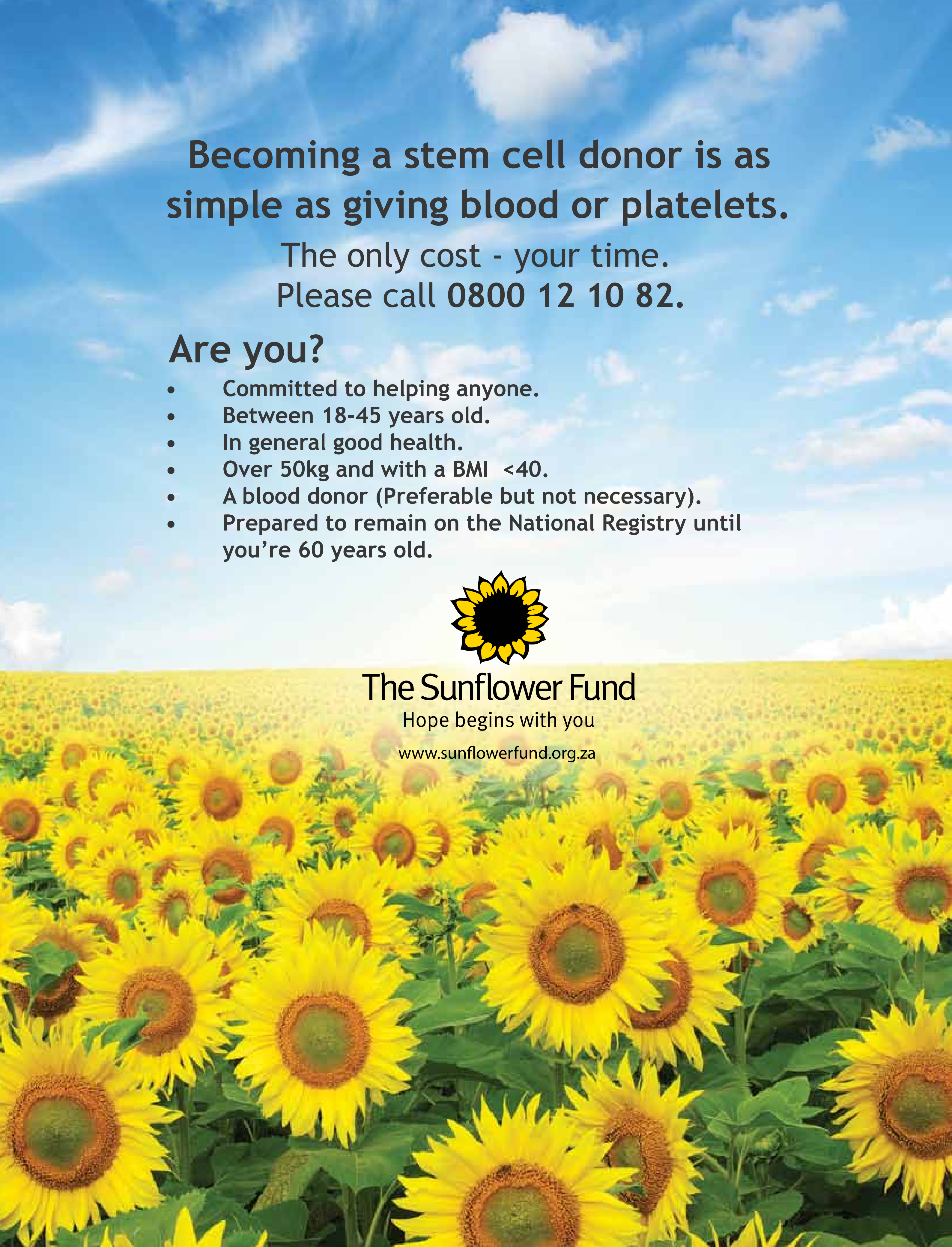
du Toit joined the South African Institute of Electrical Engineers (SAIEE) as a student in 1969. He was elected Fellow in 2002, and from 2003 he served on the SAIEE Council. In 2005 he received the SAIEE Engineer of the Year award. In 2006 he was elected as Junior Vice President, and in 2009 became the SAIEE's Centenary President. He served on the SAIEE Council as a Past President until his untimely passing.

du Toit was also a member of the Certificated Mechanical and Electrical Engineers, SA (ICMEESA). He served as a council member from 1998 until 2017, and was the ICMEESA President in 1995.

du Toit dedicated his life to the promotion of the engineering profession.

du Toit was registered by ECSA as a Professional Engineer: Electrical/ Electronic in 1979, in 1994 as a Professional Certificated Engineer: Electrical/Mechanical. He has served as chairman on various ECSA committees during his lifetime.

du Toit is survived by his wife, Elize, their 3 childen and 4 grandchildren.
Soli Deo Gloria. wn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IN MEMORIAM

1948 - 2016

Paul Roux

It is with deep regret that we report that Paul Roux, retired C.E.O of the Engineering Council of South Africa (ECSA) passed away on the 27th of December 2016. He is survived by his wife of 43 years, Sandra, their daughters and sons–in-law Michelle and Hein and Bianca and Francois, their son, Paul junior and 6 grandchildren.

BY | DU TOIT GROBLER IntPl(SA)(EE) | PrIng(EE) | PrDiplIng(EM) | BSc(Ing)(Elek)(Pret) FSAIEE | SMICMEESA

A memorial service took place in Pretoria, on 16 January 2017. Tributes were given by family members, friends, employees, colleagues and members of the Engineering Profession and Voluntary Associations.

PROFESSIONAL CAREER

In 1973 he made contact with the Engineering Profession when he became the editor of Barlow's 'Civil Engineering Equipment Digest'. In March 1977 he joined the South African Council for Professional Engineers (SACPE), when the Council was still operating from the offices of the Associated Scientific and Technical Societies in Kelvin House, Hollard Street, Johannesburg.

On 1st August 1986 he was promoted to Registrar of SACPE. His title was subsequently changed to Chief Executive Officer of ECSA. He remained CEO until 28 February 2006 when his successor Prof Ravi Nayagar took over . He was however, asked to stay on until 30 June 2006.

Towards the end of the 1980s, he managed the relocation of ECSA's offices to Observatory, and then to Bruma Lake during the middle of 1990s, where ECSA still occupies its own building, Waterview Corner.

During his employment, three Boards of Control were established, which introduced the statutory registration of Engineering Technicians, Engineering Technologists and Certificated Engineers, in addition to the professional registration of graduate Engineers. In 1990 ECSA superseded SACPE and continued to register engineering practitioners in four categories. In 1994 the registration of Lift Inspectors was introduced.

In 2001 ECSA was restructured under the umbrella of the Council for the Built Environment. Since then it has registered engineering practitioners and candidates in four professional and candidate categories, as well as specified categories.

During the early 2000s, ECSA became a signatory to the worldwide Washington Accord, which recognizes university qualifications in Engineering after 4 years of academic study. Later on, the Sydney and Dublin Accords, which recognise technology and technologist qualifications, followed. The three accords also provide for the recognition of ECSA registered professionals by the signatories of the International Engineering Registers.

Paul Roux had to implement four initiatives resulting from the Engineering Profession Act, 2000 (Act No 46 of 2000), namely:

1. The recognition of Voluntary Associations;
2. The introduction of the regular renewal of registration, and of Continuing Professional Development (CPD) for registered persons;
3. The Identification of Engineering Work (IDoEW), and implementation of reserved work; and
4. Transformation, which is an ongoing initiative.

By the time he retired in 2006, the first two initiatives had been implemented. He took a keen personal interest in the development of the Framework for the Identification of Engineering Work, even after his retirement from ECSA.

ACKNOWLEDGEMENTS

He had an in-depth understanding of the engineering profession, the voluntary side of the profession, and in particular complicated aspects of the profession, such as the role of the Certificated Engineers in the Profession.

During his career he received acknowledgements from professional councils, and voluntary associations, for his outstanding service. In 1991 and 2001 he received merit medals from SACPE and ECSA respectively. In 1996, 2005 and 2006 he was awarded Merit Certificates and Medals by individual Voluntary Associations, and also collectively by a group of Voluntary Associations.

EDUCATION AND EXTRA-CURRICULAR ACTIVITIES

Paul attended the Aucklandpark Laerskool, Johannesburg. He matriculated from the Helpmekaar Hoër Seunskool, Braamfontein, Johannesburg (now known as Helpmekaar Kollege). He served as a school prefect.

He underwent military training at the Officers' School in Potchefstroom. After 10 years, he left the Citizen Force as a Major in the Sappers Unit.

From 1970 to 1973 he studied B Juris – Law at the Randse Afrikaanse Universiteit (RAU), Johannesburg now known as the University of Johannesburg. He did his articles at Webster, Dunbar and Saner. As a student he took part in Student Golf and the Cosmology Society.

VOLUNTEERING EXPERIENCE

From 1986 to 2007 he was Captain and Chair of the RAU Alumni Golf Association. During this time, he took part in organizing and leading Alumni Golf at RAU, as well as Intervarsity Alumni Golf Tournaments associated with Davis Cup Golf. He continued playing golf after his retirement.

He was a keen photographer and contributed to the residential and security association activities where they live. In 2016 he received an award for outstanding services to the community.

In the words of Prof Nayagar: *"He leaves behind a legacy of many tributes; however, his commitment is certainly uppermost on the long list. He was committed to the cause of the professional engineering practitioner. This was evident by the manner in which he tirelessly took on various tasks and projects, both nationally and internationally, to see to it that South Africa continues to produce among the best engineering practitioners in the world.*

His hard work and commitment are profoundly appreciated by the profession."

Earn CPD Credits

The past, present and future of cable systems

The development of cables started as early as in the 1840's for telegraphic systems. These telegraphic cables were developed by, among others, Sir Michael Faraday, William Siemens and Werner Siemens.

These were manufactured using a copper wire with an applied layer of rubber insulation known as "gutta percha" (EPRI, 2006:1-2). Later applications thereof included DC electrical applications up to 3 kV (EPRI, 2006:1-2). Higher insulation levels for cables was however only achieved in 1890 when Sebastian Ferranti managed to successfully install and commission a 10 kV paper insulated cable system of 30 miles long (EPRI, 2006:1-2). This achievement by Dr. Ferranti established the use of paper insulation in the manufacturing of medium and high voltage cables, and is still manufactured till today.

BY THINUS DU PLESSIS **I** PR. ENG **I** B.ENG ELECTRICAL
ESKOM CHIEF ENGINEER FOR CABLE SYSTEMS AND METAL ENCLOSED SWITCHGEAR

Cables are also referred to as insulated cables. It is a conductor supplied in combination with layers of insulation, earthing and mechanical protection. Cables are also always used in combination with joints, terminations and ancillary equipment, to form a complete and safe insulated cable system for electrical equipment or network connections.

The power industry in South Africa is by no means behind their international counterparts when it comes to the manufacturing and installation of these low (<= 1 kV) -, medium (up to 44 kV) - and high voltage (up to 132 kV) cable systems.

The first installations of low voltage cables in South Africa may even date back as far as the Kimberley street light installations in 1882. The introduction of medium - and high voltage cable systems (up to 132 kV) followed soon in the early and middle 20th century.

The benefits of medium - and high voltage cables for power distribution application are mostly realized in city developments, where no overhead line servitudes can be established. Cities such as Johannesburg, Sandton, Durban, Pretoria and Cape Town are good examples where this is the case. This is where cable systems rated up to 132 kV are typically installed to provide the underground power connection to substations next to big city buildings, in-between busy roads, and in public access areas.

Cable Systems

continues from page 21

Sandton City development

The transmission of power in South Africa comes from generating stations, positioned mostly in Mpumalanga and Limpopo, to consumers in bigger city areas. However this remains more feasible when performed with bare overhead line systems rated up to 765 kV. These overhead line systems typically feed distribution substations positioned on the outside perimeters of big city areas, where there is plenty of space for big line servitudes. The state owned power utility, Eskom, owns and operates close to 31 000 km of these transmission overhead line networks in South Africa.

This is however different for European, United Kingdom, American and Asian countries, where the size and layout of their major city areas are too big, and over developed, to allow additional overhead line servitudes. Transmission cable systems are then their only solution to perform transmission in-feeds to distribution substations, positioned in the city centers. Transmission cable systems are also used in non-city area applications in these countries, due to people pressure for more aesthetic and pleasing power networks. This is seen in the large expansion and growth in offshore wind generation sites, and for the green energy power sales between European and UK countries. Green energy includes hydro, wind and solar power generation. These transmission cable systems are normally long-length land and submarine insulated cable systems, rated up to 800 kV, and require advanced designs for either AC or DC applications.

The conclusions identified from these advanced transmission cable design developments are often the topic of discussion and debate at the international Cigre Study Committee (B1) for Insulated Cables. South Africa is one of 24 member countries in the Cigre Study Committee B1, and is required to participate in established work groups, within the study committee, to determine the industry best practice for insulated cables design, manufacturing, testing, installation, maintenance and operations. This sharing of industry best practices in the international cable industry made it possible for Eskom to perform the recently completed Ingula Pumped Storage Scheme Power Station. 400 kV insulated cable systems were used to connect the underground generation station with the above ground level transmission station. The project involved the installation of four underground, 333 MW generating units, that are each connected to the transmission network via a 1.3 km long, 400 kV insulated cable system. The Eskom project scope for the Ingula cable systems were for the design, manufacturing, factory acceptance testing, delivery, installation, after installation testing and commissioning. The project tender was awarded to the South African company CBi Electric African Cables, who supplied the designed and type-tested cable systems, from the international insulated cable company Prysmian Cables. The installation and after-installation testing were jointly performed by Prysmian and CBi Electric African Cables, which provided an opportunity for local skills development on various aspects of the installation.

Interesting facts for the Ingula 400 kV Cable Systems Project are the following:

1) The four cable circuits are installed in a network of link tunnels, and access tunnels, which were originally used for the exploration of the Ingula generation station;
2) The tunneled cable route includes a vertical drop of 18 m, at approximately 800 m into the tunnel;
3) All four cable circuits are installed on a racking system with a height of approximately 2 m;
4) Below the ground level, the cable system terminates into a gas insulated switchgear generation transformer connection assembly;
5) Above the ground level the cable system terminates onto outdoor terminations in the transmission yard;
6) The insulated cable systems, after installation testing pass requirements, included an AC resonant overvoltage withstand test at 1.7 Uo (391 kV), for 1 hour per phase, and an additional partial discharge test at 1.5 Uo (346 kV); and

7) The project, for the four cable systems, was completed within the allocated project timelines, and no generation startup delays were experienced during the complete Ingula project due to the insulated cable system part of the project.

In parallel to the Ingula 400 kV Insulated Cable System Project, privately owned independent power producers in South Africa also performed and completed the Avon and Dedisa peaking power station projects, where short length 400 kV insulated cables systems were used for generation substation connections. Several other AC and DC insulated cable system projects for transmission applications, at voltage higher than 132 kV are also reported to be in planning, detail design and construction phase, in various Southern African power utilities.

