Scholarship Update

Tara-lee MacArthur 6/24/19 E.S. Cornwall Scholarship

LETTER TO THE SCHOLARSHIP COMMITTEE

Thank you for the E.S. Cornwall Memorial Scholarship. I am truly honoured to receive it. It is an even greater honour to be placed in such distinguished ranks as those of the past recipients, some of whom have been colleagues at one time or another and all of whom have made significant contributions to Queensland's energy future.

It has been the most intense year of growth for me and the scholarship has had an enormous impact on my professional career. I have spent the last 16 months in an intensive development program in Germany and the United States. I have been fortunate enough to be able to focus more on power transformers and their components, venturing into new areas of research and development, work alongside the top transformer experts and visit world-class facilities.

Working overseas opens so many options for my career as a woman in engineering and it's great that companies are willing to bring me on to projects and roles for such short durations. I know I'll learn so much from each of these placements and I'm excited that I can bring a different perspective to the work they're doing at the companies that I'm working for. This is my passion and it's an exciting new career pathway for me.

In addition to this work, I attended the biennial CIGRE Session in Paris