These above developments confirm then, that insulated cables are no longer only a viable power distribution option at medium and high voltage levels in South Africa, but have become a viable power transmission option at extra high voltages for AC land applications in South Africa. This provides a new, exciting perspective to the countries power industry, and provides various new engineering solutions to design and construct the network of the future. More interesting will also be developments in considering DC cable systems for city area in-feeds, submarine cable systems for offshore wind generation, and submarine cable systems for interconnections with other neighboring countries. Only time will tell if the power industry will be able to make use of all viable transmission cable technology options available at present, and whether local manufacturing of these transmission cables will be a future consideration, should demands at 400 kV pick up.

Prospective power utilities interested in these new type transmission cable systems should consider studying available Cigre technical brochures, IEC standards and SANS 62067.

Contact the author for any further information (duplestp@eskom.co.za).

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Why cable matters in wind reliability & revenue

Although cables may sometimes be an afterthought, they play a critical role in generation, transmission and distribution.

BY | TIM CLANCY & JOE DEBOLT

For anyone who doesn't realize the important role of wire and cable in wind farm reliability and performance, consider the fact that a 125 MW to 150 MW wind farm with approximately 50 turbines encompasses about 3 million feet of cable for the nacelle, tower, collection system and transmission needs. That means that a larger-scale 625 MW to 750 MW wind farm – with approximately 250 turbines – relies on 4.5 million meters of cable spanning roughly 4,500 kilometres. When it comes to satisfying the demand for renewable energy, every foot of cable counts.

As an intermittent source of power that requires high reliability with low operation and maintenance costs, a wind farm must be extremely efficient to ensure that as much power as possible can be generated and delivered to customers whenever the wind is blowing. Any downtime or delays can result in enormous losses in revenue. Consequently, all of the cables within the system – from the rotor to the electrical grid – must be engineered to ensure maximum efficiency, cost-effective performance and long-term reliability. There are also several conditions within a wind farm that require industry-standards-based cable designs, which have been qualified and tested to withstand the operating and environmental demands throughout the life of the system.
As an intermittent source of power that requires high reliability with low operation and maintenance costs, a wind farm must be extremely efficient to ensure that as much power as possible can be generated and delivered to customers whenever the wind is blowing. Any downtime or delays can result in enormous losses in revenue. Consequently, all of the cables within the system – from the rotor to the electrical grid – must be engineered to ensure maximum efficiency, cost-effective performance and long-term reliability. There are also several conditions within a wind farm that require industry-standards-based cable designs, which have been qualified and tested to withstand the operating and environmental demands throughout the life of the system.

CONDITIONS AND CONSIDERATIONS

There are many sizes, types and voltages of wire and cable used throughout a wind farm. It is not unusual to find up to 50 different cable constructions within a system, all of which play a critical role in overall wind power generation, transmission and distribution.

Cable matters in reliability

continues from page 25

In the nacelle and tower, a wide range of power, control and signal cables is needed for a variety of interdependent systems, such as the generator, gear box, pitch system, yaw gear, transformers, controllers and other devices required to effectively monitor, control or convert the wind into electricity. In the collection system, medium-voltage underground cables are needed to provide efficient low-loss transmission of power from multiple turbines to the substation. Throughout the entire system, high-bandwidth fiber-optic cables make up the supervisory control and data acquisition system needed for continuous monitoring of the performance and efficiency of every turbine. And once the power reaches the substation, overhead transmission conductors deliver the renewable power to the grid.

Cable systems deployed within the nacelle and tower of a wind turbine are faced with a rigorous environment that includes vibration, flexing, high-torsion stress, electromagnetic interference, oil, ozone and extreme temperatures.

In the nacelle, cables need to be properly sized and selected to fit seamlessly with accessories and maintain constant connections as the nacelle turns into the wind. Power cables that are undersized could overheat during peak loads and potentially cause the device they are powering to do so as well. For low-voltage signal and communications cables, knowledgeable cable manufacturers can select proper shielding to prevent interference from electric motors and help to reduce or eliminate attenuation of the signal. This can be critical to maintaining signal transmission integrity for monitoring and control of auxiliary systems within the nacelle. The nacelle cables must also be resistant to oils and ozone, as well as flame-retardant, to maximize safety.

The tight space within the nacelle requires cables that are highly flexible with an appropriate bend radius of four to six times the cable's outer diameter for easy installation. Once the electrical energy moves from the generator in the nacelle to the vertical tower, which can be anywhere from 40 to 90 meters high, there are additional cable flexibility and torsion requirements unique to wind turbine generators. Cables that connect within the nacelle and run down the tower will experience extreme torsional stresses during their lifetime due to the nature of the rotating nacelle. The cable transition inside the tower that experiences torsional movement is known as a "drip loop." It provides the needed slack to minimize mechanical stresses exerted on the cables when twisting occurs.

The flexibility of a cable is primarily driven by the conductor strand type, as well as by insulation and jacket stiffness and cable geometry. With smaller-diameter cables, the need for flexible conductors is less of an issue. Larger-diameter cables require stranded fine-wire rope conductors for better flexing and bending. Because torsional stress is dependent on radial thickness, jacket and insulation stiffness, and torque (i.e., force of twist), the overall roundness of the cable is also a consideration. If a cable is not properly manufactured to be completely round, or if it features irregular radial thickness from its center throughout its length, stresses from the twisting force will also be irregular. This can place more stress on the internal components of the cable and lead to premature cable failure. Because wind farms can be located in a variety of terrestrial and offshore locations, wind cables require a broader operating temperature of -40°C to 90°C, while maintaining stable electric properties.

Although cable type is ultimately dependent on the turbine design and transformer location, cables within the nacelle and tower must meet stringent industry standards and specifications. In North America, the trend today for turbine manufacturers is to specify cables that meet both Canadian Standards Association (CSA) and Underwriters Laboratories (UL) standards. In South Africa, cables must meet the national standard of the South African Bureau of Standards (SABS).

In wind farm projects, the collection system is one of the most critical aspects. To capture as much renewable energy as possible and eventually reach a return on the high capital investment involved in building the wind farm, the collection system (including the 35 kV medium-voltage cable portion and the associated substations and transmission lines) must be designed and built for efficiency, endurance and economics.

Unlike traditional power generation plants that are located adjacent to substations, wind farms can be located several miles from a substation. Some of the renewable energy produced will be lost from the point of power generation to the substation due to resistance of the wires and equipment the energy passes through. Any amount of energy lost in the collection system is lost revenue. While some losses are inevitable, reducing the percentage of loss can be achieved by having properly sized and engineered cables with advanced materials

CABLE CRITERIA	DESIGN ATTRIBUTES
Cold Temperature -40°C	Rubber or very flexible thermoplastic jackets
Torsion	• Rubber or very flexible thermoplastic jackets • Fine-wire rope lay conductors • Use of fillers or extruded beddings for complete roundness of cable
Flexibility	• Rubber or very flexible thermoplastic jackets • Fine-wire rope lay conductors

Table 1: Cable criteria and design attributes for nacelle and tower cables

that are fully qualified and adhere to industry standards.

For example, traditional medium-voltage utility cables have been re-engineered to use cross-linked polyethylene jackets that offer reduced, optimized neutrals to provide a higher temperature rating and better efficiency over the life of the cable through cooler operation, lower line loss and greater resistance to deformation.

Because the collection system is a static and underground system, repairs are extremely costly. To minimize the risk of expensive repairs, medium-voltage cables used in the collection system should be constructed of qualified materials and tested and proven to demonstrate long-term reliability and performance for extended cable life in underground installations. They must be able to withstand the rigours and challenges associated with direct buried installation techniques and potential hazards, such as water ingress. Water-blocked conductors, concentric neutrals, jacket and completed cable are critical features that can prevent longitudinal penetration and migration of water along the conductor and beneath the outer cable jacket.

For maximum moisture protection, these cables should comply with the longitudinal water penetration resistance requirements of ANSI/ICEA S-94-649 Part 6 and ANSI/ICEA T-34-664 and SANS 1339:2010.

Unplanned delays during deployment can adversely affect the construction of a wind farm, potentially resulting in penalties and a loss of qualifying tax credits that are contingent upon delivering power by a specific date. Therefore, it is imperative that the collection system cables install seamlessly with connectors, fittings and other accessories in order to avoid costly delays. And once installed, terminations and splices must remain stable to prevent failures and revenue-losing repairs and maintenance. Compliance with standards is vital in this regard. For example, off-centered core dimensions can compromise cable functionality and accessory compatibility.

Like nacelle and tower cables, collection system power cables should be qualified to meet or exceed industry standards. Working closely with cable manufacturers to select the right design can minimize the risk of failures and avoid commissioning delays.

STANDARDS-BASED SOLUTIONS

With the deployment of wind energy sources and the high reliability and low operation and maintenance costs, the demand for cables that meet industry standards, has become paramount. Turbine manufacturers and utilities are calling for standard-compliant cables that have been tested and proven to meet design criteria for torsion, flexibility and temperature ratings while providing lower line losses and extended cable life. Certified test reports that can be traced to applicable national industry standards are highly recommended when specifying collection system cables for wind farms. As the renewable energy market evolves, wind cable industry standards are also evolving. Renewable energy developers will soon have improved guidance and standardization when defining cable types for wind applications. Industry standards organizationsm are recognizing wind farm cables in published codes and standards.

Industry standards organizations are also recognizing traditional cables with proven long-term performance and reliability. Most traditional standards-based cable types will soon be specifically permitted within wind turbine standards, which will help level the selection and performance ratings. Cable manufacturers with quality manufacturing capabilities and long-term experience developing cables for harsh environments are well positioned to offer these cables for wind applications.

As the wind energy market continues to grow, standards-based, tested and proven cables will go a long way to ensuring reliable wind power generation, transmission and distribution – and ultimately revenue. wn

Understand & Using the 2017 NEC Ampacity Table

The new ampacity table in the upcoming 2017 National Electrical Code is of great benefit for users and installers of premise cables who intend to carry power for the connected devices. The table clarifies and simplifies the process of choosing a cable suitable for carrying such power to devices, making it a simple 'lookup' task.

The table below is representative of the one approved the National Fire Protection Agency for use in the next edition of the National Electrical Code known as NFPA-70. The complete table will be found in section 725.144 of the code. It will also be referenced in Article 800 Communication Circuits. The table identifies the ampacity of each conductor (in Amperes) in a 4-pair Class 2 or Class 3 data cable. Ambient temperature used for development of the table is 30°C (86° F) with all conductors in all cables carrying current. The table is based on 60°C (140°F), 75°C (167°F) and 90°C (194°F) rated cables.

	Number of 4-Pair Cables in a Bundle																				
	1			2-7			8-19			20-37			38-61			62-91			92-192		
	Temp Rating			Temp Rating			Temp Rating			Temp Rating			Temp Rating			Temp Rating			Temp Rating		
AWG	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C
24	2.0	2.0	2.0	1.0	1.4	1.6	0.8	1.0	1.1	0.6	0.7	0.9	0.1	0.1	0.7	0.4	0.5	0.6	0.3	0.4	0.5
23	2.5	2.5	2.5	1.2	1.5	1.7	0.8	1.1	1.2	0.6	0.8	0.9	0.5	0.7	0.8	0.5	0.7	0.8	0.4	0.5	0.6
22	3.0	3.0	3.0	1.4	1.8	2.1	1.0	1.2	1.4	0.7	0.9	1.1	0.6	0.8	0.9	0.6	0.7	0.8	0.5	0.6	0.7

The POE standards permit power voltages of approximately 50 Volts and the higher power standards use all four pairs to provide that power. For the upcoming Type 3 and 4 POE standards from the IEEE, the following cable ampacities are required.

Type 3 60 Watts 0.3 Amps per conductor
Type 4 100 Watts 0.5 Amps per conductor

Importantly, to support the highest power specification under development by the IEEE, a rating of 0.5 amps will provide that capability. Within the table, selecting ampacities from the 92-192 bundle size provides a 'worst case' design criteria. There will also be a note regarding bundles over 192 cables that will allow the ampacity to be determined by qualified personnel under engineering supervision.

Hitachi Cable America's cables rated Category 6 and higher that are of 23 gage construction or larger and rated at 75°C will provide 0.5 Ampere capability. These cables are then inherently capable of supporting a 100W POE system within large bundles and no separate 'LP' rating is required to be compliant to the electrical code. There may be future standards or proprietary systems that offer additional power handling capability. Examples of this may include:

120 Watts 0.6 Amps per conductor
140 Watts 0.7 Amps per conductor

To support such higher power ratings, there are several ways to gain that ampacity rating:

1. Reduce the bundle size such that the ampacity rating is sufficient for the anticipated power load.
2. If half of the cables in a bundle are to carry power, then the ampacity in the table can be increased by 40%. For example, a cable rated 0.5A (100Watts), that same cable in this situation could be able to carry up to 0.7A (140Watts). This 40% increase in amp rating applies to any cable type or bundle size in the table.
3. For cables specifically designed for increased power loads or higher temperature ratings, an 'LP' rating is available through a UL listing, but again is not required by national electrical code. wn

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FEATURE

This article reviews approaches to design, modelling and testing of submarine dynamic power cables given the systems requirements for floating Offshore Renewable Energy (ORE). It mainly focuses on the global loading regime and internal mechanical stress estimation in highly dynamic working conditions as well as the assessment of cable mechanical properties, strength and fatigue life.

BY I MARCO MARTA
SVEN MUELLER-SCHUETZE
HEINER OTTERSBERG
DANIEL ISUS
LARS JOHANNING
PHILIPP R THIES

Floating Offshore Renewable Energy (ORE) can potentially provide a significant share of the future energy generation mix. Floating foundations greatly expand offshore wind turbine deployment areas by overcoming water depth constraints. Additionally, they open up opportunities for changes to manufacturing and deployment practices that may deliver significant cost reductions. Few full size floating wind turbine prototypes have been installed with more deployments announced[1].

Developers of both wave and tidal energy converters are also deploying an increasing number of floating prototypes[2].

Development of submarine MV power cable solutions

Most floating ORE connections to the power grid require dynamic inter-array submarine power cables.

These cables must continuously withstand dynamic mechanical loading regimes during their lifetime.

Devices are typically deployed in high environmental energy density locations and must withstand full year-round environmental conditions for the project lifetime of typically over 20 years. Most technologies are designed to work in relatively shallow water (i.e. up to few hundred metres), some to respond to wave motion in highly dynamic fashion. Consequently, dynamic power cables between floating hosts and the seabed lie mostly in the wave zone and are subjected to very severe loading regimes. These power cables must be designed to operate in highly dynamic conditions with cyclical axial loading sequences and continuous

Submarine Power Cables

continues from page 31

bending cycles due to both environmental loads and the relative motion of the device system components.

Failures risks include tensile failures, buckling due to extreme axial loads sequences, as well as bending failure due to extreme bending loads and related cable deformation below the specified minimum bending radius. Torque balance and cross-section stress balance are fundamental requirements for any dynamic cable. However, dynamic cables for floating ORE applications are expected to require special care and full assessment of their dynamic behaviour in operation as they are subjected to a loading regime where the potential for hockling and kinking is significantly amplified.

Inherent compliance together with typical internal components arrangement and geometry make dynamic cables especially vulnerable to alternating bending loads where radially compressed layers/elements are subjected to relative motion resulting in significant risk of wear, deformation and the degradation of physical properties.

Continuous dynamic cyclic loading during operation also exposes these cables to high risk of fatigue failure. Thies et al[3] assess the global loading regime and fatigue failure modes for a submarine cable connected to wave energy converter. Nasution et al[4,5] investigate fatigue life of stranded copper conductors subjected to severe combined tensile and bending loads.

A research project was carried out with the objective of identifying suitable design solutions for power cables in highly dynamic operating conditions in order to ensuring safe, reliable and cost effective electrical connections for floating ORE. This involved reviewing and strengthening the hydrodynamic and mechanical modelling methodology applied in dynamic cable design. A highly dynamic test cable was then designed and manufactured applying both best practices and novel solutions. Finally, the cable performance was thoroughly assessed through comprehensive mechanical testing and analysis.

METHODOLOGY

Present submarine cables design and manufacturing practices rely on a combination of theoretical and empirical models selected and developed through years of experience. A number of specialist finite element analysis (FEA) software applications are used for loads/stress analysis and design optimization.

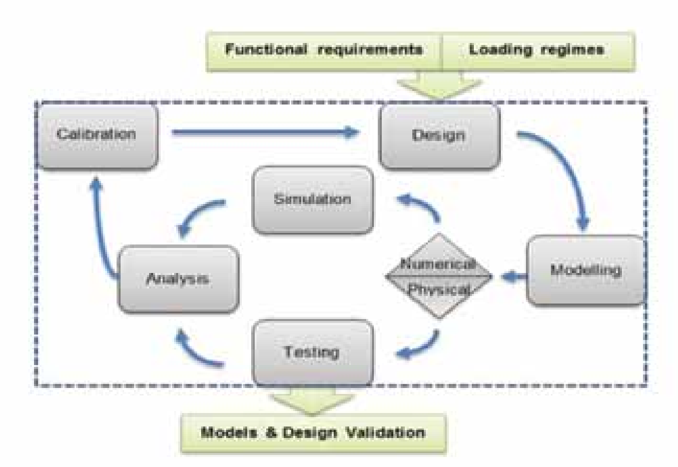

Figure 1: Methodological approach

However, uncertainties still remain regarding the precise characterisation of stresses and strains acting within a cable structure and their effects. From a structural mechanics prospective, submarine cable can be seen as an assembly of both metallic and polymeric elements with significantly different geometries and material properties. The widely dissimilar deformation responses to loading for the different elements, the effects of the interaction between adjacent components as produced by friction and stick-slip regimes on stress distribution and the impact on the individual elements material surface finish and overall mechanical properties of minimal changes in the manufacturing process are only a few of the substantial challenges to accurately model loads and related effects through numerical analysis.

Given these uncertainties, a cautious approach to design and modelling was applied throughout the project. Best practice design and manufacturing methodologies were critically reviewed and assessed together with relevant documentation – although specific submarine dynamic cable standards have not yet been issued – including ISO 13628-5[6], DNV-RP-F401[7] and CIGRE Electra No.171 recommendations[8]. All important design decisions were supported by numerical simulation and calibrated through physical testing. The overall iterative approach is shown in Figure 1 and is briefly explained in the following paragraph

The project started with the consolidation of significant amount of information collected on floating ORE through contacts with developers as well as literature. This included functional requirements for dynamic power cables and related accessories

as well as information about hydrodynamic behaviour and loads.

Comparing and contrasting numerical and experimental results allowed the optimization and validation of design and manufacturing choices. The test program involved identifying and applying appropriate measurement and monitoring techniques aimed at assessing and validating design and modelling assumptions. A selection of cable samples and associated components were subjected to both extreme and cyclic loading regimes. A specific focus was on the assessment of fatigue failure modes and fatigue life estimation methods and included a combination of standard methods, novel test configurations and detailed component and materials analysis.

Results and analysis from both modelling and testing activities informed the design of a test cable that was manufactured and then subjected to a further cycle of accelerated testing.

The following sections present further details regarding the design activities in form of modelling and physical testing, presentation of results and conclusion.

MODELLING

A detailed understanding of both the hydrodynamic loading and internal mechanics of subsea cables is required in order to design and manufacture a cost-effective yet robust and reliable product.

Global hydrodynamic loads are the result of the combined action of direct environmental loads acting on the submarine cable together with secondary loads transferred to the cable by the motion of the floating structure due to wave, currents and wind.

In order to estimate the global load impact on the cable structure, all combinations of axial, bending and torsional loads must be converted into stresses acting locally on each cable component. This informs the calculation of the structural strength of each cable component as well as the assessment of risk of failure/damage due to extreme as well as cyclic loads.

HYDRODYNAMIC MODELLING

Numerical modelling of cable dynamics and global loads estimation was carried out using OrcaFlex, finite element analysis software developed by Orcina Ltd.[9]. The application allows modelling power cable responses as well as investigating coupling effects between the cable and the floating host and/or the mooring system.

Simulations were carried out for a selection of devices representative of different energy extraction technologies and mooring configurations. The analysis included all main floating wind turbines foundation designs, namely: spar, semisubmersible and TLP as well as three floating wave energy converter types: an attenuator, a point absorber and an oscillating water column. In each case, the environmental conditions and loading of the deployment sites were applied and cable mechanical properties, accessories selection and deployment arrangement were adapted to suit the system requirements.

It should be noted that it was not always possible to run simulations with dynamic behaviour fully defined by response amplitude operators (RAO) for all investigated configurations. In those cases, system configurations were defined through given information on devices mass distribution, displacement and mooring arrangements. Consequently, effects due to power take off activity or, if applicable, motion control systems were explicitly excluded. In all cases, time-domain analysis was carried out in order to ensure the inclusion of non-linear coupling and structural effects as well as system responses to time varying currents and waves.

The activity allowed the definition of a global loading regime envelope covering a wide range of floating ORE devices. This covered both extreme and cyclic loading in the axial direction, in bending and shear. Through the analysis of dynamic behaviour and loads distribution along the cable route, critical cable sections subjected to more intense loading in operation and hence requiring special attention were also identified.

MECHANICAL MODELLING

The von Mises Stress represents the maximum effective stress produced by the combination of tensile, compression, bending and shear loading[10]. For the present analysis the von Mises stress acting on each point of the individual components has been derived from the global load modelling. It is calculated by applying a combined approach of FEA modelling and cable structural analysis. Failure mode and effect analysis (FMEA) assessment can then be directly applied to confirm that all cable components can reliably operate under expected range of extreme environmental loads and hence validate the design.

FATIGUE LIFE ESTIMATION

Fatigue life modelling and estimation is a more complex process. During the

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expected lifetime of 20 or more years, dynamic power cables would see a whole variety of site dependent environmental conditions, ranging from violent storms to very calm sea states. The design challenge is to apply an efficient, but sufficiently reliable method to account for lifetime accumulated loading effects to ensure that the cable design life meets the specification requirement. A widely established method involves analysing metocean data for a given deployment site to generate the environmental load spectrum for the required period based on the probability of the occurrence of given sea states, current and wind. Global loads are then converted into internal stresses whose effects on fatigue life are subsequently evaluated with the use of S-N curves and Miner-Palmgren summation of fatigue damage principles[11]. A safety factor is then applied to account for uncertainties and simplifications.

In this project, the method is applied as follows:
A significant number of representative load states combinations are selected and hydrodynamic modelling carried out so that in each case the related cable short-term global loading time history can be extracted. Von Mises stresses are then calculated by applying the same principles described above for extreme loading assessments. In this case, however, analysis is carried out in the time-domain rather than for an individual event. Consequently, loads to effective stress calculation are more efficiently managed through conversion functions that account for the contributions of acting global axial, bending and torsional environmental loads combinations and produces effective stress time series for the affected cable components.

The conversion functions can be conveniently simplified by limiting their range of validity within a pre-defined minimum that is, loads magnitudes below which further global loads variations result in very marginal changes contribution to effective stress, and maximum loads that must not be exceeded as likely to cause failures.

Within the restricted ranges, it is normally possible to define linear conversion relations linking to a good approximation inner cable components maximum effective stress (σ_{MES}) to both curvatures (ρ) and axial load (T) as follows:

$$\sigma_{MES}[MPa] = A \times \rho[m^{-1}] + B \times T\ [kN] \qquad (1)$$

Where both A and B are coefficients that need to be calculated for each component.

The *short-term* time histories of *von Mises* stress calculated with equation (1) can then be filtered through the *Rainflow counting algorithm* in order to convert the irregular varying stresses into simple stress reversal cycles. Additionally, the *Goodman relation* (2) is applied to calculate fatigue limit of the material σ_{fat} when subjected to alternating stress – or endurance limit for materials that do not have fatigue limit (e.g. copper) –as function of both stress amplitude σ_a and related mean stress σ_m produced by Rainflow counting. This is required in order to ensure consistency when applying S-N curves that are normally produced by subjecting test pieces to alternating stress regimes with mean stress $\sigma_m = 0$

$$\sigma_{fat} = \frac{\sigma_a}{1-\left(\frac{\sigma_m}{\sigma_{uts}}\right)} \qquad (2)$$

Where σ_{uts} is the material ultimate tensile strength.

Any S-N curve can be described by a modified Basquin's equation as in the form

$$N = a_D \times \Delta\sigma^{-m} \qquad (3)$$

Where N and $\Delta\sigma$ are, respectively, number of cycles and stress range (that is, $2 \times \sigma_a$), while " a_D and m are parameters given for the component/material.

The *Miner-Palmgren* rule of damage accumulation can then be applied to calculate the approximate damage produced by each of the short-time periods.

$$D_{short\_time_k} = \sum_i \left(\frac{n_i}{N_i}\right) \qquad (4)$$

Where:
N_i is the number of cycles to failure at constant stress range as extracted from the relevant S-N curve and

n_i is the number of alternating stress cycles at the i stress amplitude in the *short term* period.

The total estimated *long-term* fatigue damage and consequently the cable theoretical fatigue life can then be produced as collation of all the k *short-term* damages according to the probability of load states occurrences in the required period. The final critical step is the appropriate definition and application of safety factors to determine the cable design life.

The fatigue life estimation method described above has the advantage of allowing efficient handling of large amounts of data. However, it carries uncertainties and explicitly introduces major simplifications

to the actually occurring physical processes. Extensive tests and measurements are essential to minimize uncertainties, calibrate the design procedure and determine the suitable safety factors that may be applied to each component and eventually the whole cable design. An overview of the project test plan is in the following section.

TESTING

The test plan included a range of both static and dynamic mechanical tests. In the initial part of the project, experimental data was required to support the progressive development and calibration of the methodology used for the estimation of dynamic cables mechanical properties. Additionally, accelerated stress testing – where loads conditions exceeding normal operations are applied in order to accelerate components degradation and the development of failures – informed and validated fatigue related failure modes and effect analysis (FMEA) assumptions as well as the suitability of specific design choices.

In the latest part of the project, the full set of tests was carried out on a newly designed highly dynamic test cable in order to reassess and validate both modelling practices and design choices. Accelerated life testing focused on components reliability and fatigue life estimation. Static tests and related aims are summarized in Table 1.

The procedures followed established practices as described by Electra No.171 and ISO 13628-5[6, 8].

STATIC MECHANICAL TESTS	
TEST TYPE	**AIMS**
Bend stiffness	Measurement of cables inherent stiffness. Mechanical models validation
Tensile	Measurement of both axial and torsional stiffness. Verification of components strength. Mechanical models validation

Table 1: Summary of static mechanical tests

Table 2 shows a summary of the dynamic mechanical test activities and the related aims. Overall number of cycles applied at different curvature and axial loading combinations exceeded 2.5 million cycles.

DYNAMIC MECHANICAL TESTS	
TEST TYPE	**AIMS**
Power cores Bend vs. template (PC-BaT)	Component level accelerated stress testing. Development of failure modes and effects analysis. Design choices verification.
Full cable bend vs. template (FC-BaT)	Full cable level accelerated stress testing for FMEA and design choices verification.
Fully dynamic pitch, roll and heave combined loading (DMaC)	Accelerated life testing for reliability and fatigue life assessment

Table 2: Summary of dynamic mechanical tests

Electrical measurements were carried out both before and after dynamic loading on a selection of samples according to IEC 60502-2[12] in order to confirm compliance to cable standards acceptance criteria as well as assessing possible performance degradation. All samples were dissected and visually inspected to verify type, magnitude and location of any damage/failure caused by the dynamic loading on each cable component. A further detailed analysis was carried out in material testing laboratory also assessing material properties changes produced by the loading regimes.

Further details on dynamic test procedures are presented here below.

BENDING AGAINST TEMPLATE: PC BaT AND FC-BaT

The test method involved subjecting the specimens to cyclic bending against a shaped template to apply a specific curvature. In some of the test settings, a constant axial load was also applied. The procedure followed DNV-RP-F401 guidelines[7]. One test arrangement example is shown in Figure 2.

The test plan included both *FC-BaT* tests carried out on full cable samples in order to fully assess components interactions effects within the cable structure and *PC-BaT* individual power cores test for a more focused analysis of metallic screen and conductor fatigue performance.

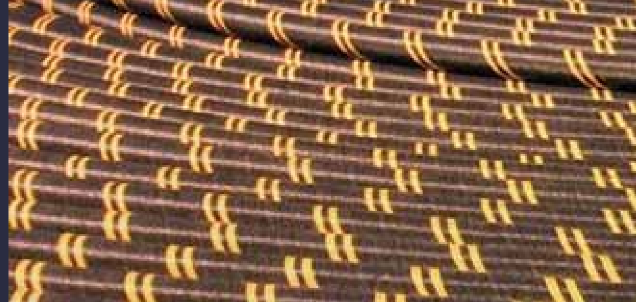

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Figure 2: Bending against template test arrangement

DMAC LOW CYCLES FATIGUE TEST

The Dynamic Marine Components test facility (DMaC) is a purpose built test rig where specimens can be subjected to a loading regime that closely replicate forces and motions of the offshore environment in controlled laboratory conditions. At one end of the test rig, a linear hydraulic cylinder can apply tension and compression force (replicating heave), while at the other end the headstock can move with two degrees of freedom (replicating pitch and roll). The test arrangement is shown in Figure 3, a detailed test rig description is given in[13].

Figure 3: DMaC test arrangement

Four dynamic cable samples were tested on the DMaC test facility as part of this project. In all cases, the applied loading regimes were based on the results of *OrcaFlex* simulations that included submarine power cable with the specimens' mechanical properties. The section along the cable route subjected to the highest load was identified and the relative curvature and axial loading time series extracted to be used as DMaC input.

The procedure ensures that the loading regime applied to the sample closely reflects the full spectrum of combined axial and bending variable loading acting in offshore field deployments. At the same time, DMaC loads time series can also be adapted according to the test objectives, e.g. reaching the calculated sample fatigue life when applying the *accelerated stress testing* approach.

RESULTS

Main project results include the definition of loading regimes envelops for dynamic power cables connected to a range of floating ORE devices, the assessment of failure modes occurring under this highly dynamic operating regime together with their effects on cable functionality and safety and the implementation and validation through testing of suitable design and manufacturing solutions optimized for floating ORE operations.

The rest of this section provides a brief, mainly qualitative summary of each of the results areas. In each section, one aspect is also selected for a more detailed description.

GLOBAL LOADING REGIMES NOTES

In all configurations investigated as part of this project, the tensile load was never found to be a critical loading regime as its magnitude never exceeded 100 kN. On the other hand, axial compression loads were significant in some of the configurations posing some risks of buckling and/or birdcaging. In all cases suitable route configuration together with cable structural strengthening with anti- buckling tape was estimated to ensure safe and reliable operations.

Extreme bending and/or fatigue damage due to cyclic bending loads was a significant issue in all configurations. In all cases it was the governing design factor for dynamic cable, cable protection systems and cable route configuration in the water-column.

The relation between cable mechanical properties and global

hydrodynamic loading was also investigated. Comparing the behaviour of cables with significantly different mechanical properties confirmed that responses to acting forces and, consequently, cable global loads in dynamic regimes are significantly dependent to cable mechanical properties. An example is shown by comparing two cables, identified as CX2 and CX3, subjected to the same environmental loading regime. The cables have identical functional specification as well as route configuration, but significantly different structural properties as shown in Table 3.

	EA	EI	MASS/OD
CX3/CX2 RATIOS	2.3	9.2	1.4

Table 3: CX2 vs. CX3 key mechanical differences

Figure 4 compares: a) maximum axial load and b) maximum curvature as calculated along the two cables lengths. The plots indicate that in the given configuration and operating mode, maximum tensile and bending loads acting on CX3 are, respectively, about 30% and 50% lower than on CX2.

In other words, cable design can potentially contribute to actively reduce and not only to withstand global loads. Clearly the impact on an actual implementation where cable responses need to be optimized for the whole spectrum of environmental loading in operation cannot be as significant as shown in this example. Its contribution may however be significant in highly dynamic implementations.

FATIGUE LIFE ESTIMATION AND FAILURE MODES

During the physical tests full-scale cable specimens were subjected to the number of load cycles – both on the FC- BaT and DMaC test rigs – equivalent to the estimated fatigue limit. In all cases, the following cable dissection revealed damage distribution on both functional and structural components mostly in line with expectations. On the other hand, only partial or minimal degradation of the components functionality was measured. The results confirmed the understanding of failure mechanisms under dynamic load, and informed the selection of design solutions included in the highly dynamic test cable aimed at minimizing components degradation due to frictional effects under a highly dynamic loading regime.

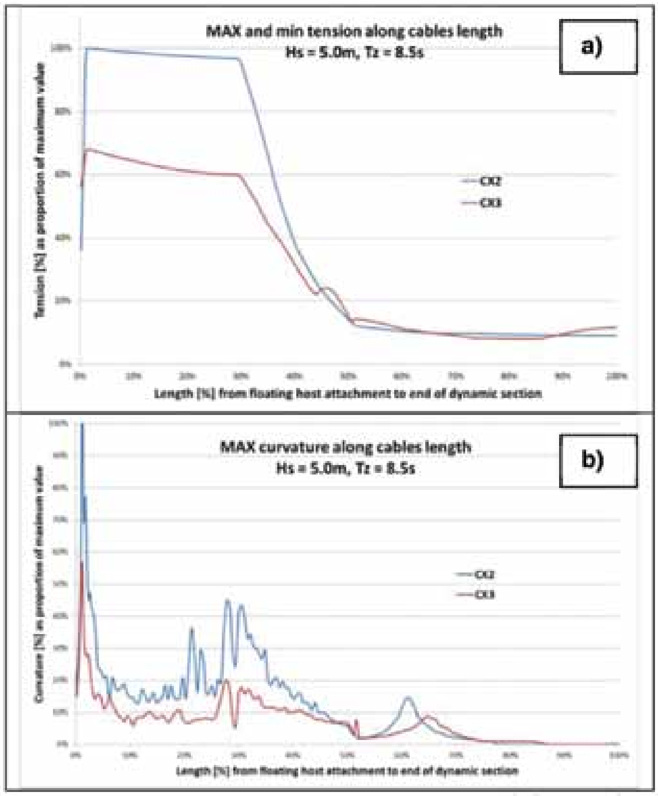

Figure 4: Structural properties effects on global loads

Fatigue failure in metals starts with the formation of cracks on the components surface. Fretting is one of the crack initiation mechanisms identified in copper wires conductors. It occurs at the contact area of two metallic bodies under load subjected to very small amplitude relative motion[10]. Matching oxide dark patches are normally seen on the copper wires contact points between layers when inspecting conductors subjected to cyclic loading. The thickness of oxide layer was found to increase in the section subjected to higher bending loads causing pitting on the wires surface and brittle debris flaking off.

Figure 5 shows the fretting fatigue failure of a conductor copper wire. The arrows marked with A indicate a relatively deep pitting developed at one of the contact points under the oxidized layer from where the fatigue crack propagated. It can also be noted that the adjacent point of contact, marked by the B arrow, presents a larger plastic deformation due to conductor compacting, but no sign of cracks under the oxidized layer.

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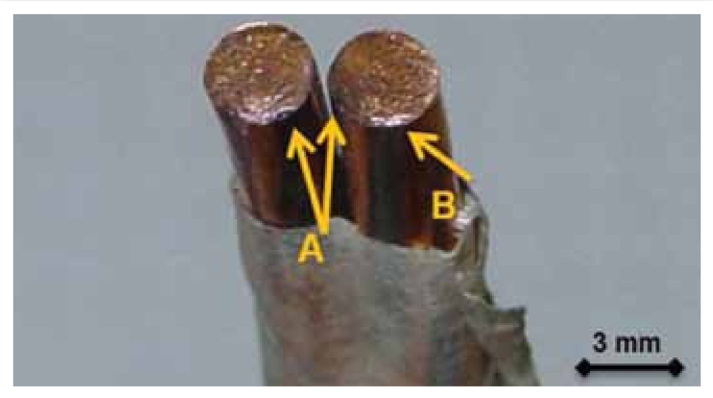

Figure 5: Fatigue failure of a copper conductor wire

MECHANICAL DESIGN NOTES

Although the description of specific mechanical design solutions is not the subject of this paper, some general notes are added here below for completeness.

The specification of the basic functional requirements for the highly dynamic test cable are shown in Table 4:

Nominal voltage	12/20(24)kV
Conductors	3x 50 mm^2
FO element	6x SM + 6x MM (*)
Minimum standards applied	IEC 60840; IEC 60502-2

(*) SM = Single Mode; MM = Multi Mode

Table 4: Test cable basic functional requirements

The cases investigated throughout this project presented a variety of functional specifications and loading regimes demanding slightly different dynamic cable design solutions. It is noteworthy that in all cases fatigue was found to be the governing failure mode. Maximizing cable fatigue life was a key project design objective. Design solutions and manufacturing practices minimizing stress distribution within cable structure under dynamic loading regimes were tested, selected, implemented in a specially designed test cable and finally validated. They can be summarized with two general principles:

- Optimal components stress balance - where the near totality of loads are carried by cable components included for strength and protection - must be ensured in all global loading operating conditions in order to prevent mechanical overloading of the cable functional elements including conductors, insulation systems, metallic screens and fiber optics.
- Decoupling of the structural metallic and polymeric strength elements from the functional components must be maximized to ensure both good stress distribution in bending and easily slip in all operating load conditions. This then minimizes materials degradation due to friction effects.

The cable bend and axial stiffness, as well as its mass/volume ratio may be also optimized in order to minimize the cable responses to both direct and secondary loading.

CONCLUSION

The project enabled to further strengthen capabilities in modelling, design and testing of dynamic submarine power cables. Specific solutions addressing floating ORE systems requirements were implemented in a specially designed and manufactured test cable. An extensive test program was carried out to validate design solutions and confirm cable reliability. wn

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FEATURE

BY | VICENÇ MERCADÉ | DANIEL CALVERAS | NEUS GENERÓ | CHRISTIAN SCHLYTTER-HENRICHSEN

Medium Voltage Hydrocarbon Fire Resistant Cable For Oil & Gas Application

A medium voltage fire resistant cable has been developed and tested exceeding existing fire performance requirements.

The main purpose of this study is to describe the need for an improved fire resistant cable solution/design to demonstrate the fire properties of a novel cable design.

The study gives an overview of existing international fire test requirements and a description of the technology behind the cable development.

Finally it concludes in safety contribution and cost reduction for the Oil & Gas industry.

Oil & Gas is traditionally an industry that drives technical innovation in order to reach more and more challenging solutions in a wide range of areas. Health and Safety is one of the major areas where this industry has developed new products to ensure human and equipment safety. One of the most important hazards of this industry is the fire risk. When a fire occurs at a refinery, offshore facility or petrochemical plant, the electrical systems that serve critical circuits such as process equipment, ventilation, fire extinction systems, alarms and other emergency systems must remain operational. Otherwise safety would not be guaranteed.

In recent years a great deal of research has taken place internationally to ascertain the types of fire which could occur in a petrochemical installation. This research has taken place in both real, by simulation and laboratory conditions. As a conclusion of this research, three different type of fire scenarios have been defined; cellulosic fire, hydrocarbon fire and jet

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fire. However, classification societies define hazardous zones only taking into account cellulosic fire. Otherwise a specific risk assessment is required.

In a Hydrocarbon Fire (HCF) risk zone all cables must be protected by external passive fire protection system. The passive fire protection system insulates the electrical installation and prevents it from collapsing when subjected to the effects of fire. This ensures the integrity of the electrical system during evacuation time. The new developed medium voltage cable incorporates the required passive fire protection (PFP) into its design in order to keep electrical integrity during a HCF scenario.

FIRE SCENARIOS

Cellulosic Fire

Intended to simulate natural carbonaceous-type materials such as wood and paper, these fires have relatively slow heat rise and peak temperatures of 950 °C.

Scenario in which is based IEC standard (IEC 60331- 21).

Hydrocarbon fire

Although the Cellulosic curve has been in use for many years it's certain that the burning rates for certain materials, e.g. petrol gas, chemicals etc., were well in excess of the rate at which for instance, timber would burn. As such, there was a need for an alternative fire exposure conditions intended to represent fires fuelled by oil spills or gas clouds, characterized by higher heat fluxes and faster time to a maximum temperature of 1100 °C.

After the Piper Alpha Platform fire in 1988, protection against hydrocarbon-fuelled fires has become the norm for the offshore industry.

Such scenarios are defined by EN 1363-2:1999 and ISO-834-3, with heat flux of 200 kW/m^2.

Jet fire

A unique type of hydrocarbon fire caused by pressurized gases or fuels that are released through a leakage and then ignited. A jet fire has even higher heat fluxes, where peak temperatures can exceed 1200 °C and recognized by highly erosive forces. Scenario in which are based on ISO 22899-1 with heat flux greater than 200 kW/m^2.

HAZARDOUS AREAS

Oil & Gas facilities are frequently equipped with storage, drilling and production equipment and, consequently, the presence of hydrocarbons. On those Oil & Gas facilities not intended to perform these type of operations, the presence of hydrocarbons may be temporarily. Any zone where hydrocarbon vapours are present during the operation is classified as a hazardous area.

Hazardous areas are defined by the classification societies and IEC standards, such areas where a flammable atmosphere may be expected to exist continuously or intermittently, are defined as a hazardous area. Thus, flammable atmospheres may arise from storage, leakage, or any other source that that can release flammable liquids and gases on the installation.

Classification societies does not recommend to install electrical equipment in hazardous areas unless essential for operational purposes[1]. Where the installation of electrical equipment in a hazardous area is necessary, the selection and installation of appropriate equipment and cables has to be in accordance with IEC 61892 or other recognized standards[2].

IEC 61892-4 does not provide a cable selection guide other than for a simple CF scenario. Consequently, it does not include or consider a much more harsh fire scenario as that of a HCF. However, guidance about how to test under HCF condition is given as a non- normative note[2].

Hazardous zones are classified in three different classes: zone 0, zone 1 and zone 2[1,3]:

Zone 0: ignitable concentration of flammable gases or vapours are continuously present or present for long periods.

Zone 1: ignitable concentration of flammable gases or vapours are likely to occur in normal operating conditions.

Zone 2: ignitable concentration of flammable gases or vapours are not likely to occur, and if it occurs, it will exist for a short time.

Resulting from this zone classification, cables are generally not to be installed in hazardous areas. In zone 0 cable must be associated to a necessary circuit if it is essential for operational purpose.

In zone 1 cables must be armoured, metallic sheathed, mineral insulated or installed in a metallic conduit. Cables also need to be sheathed with impervious jacket and armoured to prevent gas migration and mechanical damage.

TEST PROCEDURES

HCF test set-up

The test furnace was a gas heated horizontal furnace with a total of 16 propane burners.

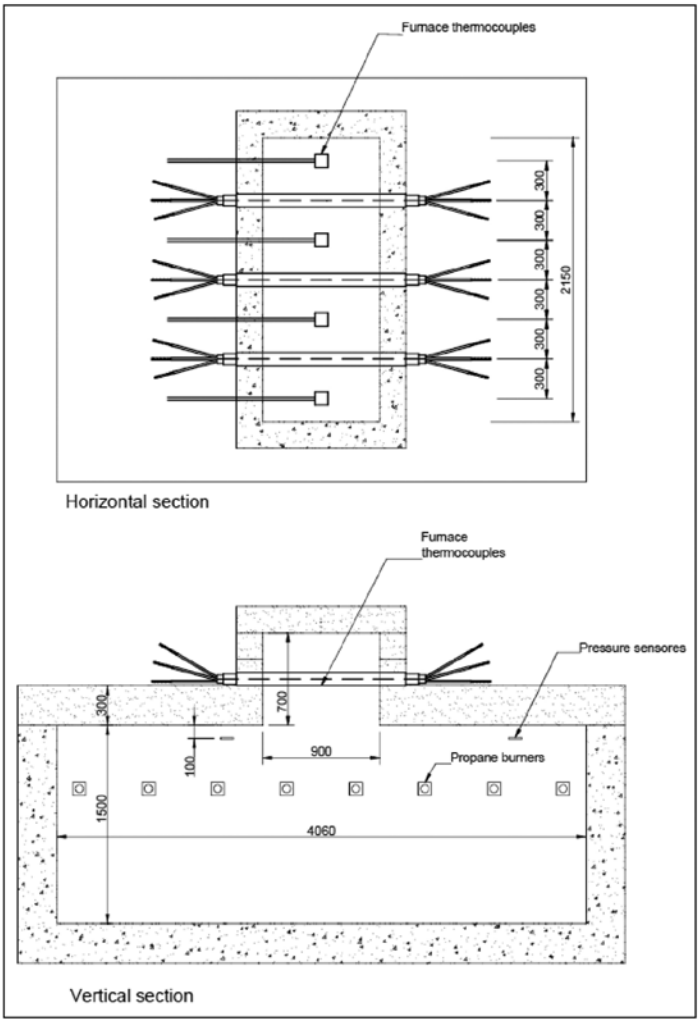

Fig 1 - Furnace setup

At the top of the furnace, there was made an annex to reach 900 mm exposure length of the cables according to NEK TS 606:2016[4]. The furnace lining consists of materials with an approximate density of 550 kg/m³. See Figure 1 for further description of the furnace.

The furnace thermocouples were designed according to IMO – FTP Code (Fire Test Procedures Code), part 3 paragraphs 7.3[6]. There were a total of 4 thermocouples poisoned in the same level and direction as the cables, with the face towards the furnace burning chamber, see Figure 1. The reason to put the thermocouples in the same level, and in the same direction/angle as the cables, is to measure the temperature in exact the same position as the cables (the temperature will vary inside the furnace depending on the position and level).

The pressure inside the furnace was measured by T- shaped sensors according to IMO – FTP Code, part 3 paragraphs 7.4[6].

TEST CONDITIONS

The furnace temperature was measured with an accuracy of ±15K, and the tolerances were based on EN 1363-2:1999[5]. See Figure 2 for average furnace temperature during the test. The temperature inside the furnace during the test was given by mean of the four thermocouples described above.

Heating curve was the Hydrocarbon fire curve in accordance to EN 1363-2:1999[5], which is in accordance with the newly adopted NEK-TS-606:2016[4]:

$$T = 1080\,[1 - 0{,}325e^{-0{,}167t} - 0{,}675e^{-2{,}5t}] + 20$$

t is the time from start of the test in minutes
T is the average required furnace temperature in °C

The intended pressure during the test was +20 Pa (compared with the atmosphere pressure outside the furnace). The sensors were positioned at the level 400 mm below the cables; see Figure 1.

The cable was installed in the furnace with supporting outside the burning chamber, on both ends of the cable. There was no support of the cable along the exposed length.

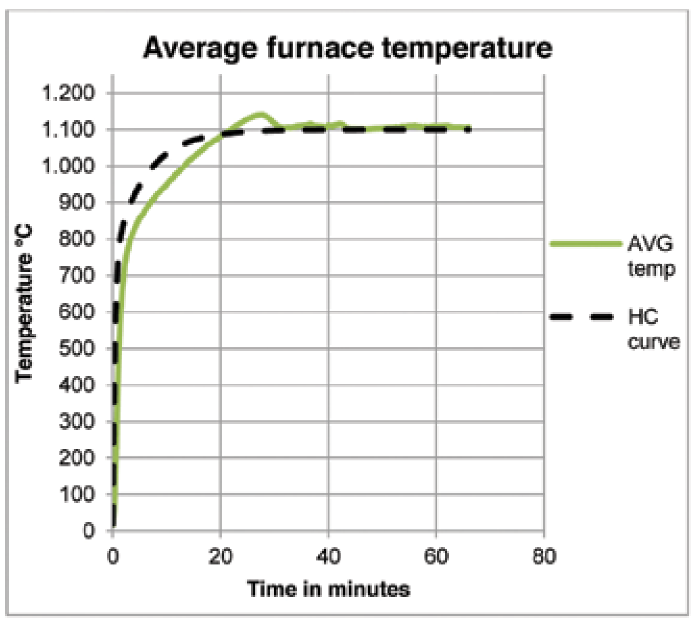

Figure 2: Average furnace Temperature

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The average ambient temperature inside the test hall was 19°C during the test.

TEST SPECIMEN

The tested cable was in full scale, and produced by General Cable. The cable was transported to SP Fire Research AS for fire testing. The cable was stored in the test hall prior to the fire test for conditioning until ambient temperature was reached inside the whole cable.

Figure 3 – Cable design

SP Fire Research AS controlled the cable, and found it to be in accordance with the description given by the client. The cable was installed in the furnace by technical staff from SP Fire Research AS prior to the fire test. The exposed length of the cable was 900 mm based on NEK TS 606:2016[4]. There was no support of the cable along the exposed length, in order to replicate a worst-case scenario. The cable was supported on both ends, outside the burning chamber. The cable was orientated horizontally.

ELECTRICAL CIRCUIT

IEC 60331 "Tests for electric cables under fire conditions – circuit integrity" states that the test voltage between conductors shall equal the rated voltage between conductors, and the test voltage from conductor to ground shall equal the rated voltage from conductor to earth. In this case the test object is a 15 kV, three-phase cable with individual metallic earth screen on each phase and a common fire-protected outer sheath. The design indicates that a conductor to earth-failure must occur prior to a conductor to conductor failure, thus the power supply was designed for a voltage of 8.7 kV applied between conductor and ground. The three conductors were connected in parallel and all individual earth screens were interconnected and grounded.

Electrical field grading terminations were assembled on each of the six cable ends and the test object was verified partial discharge-free at 10 kV (conductor to ground) prior to the fire test. This was performed in order to ensure that any cable damage during the test was related to the HCF curve exposure and not electrical issues outside of the heat oven.

IEC 60331 comprises low voltage cables up to and including 0,6/1 kV and the test acceptance criterion for such cables is no breaking of a 2 A fuse during the test period. For higher voltages, slow fault development is not relevant and the acceptance criterion for the 15 kV cable was based on no collapse of the supply voltage (total cable breakdown) during the test period.

The layout of the electrical circuit was designed to fulfill the technical requirements described. In addition HSE requirements for high voltages were considered. The electrical equipment was built into an insulated cabinet to avoid contact electricity. Red flashing lamps were installed at selected locations to visualize supply power switched on.

A voltage indicator lamp was installed at the primary side of the high voltage transformer to visualize power on the test object. A high voltage probe was used for the operator of the electrical equipment to monitor the applied voltage and adjust it to correct level during the test. A logger signal was transmitted to the HCF control room for continuous monitoring of the electrical integrity of the test object. A sketch of the electrical circuit is shown in Figure 4.

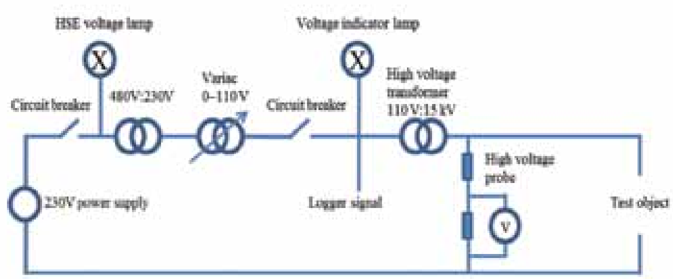

Figure 4 – Electrical circuit

The area of the furnace and electrical equipment was visually fenced with marking bands and high voltage signs. During the HCF test the operator of the electrical equipment was responsible for avoiding persons entering beyond the marked "danger area".

HCF CABLE SOLUTION TECHNOLOGY

The cable design to pass the HCF fire test is based on the use of specific ceramifiable compound as a fire barrier.

The base-polymer for the Favuseal HCF technology is found in the Ethylene Vinyl Acetate (EVA) family of products. This foundation gives excellent processing capabilities via injection molding, vacuum forming, compression molding, and ultimately, extrusion processability. This type of polymer is also found to be a good carrier of the extreme technology found inherently in the Favuseal compound.

The Favuseal HCF material is designed and engineered to exploit two inherently strong endothermic reaction processes ignited at two separate temperature intervals on the HC fire curve. The first endothermic reaction process, recognized by the release of "trapped water", has the added benefit of swelling effect of the Favuseal HCF technology.

Consequently, a robust thermal barrier is created reducing the heat penetration through the Favuseal HCF material inwards towards the MV cable core. The first endothermic reaction process is actually so strong in nature that it cools of the surface of the object it is protecting. The second endothermic reaction happens at a higher temperature. Although not as endothermically strong as the first reaction, it further helps to cool down whatever object the Favuseal HCF compound protects.

The "cooling" effect is a result of the pyrolysis of the polymeric binders in the material, resulting in a transformation away from a polymer into a solid micro- porous ceramic state. This end-result is a stable ceramic layer that is able to withstand in excess of temperatures of 1.500˚C, well within the defined temperature of the HCF curve.

HOW FAVUSEAL TECHNOLOGY CONTRIBUTES

The outer diameter (OD) of a cable is very small in terms of traditional fire protection meaning that the ability of the object to absorb applied heat is extremely low compared to traditional objects protected under a HCF scenario. In addition, a cable is flexible making the use of traditional PFP products redundant. The "in situ" application of fire protection via spraying or construction of fire boxes on the cable trays is an old an outdated way of providing passive fire protection of a cable design.

The Favuseal material represents a flexible, low cost, and easily applied technology in order to have PFP to cables via the use of existing extrusion machines readily available in a cable factory. Expensive on-site application of passive fire protection products is, consequently, a thing of the past and not feasible from a total cost of ownership point of view. In addition, the internal rate of return of doing an initial investment into a Favuseal "powered" cable is extremely high when compared to the traditional way of providing PFP to a cable design. Once the extreme Favuseal compound is extruded onto the cable in a solid layer, it gives continuous 24/7 active passive fire protection for the life of the installation. The ide of providing inherent protection to the cable at factory-level is completely new, and represents truly amazing cost savings to the end customers of and users of such cables.

In conclusion, it is the two strongly energy consuming endothermic reaction processes, resulting in a very low lambda value ceramic state, that makes the cable survive the temperature curve defined by ISO-834-3, 200 kW/m2. In addition, the solid ceramic micro porous state of Favuseal makes an excellent thermal barrier, and yields added mechanical protection, for the exposure time of the testing in mention.

TEST RESULTS

Failure occurs when there becomes a short circuit between one of the conductors and the screen around the actual phases, or between the conductors and the braid armour. The cable was tested with operating voltage to the conductors during the test.

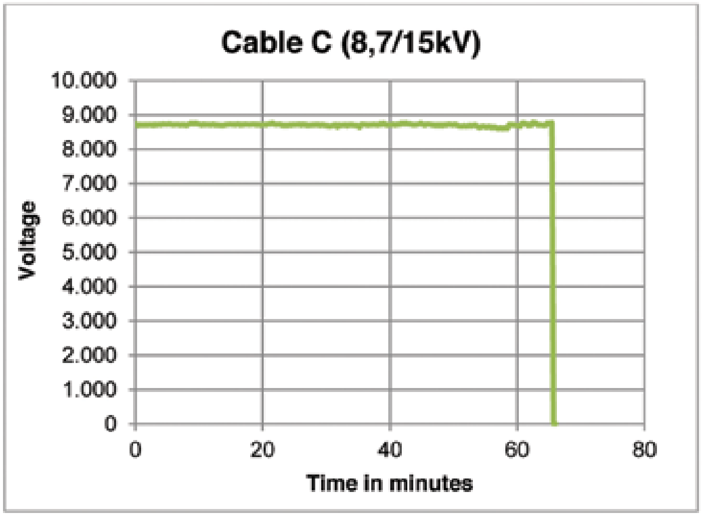

Figure 5: Test result and time breakdown.

MV Fire Resistant Cables

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Test duration was 66 minutes, and the time to breakdown was 65 m, 30 seconds. There were a total of three cables in the same test. This paper and the given test results describes one cable only. The three cables were connected to an independent power supply and did not influence to each other during the fire test.

The applied voltage and the time to breakdown were given by the logger signal during the test. See Figure 5 for graphical presentation.

CONCLUSION

A fire accident is an immense disaster and gives images that will always remain in our minds. Recent catastrophes have been published in the most important information media and the consequences of such accidents are huge.

Human lives but also enormous financial consequences arise after a fire accident. Oil platforms and refineries have been out of order for months after an accident. Direct repair cost, but also the cost related to lost business, replacement of infrastructure, materials brings the direct and indirect financial loss to the millions.

Protecting power supplies contributes to keep active protection systems, such as smoke extraction systems, fire escape signs, detection systems, and the total integrity of technical installation intact, so that light and communications remains available allowing for a proper and safe evacuation to be executed.

It goes without saying that adopting to a HCF resistant cable contributes to an overall safer industry, dramatically reduces the risk of failure during a fire scenario, and ultimately, significantly impacts the financial burden in case of a fire in a positive way.

During new build FEED phase, there are several advantages of using HCF cables instead of plain fire resistant cables. Engineers will be able to route the cables through HCF classified zones without any additional engineering to protect electrical and instrumentation circuits via use of external PFP products, thus, reducing the overall cost significantly for the end-client.

In addition, finding a complex cable route to skip HCF classified zones are also a thing of the past, as is the problem regarding possible space constraints.

Additionally, the need for cable tray wrappings or protection do not need to be considered in order to reach HCF compliancy. The cable itself has inherently full fire protection if subjected to a HCF scenario for the entire life of the installation.

More importantly, a certified HCF cable is not in need of any de-rating, which is the case if one adopts to applying external thermal barrier products onto the cable, or cable tray, which is commonly used in the industry.

The uncertainty of ampacity de-rating will not be an issue any more because the values given in the cable data sheets can be used without need of any additional calculation.

There are also a plethora of advantages during maintenance and possible repair/ inspection operations. The cable is directly installed in a cable tray without any additional wrapping or protection. Huge amount of hours, but also the uncertainty of introducing 3rd party products that may, or may not, inflict the operations of the cable, is greatly reduced.

In conclusion, the introduction of a fully certified HCF cable represents a paradigm shift in the on- and offshore industry. The savings, in both time and money, when adopting to a ready-made HCF cable are great, especially from the view-point of the asset owner.

By using HCF cables including PFP in its design, estimated space saving on boxing and wrapping cables is estimated to be in the range of $10kg/m^2$.

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5. EN 1363-2 – Fire Resistance Tests. Part 2: Alternative and additional procedures
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- Pushing Security from the Cloud Down to Every Last Endpoint

No question the Internet of Things (IoT) has had a profound impact on our lives.

BY | WARREN KURISU

In fact, the term IoT has practically made it into our daily lexicon of words that now includes such recent additions such as "smartphone," "selfie," even "texting."

While the IoT pervades our lives, most people are hard-pressed to define what is IoT? Different companies from different industries seem to have their own unique spin as to what IoT means to them. For the sake of this discussion, let's define IoT generally as a network of physical devices that communicate between each other and perform certain tasks they are programmed to do. These devices leverage all types of available connectivity and rely on a variety of communication protocols for safe and secure transmission. Data is transmitted between devices, processed, and stored throughout the network, and increasingly, includes connectivity to public and private clouds.

M2M within the IoT

M2M AND ITS RELATION TO IOT

The term Machine-to-Machine, or M2M, has been around for decades. An M2M architecture is characterized by isolated instances of device-to-device communication, where the devices connect using a variety of wired or wireless connections. Initially, these connections included serial, Ethernet, and cellular. Typically, these devices connected point-to-point or within the confines of a local or enterprise network, but did not connect to the Internet.

As the Internet developed and became more accessible and ubiquitous, devices gained the ability to communicate to the Internet via enterprise networks and service providers. This broader, Internet-connected network of devices is what we call today, the Internet of Things. While M2M still refers to device-to-device communications, IoT devices can talk vertically up and down within the IoT infrastructure (endnode-to-gateway-to-cloud) or horizontally to other devices within the same network (e.g., printer, computer, server, other mobiles devices, etc.) as depicted in figure 1.

SECURITY, M2M, AND IOT

As a business person and technologist, it is important to understand the value of what is being protected, what is being

IoT

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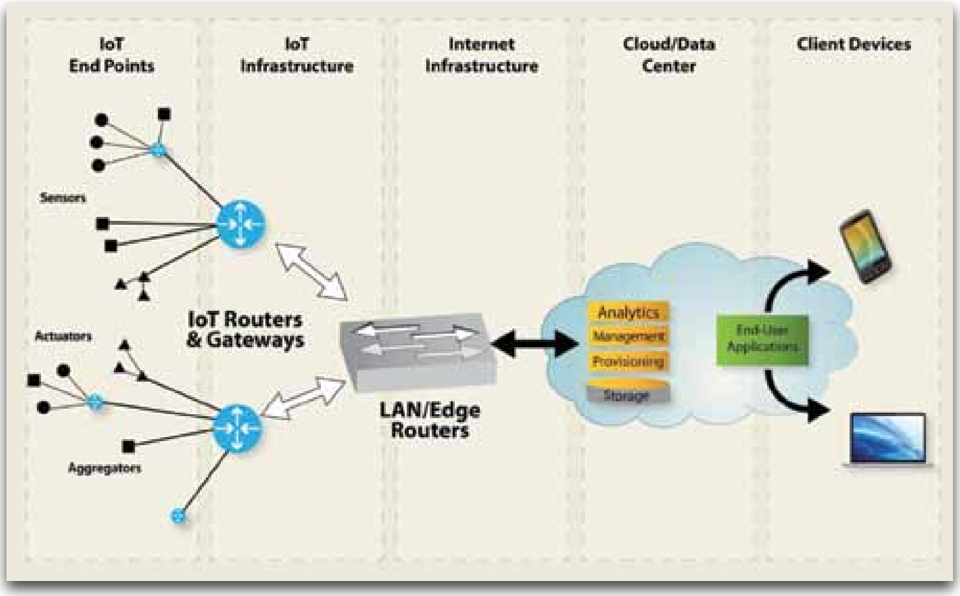

Figure 1: IoT connectivity includes the traditional M2M connected devices, but extends across the network, to the cloud, and beyond.

secured, and the type of resources that should be spent to secure it. For example, because M2M predates the cloud, and communication did not include an Internet connection, there were fewer, if any, network-based security concerns because point-to-point connections were behind the company firewall with no connection outside the enterprise. Furthermore, back then, hackers had less motivation to break into an M2M network because the value of the data was perceived as having nominal value.

But that was then, and this is now. High value content is flowing throughout the IoT and more M2M devices are saddled with communicating high-value infor- mation via an IoT connection. As a result, the security threat has greatly increased for M2M.

For example, individual machines (e.g., sensors, actuators, medical devices, etc.) can now be accessed from the Inter- net through enterprise connections; as a result, critical or private data can be stolen, or machine operation can be altered in a way that disrupts operations or worse, leads to bodily harm. All of these devices with connections, which broadly include edge devices, gateways, mobile devices, and cloud connections, increase the surface area for a potential attack.

FOR BOTH M2M AND IOT – SECURITY IS PARAMOUNT

If you're developing an M2M network with some outside connection to the Internet, you need to be vigilant and smart in your approach to providing security.

Looking at security strictly from the IT perspective might provide some assurances of network security, but it also means you potentially need to spend enormous amounts of time configuring firewalls, managing access control lists, and ensuring security defects are addres- sed (e.g., Heartbleed and Shellshock security vulnerabilities).

Thankfully, the industry is responding with a spectrum of solutions for addres- sing security in connected devices. These companies encompass processor IP vendors, semiconductor vendors, and Independent Software.

Vendors (ISVs), who are all expanding capabilities to ensure security in connec- ted devices.

HARDWARE-ENFORCED SECURITY

Protecting data is both a hardware and a software issue now that machines are more intelligent – and more connected.

Many of the most secure techniques are rooted in finding the devices that leverage the right security-enabled hardware. Numerous stand-alone hardware security modules are available with a sophis- ticated and robust set of capabilities, as well as low-cost solutions having only a subset of these capabilities. For years, application processor vendors have integrated hardware security mechanisms into their devices. Examples include Intel with Trusted Execution Technology (TXT) and ARM® with TrustZone® in the Cortex®-A architecture.

However, as one moves down in performance and capability to the micro- controller level where many of today's sensors, actuators, and low-end controllers reside, it is more difficult to find advanced hardware capabilities. But, that is changing too. ARM for example, seems to be ahead of the curve with its new ARMv8®-M architecture. This new architecture adds fast, low-overhead security extension with its own built-in ARM TrustZone technology. So ARM is addressing hardware

security that spans the IoT spectrum from the lowest-end 32-bit devices up to the application processors that can drive the cloud infrastructure.

One common use case for using a hardware security module or other hardware security mechanisms, is the inclusion of secure storage of data and keys. There have been high-profile cases where software programs were used to encrypt data on a drive. Instead of storing encrypted data deep within the hardware, the root key for decrypting everything was in a plain text file, leading to a very easy compromise or exploitation. A hardware security module protects users from these types of events happening. Hardware-based key storage means no one can access the security keys or crypto keys without proper permission or authorization.

Also, hardware security features must also include cryptographic capabilities and accelerators. Hardware should include a random number generator to ensure generation of cryptographic hash values. While software-based pseudo random number generators are enough for some applications, they are not as random as true hardware-based random number generators and therefore make it easier for a hacker to compromise the system. These hardware random number generators are now available on devices from high-end microprocessors to low-end 16-bit microcontrollers. If the security provided by a software solution is enough, there are many software solutions easily accessible to developer.

SOFTWARE-ENABLED SECURITY

A security framework that enables quick and easy build-out of the system with robust

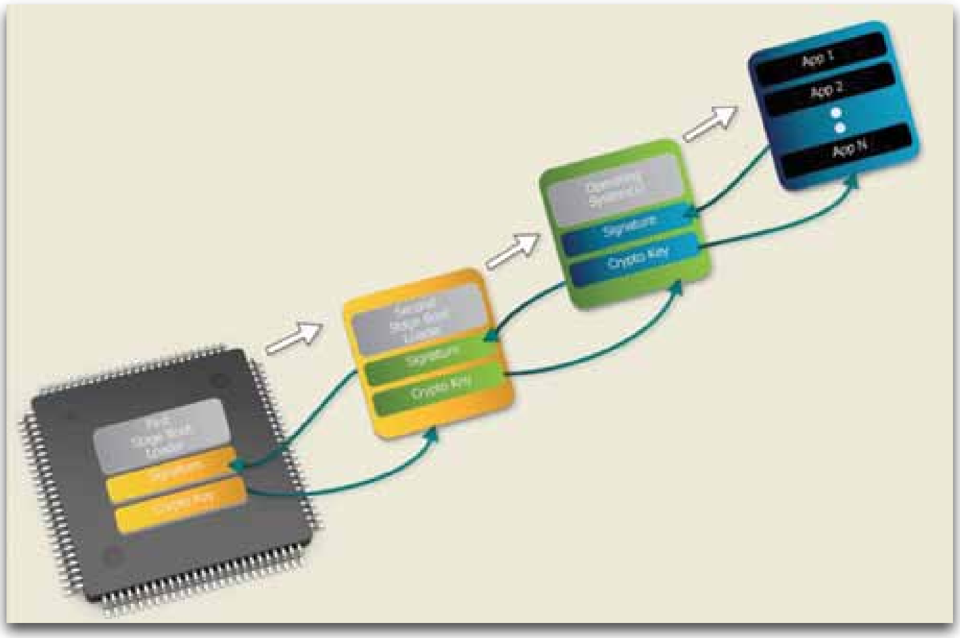

Figure 2: Security requires establishing a chain of trust that begins in the hardware and extends to every bit of software that is loaded on the device.

security features is essential. This software security framework must be built on top of a system that begins execution from a high-assurance boot sequence, to ensure a chain of trust that is established by authenticating and valid- ating the boot loader, and then extended to every other OS, application, and soft- ware update loaded on the system (figure 2).

Figure 3 is an architectural view of an embedded security framework tailored for Industrial IoT devices. It was built to run on devices that require a Real-Time Operating System (RTOS) or Linux, and to solve many of the issues around embedded security. With it, software developers can utilize secure boot, secure remote firmware updates, and managing keys and certificates. The framework's scalability provides basic foundational security on tiny devices within M2M, such as sensors or actuators that are built on small, low-power eight-bit microcontrollers – all the way up to more complex IoT devices which require more capabilities.

PUTTING IT ALL TOGETHER

Developers recently announced a complete end-to-end IoT solution which addresses many of the concerns outlined in this article. A key component to the solution is the secure, converged IoT gateway that is fully customizable in both hardware and software. The gateway configuration shown in Figure 4 includes: (1) high-assurance boot; (2) establishment of an ARM® TrustZone®-enabled secure world partition; (3) validated and authenticated Nucleus RTOS instantiated within the ARM secure partition; (4) validated and authenticated Mentor® Embedded Linux instantiated in the "normal world", or non-TrustZone partition; (5) applications running on both Nucleus and Mentor Embedded Linux; and (6) an integrated tools solution with

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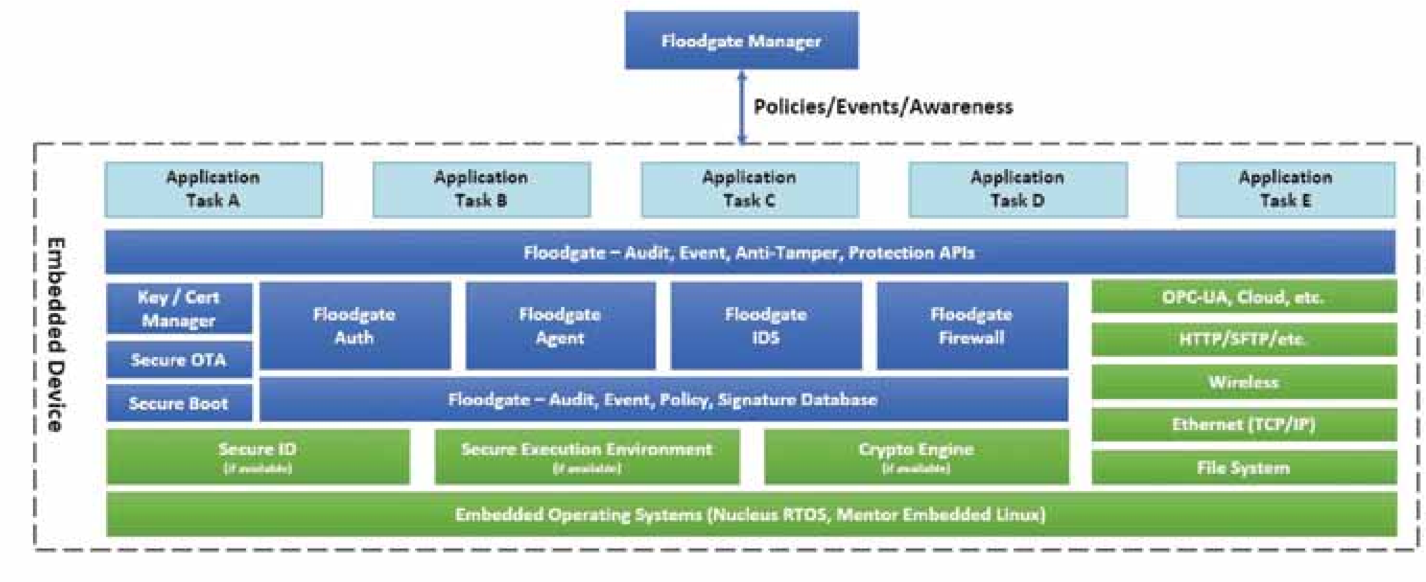


Figure 3: A complete security framework that leverages hardware security features.

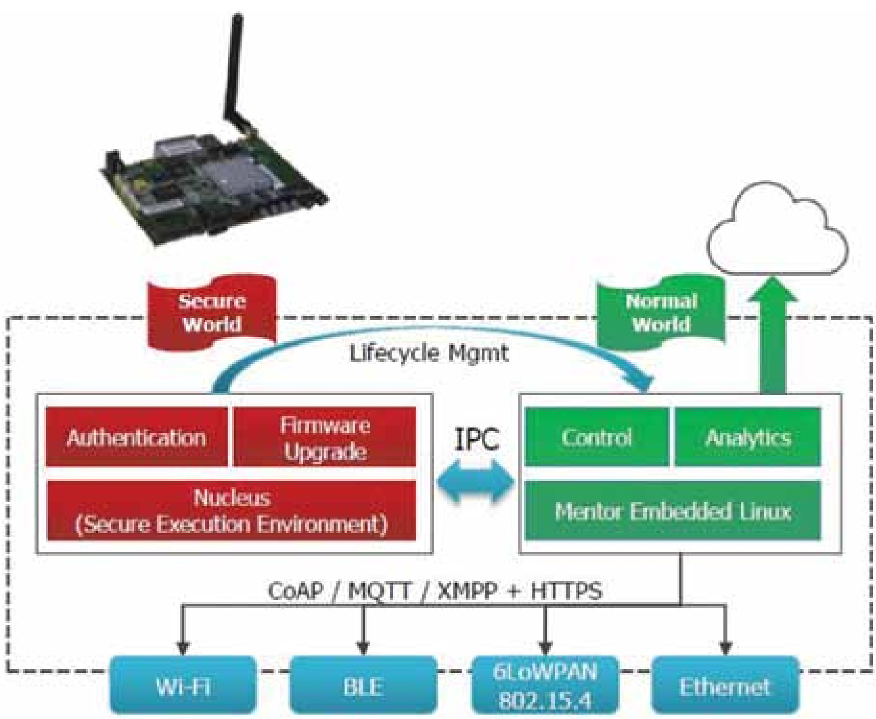


Fig 4: Mentor's fully customizable gateway solution fully leverages today's most advanced hardware and software security capabilities.

the Eclipse-based SourceryTM CodeBench development tools. It supports a broad range of protocols that enable connectivity "south" to connected edge devices and "north" to the cloud. The ability to customize this solution in both hardware and software supports the connectivity of both "brownfield" (i.e. existing, legacy devices) and "greenfield" (i.e. new, updated devices) devices that fully enable M2M and IoT connected devices to realize their true value to their businesses.

The IoT, which includes M2M, presents a complex set of challenges for the modern software developer. Security is needed everywhere. Devices are everywhere. The devices themselves are evolving to perform a new set of capabilities and tasks. Machine intelligence in industrial environments is now being pushed from the cloud toward the edge. With increasing amounts of data now being stored in edge devices and gateways, a more comprehensive security strategy is needed. wn

AfrikaBot

An exciting STEM programme for high schools using robots

BY | MICHAEL ETTERSCHANK

Creating science, technology, engineering and mathematics (STEM) education opportunities for high school learners can be very costly, especially if the wrong equipment is selected.

These days 'everybody' seems to be marketing a robot, for teachers it can be bewildering trying to figure out what to buy.

University of Johannesburg TechnoLab is your friend. We have carefully selected hardware that is world class, affordable, and comes with a free training developed by leading engineering academics in SA and USA.

The RobotScience project at UJ TechnoLab developed AfrikaBot 'the world's most affordable robotics challenge', so your teenagers can test their basic engineering skills, building and programming their own robot, programming it to solve a maze.

Free graphical and text software from novice to advanced undergraduate level allows disadvantaged teenagers, high school learners and university students to start inventing...

Wealthier schools and individuals can buy a ready built robot kit from Parallax Inc. The imported robot is called the BOE Shield Bot.

Schools operating with limited budgets can simply build the AfroDuinoBot themselves, from low cost parts board, to create a cost effective STEM robotics programme.

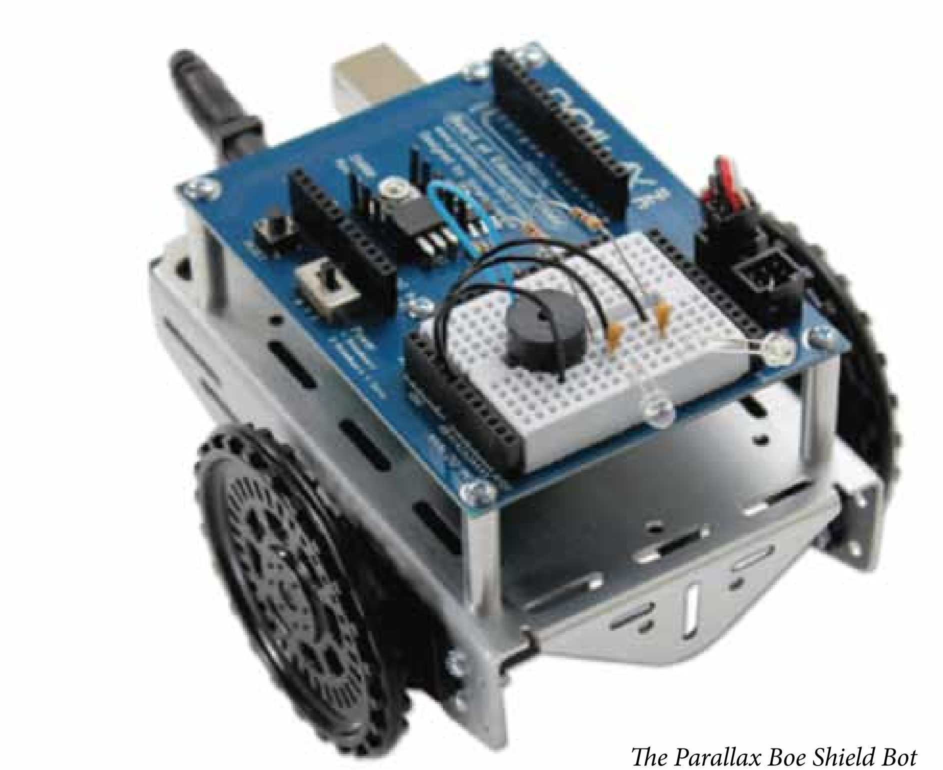
With the hardware we recommend, there's a number of free programming options. that These include graphical software that allows complete novices to perform complex tasks Once the learners are confident, they can use FREE computer text code programming software, that allows increasingly complex programming for complicated tasks.

The availability of free, high quality videos, rapidly builds confidence in learners. The RobotScience project recognizes teachers and learners may have very little prior learning in engineering. Starting an engineering or robotics club in your school has never been easier, with thousands of videos that cover every aspect there to guide you.

The RobotScience project offers support to dedicated teachers across the spectrum, from poor to wealthy communities, who want to expose learners to STEM activities. Teachers are urged to help the learners form an engineering club, and meet regularly (weekly) with a view to entering AfrikBOT, 'the world's most affordable robotics competition'.

To build the AfrikaBOT practice maze can cost as little as R280, using a standard door. Support for clubs is available through email, online videos and a comprehensive website.

Organisations such as the South African Institute of Electrical Engineers (SAIEE) support AfrikaBot, because it is such a versatile platform. SAIEE funds have been applied to helping the most disadvantaged communities to participate.



The Parallax Boe Shield Bot

TEACHING STEM WITH AFRIKABOT

Teenagers soon became bored and lose interest in science and mathematics where they can't see the practical application of this knowledge. The small desktop-scale robot used to enter AfrikaBOT applies scientific and mathematical principles systematically to solve fascinating problems. The AfrikaBOT challenge holds the interest of learners. Graphics software makes the first steps easy until learners are hooked on science.

The AfrikaBOT maze challenge operates on many levels of complexity. Where a fourteen-year-old might simply move the robot through the maze avoiding obstacles, using drag-and-drop graphical software, a fifteen-year-old will perform the same task using computer text code to control the servo motors. A sixteen-year-old can implement basic sensor systems that guide the robot through the maze. Undergraduate university engineering students can apply mathematical models to solve the maze problem, postgraduate university engineering students might use the AfrikaBot maze to prototype advanced robotics equipment, like such as laser scanners, to map a path through the maze.

Robots consist of electronics and mechanical actuators, which can cost lots of money. By lowering the cost of robotics dramatically, UJ TechnoLab hopes to empower youth and create a sense of hope in poorer communities. On a national level, it is hoped that South African universities in other regions, will initiate their own AfrikaBot chapters using these resources.
www.robotscience.co.za
www.youtube.com/electronicsafrica
www.parallax.com
www.arduino.org
www.arduino.cc

The AfrikaBOT competition has a line the robots can follow to find a token. The robot picks up the token and carries it to the end of the maze. An electronic timing system with laser beams provides accurate timing.

THE PARALLAX BOE SHIELD BOT

The Parallax Basic BOE Bot with Stamp 2 microcontroller is an extremely well documented robot that has a free graphical software interface, and also BASIC text programming. The Parallax BOE Shield Bot is a more advanced robot, that can be programmed with graphical software and C++ text code. More information is available here:
www.parallax.com
www.learn.parallax.com

Teenagers rarely are able to make anything for themselves, having been relegated to the role of consumer. The AfroDuinoBOT can be built by teenagers, with very little intervention, if they watch the videos UJ TechnoLab have made showing them how.

Using a cheap soldering iron bought at the local hardware store will destroy the delicate printed circuit board of the AfroDuinoBOT. TechnoLab has come up with a low cost, high quality solution: We hook up a 24v type Magnum soldering iron directly to a 12 volt 1 Amp wall plug transformer. The resulting iron is the perfect temperature for electronics.

LOW COST QUALITY SOLDERING IRON

The AfroDuinoBOT assembly process teaches teenagers about electronics, as they are able to solder small parts onto the printed circuit board (PCB) .

Assembly of the robot introduces learners to mechanical concepts, getting the robot to perform tasks introduces learners to the world of programming.

The Parallax Boe Shield Bot is an excellent robot for teenagers, because many youth youths that are interested in tech stuff, already have Ardunio controllers. For those who don't the Arduino, UNO is inexpensive and comes with a wide range of software, as well as extensive online support for learners and educators.

The first step for a new training scheme can be to acquire a fleet of 10 Parallax

AfrikaBot

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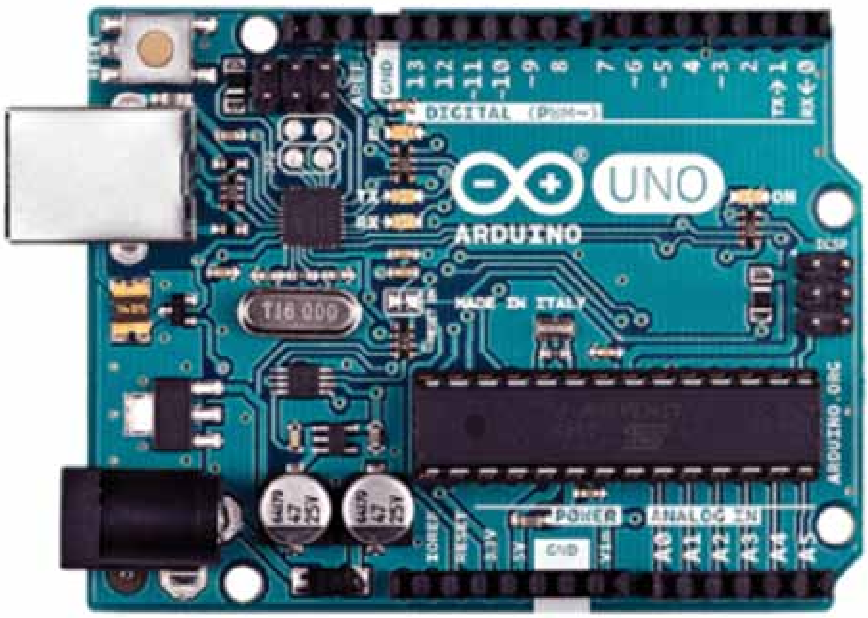


Arduino Uno

Boe Shield Bots from the local supplier Mantech.

Should a teenager invent something useful with the Arduino UNO controller, the cost of acquiring further controllers is quite inexpensive.

ARDUINO UNO

The AfroDuinoBOT robot was developed in conjunction with our supplier. This puts a robotics controller into the hands of teenagers who would otherwise never be able to afford the equipment.

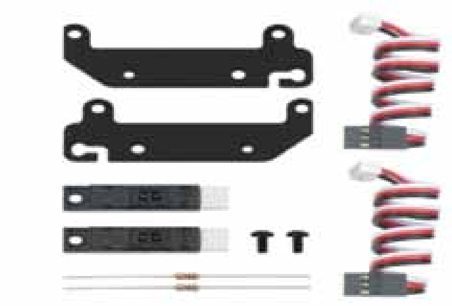
HARDWARE CONSIDERATIONS

UJ TechnoLab encourages DIY and improvisation, which we believe helps in creating the engineers of tomorrow from among high school learners of today, and sparks creative thinking.

If there is access to a Computer Numerical Controlled (CNC) machine, or a 3D printer, learners can download ready-made Computer Aided Design (CAD) designs from our website, to make the body of the robot.

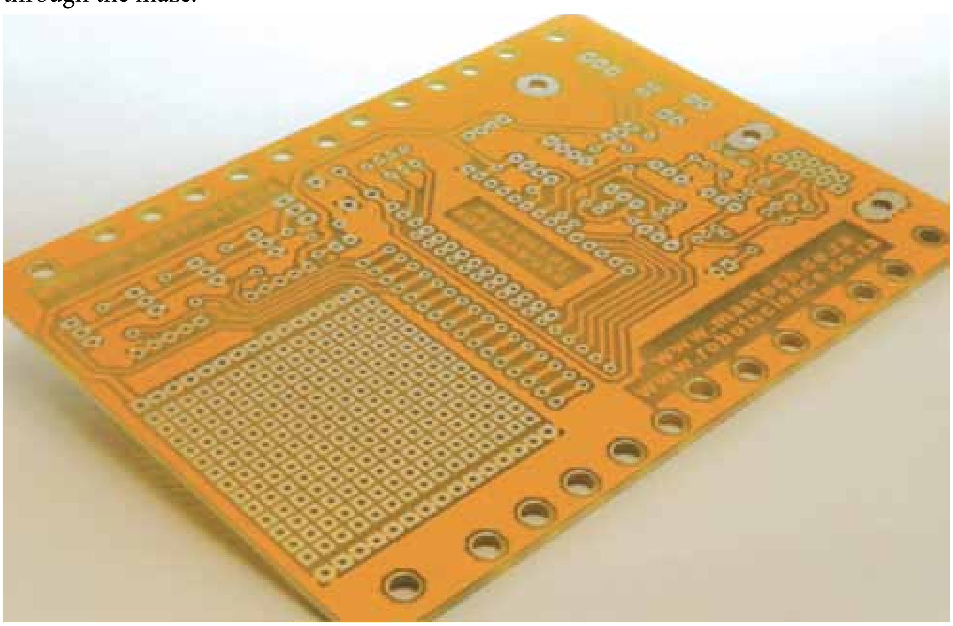
Teenagers who have learnt text code programming, can start using more complex sensors to move their robot through the maze.

PARALLAX WHEEL ENCODER SENSORS



Availability of various kits from local supplier www.mantech.co.za means that no great difficulties will be experienced obtaining parts to build the AfroDuinoBOT. Every aspect of building robot in school clubs has been given considerable thought, to ensure that success can be achieved with access to just a few hand tools.

After a teenager has built the robot and entered the competition, we hope they will start trying out their own inventions. wn



Printed Circuit board

IN MY OPINION : DR ALISTAIR WALKER

Response to 'Software Cost Estimation'

I wish to respond to the article *'Software Cost Estimation'* by G Bougaardt, published in **watt**now October 2016. The article provides a helpful overview of the subject from a project management perspective. The view provided is what one might refer to as the 'traditional' or classical approach to software cost estimation. By the end of the article, the author firmly supports the view that 'lines of code' is the most promising approach to use as a basis for software cost estimation.

BY I DR ALISTAIR WALKER I FSAIEE I BSC ENG I MSC ENG I PHD

The alternative approach to software cost estimation (i.e. function point counting) is dismissed after a short overview of the key concepts, indicating that the disadvantages outweigh any advantages that might accrue.

The author indicates that while function point counting has found application in business applications, no such methods exist for non-business applications i.e. embedded systems, multilayer systems and the like.

I would like challenge the assumptions the author has made, referring to:

a) objective versus relative size estimation techniques;
b) the effort needed to produce estimates of project development effort early in the project cycle;
c) the problem of software cost benchmarking and competitive bid evaluation.

OBJECTIVE VERSUS RELATIVE SIZE ESTIMATION TECHNIQUES

The key problem with using lines of code as the basis of a software effort estimation method is that it is always a relative measure. It is relative to the extent and value of the judgement of the experts using the Delphi estimation technique to estimate the code volume of the intended project. Estimates based on this technique will vary between serial projects undertaken by the same team, and will vary between different project teams in the same organisation, and between organisations. Needless to add, the estimates will depend on the assumption made regarding the type of software implementation technology applied (i.e. language and development environment) and the constraints on using 'off-the-shelf' prebuilt (i.e. reusable) components or libraries.

What is needed in this situation is a type of measure that can be demonstrated to produce reliable and objective estimates of software development effort across projects within an organisation, and between organisations i.e. to support competitive bidding opportunities.

In the building industry, we are familiar with the concept of 'square metres' as the initial basis for estimating the cost of a new structure. Once the floor size

is known, and the type of construction method defined, a quantity surveyor or architect can readily prepare estimates of the cost to client for the initial structure.

What we desperately need in the software development industry is the equivalence of the 'square metres' so effectively used in the construction industry.

'Lines of code' simply does not answer this need in the software industry, on account of the fact that it is a relative measure of application size. Referring again to the construction industry, if the quantity surveyor walked about the proposed site and measured the distance using his elbow to finger tip (i.e. the cubit) (instead of using a calibrated tape measure) his estimates would be rather quickly challenged as being a relative measure of distance.

In contrast to this fatal weakness of using lines of code as an estimation basis for project size and effort, functional size measurement techniques (i.e. the larger scope of function point methods) are well defined in several international standards, the initial versions of which were published by the International Organisation for Standardization (i.e. ISO) as far back as 2002.

There is a collection of function counting methods that do focus on the needs of business applications (e.g. [1],[2],[3],[4]), but a generic method does exist for counting function points for non-database applications [5].

Furthermore, there are accessible repositories of project data [6,7] applying the methods based on references [1-5].

Needless to say, there are no international standards for using lines of code as a basis of project estimation, nor are there any international standards that apply lines of code as a software measurement technique.

EARLY ESTIMATES OF PROJECT DEVELOPMENT EFFORT

Perhaps the major objection to using the techniques listed in [1-5] is the claim that the amount of effort required to produce the size estimate outweighs any advantage of using the technique.

What is frequently overlooked is that these methods are readily scalable i.e. when a quick engineering 'thumb-suck' is needed for a quick 'go-no go' decision the methods can be readily streamlined to provide quick 'rule of thumb' estimates – which in most cases are sufficiently accurate to support early project scenario planning and sizing.

SOFTWARE COST BENCHMARKING AND COMPETITIVE BID EVALUATION

Finally, the last point to be addressed in using lines of code as a project estimation method is that is it simply does not lend itself to competitive bidding evaluation. For example, using functional size methods, the developer function point cost can be requested when bidding for a development/ maintenance IT support activity (for a given type of technology development context). This step would be simply meaningless if trying to use lines of code for an equivalent purpose.

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6. ISBSG (International Software Benchmarking Standards Group (www.isbsg.org)
7. Finnish Metrics Association (www.fisma.fi/in-english/)

calendar

FEBRUARY I MARCH I APRIL 2017

FEBRUARY 2017

15-16	Internet Of Things (IOT) Standards and Applications	Johannesburg	roberto@saiee.org.za
16	Annual General Meeting - Westerrn Cape Centre	Western Cape	www.saiee.org.za
22-23	Incident Investigation & Management	Johannesburg	roberto@saiee.org.za

MARCH 2017

2	Application of LV Frequency Control to Industrial Drives	Johannesburg	roberto@saiee.org.za
9	2017 SmartGrid Conference Launch	Johannesburg	minx@saiee.org.za
7-8	Electrical Trade Expo	Cape Town	www.voltex.co.za
7-10	Managing Projects Effectively	Johannesburg	roberto@saiee.org.za
13-17	Smart Meters For Smart Grid Training	Johannesburg	roberto@saiee.org.za
14-15	Fundamentals Of Practical Lighting Design	Johannesburg	roberto@saiee.org.za
15	Power Transformer Unit Protection And Testing	Johannesburg	roberto@saiee.org.za
16	Power Transformer Operating And Maintenance	Johannesburg	roberto@saiee.org.za
22-23	Photovoltaic Solar Systems	Johannesburg	roberto@saiee.org.za
23-24	HV Testing And Measurements	Johannesburg	roberto@saiee.org.za
28-30	Substation Design And Equipment Selection	Johannesburg	roberto@saiee.org.za
28-29	Power & Electricity World Africa	Johannesburg	www.terrapinn.com
30	SAIEE Annual General Meeting	Johannesburg	www.saiee.org.za

= CPD Courses

ENGINEERINGHUMOUR BY I POPPA HOWARD

An elderly gentleman, who was nearly stone deaf, had the latest scientific state-of-the-art hearings aids fitted, that allowed him to hear 100 percent. After 6 months he went back to the doctor for a check-up, and the doctor said: "Your hearing is absolutely perfect, your family must be really pleased that you can hear again." The gentleman replied, "Oh no, I haven't told them yet. I just sit around and listen to their conversations... I've changed my will four times!"

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.

We hope that this section of the magazine not only becomes a regular feature, but that it is widely read and distributed among your peers. Remember, it can only become a success with the full participation of our readers! Send your burning questions to minx@saiee.org.za - subject 'WATT?'.

We look forward to hearing from you.

- Ed

The rapid pace of technological change and product development is a global trend that affects entire economies. We may have access to more information than ever before, but is this information readily understandable? Does it give us insight into the fundamental issues? Is it precise and based on technical clarity?

QUESTION ONE

What are the implications when using a Variable Speed Drive (VSD) driven electric motor in hazardous areas classified as Ex n (non-sparking/spark proof), Ex d (flameproof) and Ex tD (dust ignition proof)?

ANSWER ONE

When an electric motor is driven by a VSD in one of the abovementioned hazardous areas, the certification of the electric motor is deemed null and void and recertification of the motor and VSD combination is required. This can be done at an accredited testing facility such as the SABS test facility.

There are three criteria that need to be met in order to obtain combined certification.

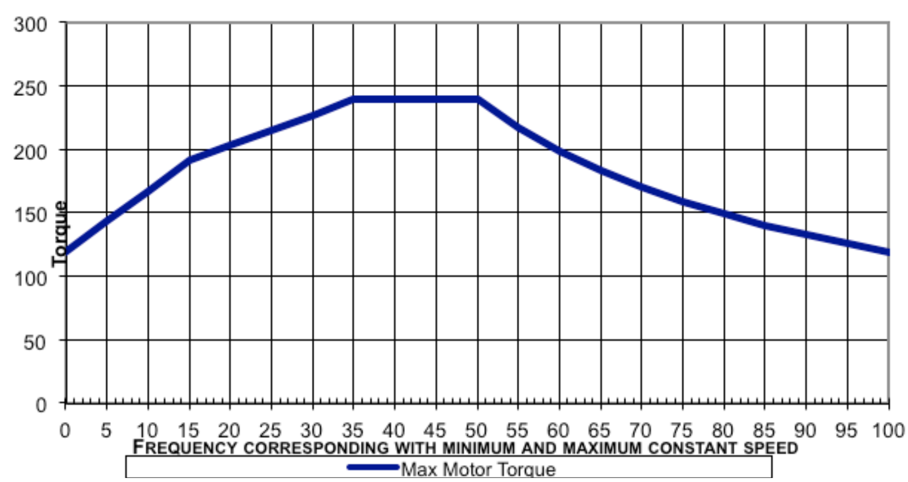
1. Establish a thermal envelope for VSD driven electric motors;
2. Protection within the VSD according to the thermal envelope of the electric motor;
3. Correct selection of electric motor and VSD combination according to the thermal envelope.

A THERMAL ENVELOPE FOR VSD DRIVEN ELECTRIC MOTORS

VSD driven electric motors have reduced thermal capacity due to three main reasons:

- Increased motor losses due to the wave form of the motor current as supplied by the VSD.
- Decreased motor cooling on internal and external cooling paths due to slower rotation.
- Field weakening when the motor is operating above its nominal frequency.

The thermal envelope compensates for the motor reduced thermal capacity by providing a torque/speed curve. As thermal capacity reduces so does permissible torque, thus always ensuring at whichever torque/ speed combination the motor is operated



Thermal envelope for VSD driven electric motors

WATT?

at it will be within its design temperature classification.

PROTECTION WITHIN THE VSD ACCORDING TO THE THERMAL ENVELOPE OF THE ELECTRIC MOTOR

Once a thermal envelope of the electric motor has been established, the next step is to prove that the VSD will inhibit the motor from operation outside of the thermal envelope.

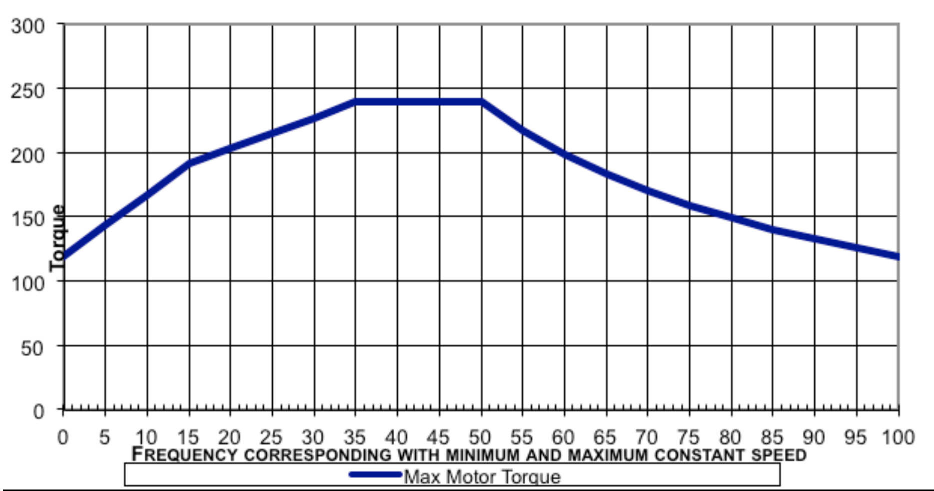
This is achieved by setting the correct current limit values in the VSD. The VSD needs to have functionality that continuously and accurately measures the current drawn by the motor at each Pulse Width Modulation (PWM) pulse. This equates to between 1 250 and 10 000 measurements per second. This current measurement needs to include the additional harmonic distortion.

In the event of operating conditions outside of the thermal envelope the VSD should immediately detect this and trip. This is achieved by setting the VSD parameters to cater for the following:

- Overload at nominal speed.
- Overload at any other speed as defined by the selection curve.
- Overload due to under voltage.
- Stalling.
- Dynamic overload, i.e. overload of a variable nature such as repeated starting, cycling duty causing rapid acceleration and/or deceleration and rapid and/or continual change of motor rotation direction.
- Any combination of the above.

CORRECT SELECTION OF ELECTRIC MOTOR AND VSD COMBINATION ACCORDING TO THE THERMAL ENVELOPE

On the basis of the previously determined electric motor thermal envelope, it is required to select the correct VSD driven electric motor for the given application. This will ensure it is capable of providing the necessary torque whilst remaining within the limits of the thermal envelope. This is shown below where the blue line is the motor thermal envelope, the green line is the a 10% safety derating and the red line is the load requirement.



Installation Requirements:

- Installation practice as defined by SANS 10086-1 and SANS 10086-2.
- SWA PVC Armoured cable as per SABS 1507, 3-core and earth or 3-core and separate earth.
- Cable must be solidly earthed at both ends.
- VSD and Motor solidly earthed.
- VSD to be mounted outside of the hazardous area.

CONCLUSION

It is a legal requirement to have both electric motor and VSD certified as a combination when operating in hazardous areas, Ex n (non-sparking/spark proof), Ex d (flameproof) and Ex tD (dust ignition proof).

Manufacturers of both electric motors and variable speed drives should be able to provide the necessary data to assist in this process and some have pretested a specific range of electric motors and VSD's making the process easier and more affordable. wn

Information provided by Zest WEG Group

February

Movers, shakers and history-makers

COMPILED BY I JANE BUISSON-STREET
FSAIEE I PMIITPSA I FIITSPA

1 FEBRUARY

1864 The Philological Society of London decided on a new dictionary in 1859 and five years later the first volume of the Oxford English Dictionary (A-Ant) was published.

2 FEBRUARY

1653 New Amsterdam, a 17th-century Dutch settlement established at the southern tip of Manhattan Island, became a city, which has been renamed New York.

3 FEBRUARY

1488 Bartolomeu Dias discovered Mosselbaai (Angra dos Vaqueros).

4 FEBRUARY

1920 The first flight from London, England to Cape Town, South Africa took off. The pilots were Captains S Cockerell and F C Broome. Their flight took a total of 45 days with a flight time of 109 hours and 30 minutes, as well as four aircraft.

5 FEBRUARY

1999 President Nelson Mandela delivered his last major address to parliament.

6 FEBRUARY

1835 Dr. Newton Adams, from New York State, arrived in Port Natal. He was regarded as an exceptionally skilled physician and surgeon, by colonists and Boers, who often travelled long distances to see him. His Zulu name meant 'the teacher with three coats', which arose from his putting on a different costume for each 'role' (teacher, missionary and doctor). When he died in 1851, aged 45, most Durban's residents, irrespective of race, rode out to attend his funeral.

7 FEBRUARY

2006 Grant Baker, KwaZulu-Natal became the first surfer from outside Santa Cruz, California, to win the Mavericks Surf Contest.

8 FEBRUARY

2005 A scientific study, funded by the Norwegian government, announced that worms squirming on a fishhook feel no pain nor do crayfish and crabs cooked in boiling water.

9 FEBRUARY

1969 The Boeing 747-100 jumbo jet took to the sky for the very first time.

10 FEBRUARY

1908 A new department of the Transvaal University College (T.U.C.), started classes in Pretoria. This department, consisted of four professors, three lecturers and thirty-two students, developed into the University of Pretoria. The nickname Tuks or Tukkies is derived from the TUC acronym.

11 FEBRUARY

2000 The Nelson Mandela Museum was officially opened exactly ten years since his release from prison.

12 FEBRUARY
2001 The Anna Kournikova Virus hit the Internet.

13 FEBRUARY
2005 Ladysmith Black Mambazo won their second Grammy Award for their album Wenyukela.

14 FEBRUARY
1906 Electrically powered units replaced Johannesburg's horse-drawn trams. The trams remained in service up until 1948.

15 FEBRUARY
1852 The Great Ormond St Hospital for Sick Children, London, UK, admitted their first patient.

16 FEBRUARY
1659 The first cheque for making a payment was written. According to ComputerWeekly.com, two-thirds of today's under 25s have never written a cheque.

17 FEBRUARY
1933 The first issue of "Newsweek" magazine was published.

18 FEBRUARY
1979 For the first and only time in recorded history, it snowed in the Sahara Desert.

19 FEBRUARY
1964 A half ton of Beatles wigs was flown from the UK to the USA.

20 FEBRUARY
1859 Turffontein, the first suburb of the town Johannesburg, was laid out on the remaining farm in 1886.

21 FEBRUARY
2001 At the Macworld Expo in Tokyo, Japan, Apple Computer introduced the iMac Special Edition. It was available in Flower Power, Dalmatian Blue, or Graphite designs.

22 FEBRUARY
1857 Pretoria's first church, a mud-walled and thatch roofed structure, was inaugurated. The church was built in a square in the centre of Pretoria, hence the name Church Square.

23 FEBRUARY
1940 Walt Disney's animated movie "Pinocchio" released

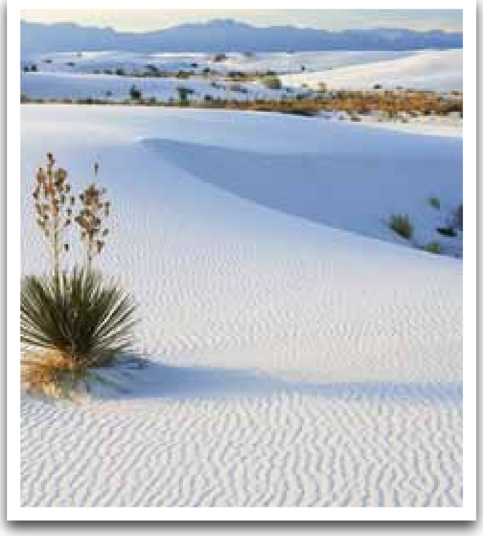
24 FEBRUARY
1857 The University of Calcutta is formally founded as the first fully fledged university in South Asia.

25 FEBRUARY
1937 Daniel (Dan) Sefudi Rakgoathe was born in Randfontein. Rakgoathe was awarded a Fulbright scholarship and completed an MA degree in African Studies at the University of California, Los Angeles.

26 FEBRUARY
1916 Mutual Films signed Charlie Chaplin to a contract for a salary of $670,000 per year. At the young age of 26 Chaplin became the highest paid entertainer – and one of the highest paid people in the world.

27 FEBRUARY
1998 Steve Jobs, in his role as Acting CEO of Apple, decided to trim some of the product fat. As a result, the Apple Newton – their attempt at a PDA (personal digital assistant) – was officially discontinued after 5 years.

28 FEBRUARY
1896 Walter Arnold of East Peckham, Kent, UK, became the first person to be convicted of speeding. He was fined one shilling, plus costs, for speeding at 8 mph (13 km/h), thereby exceeding the contemporary speed limit of 2 mph (3.2 km/h).



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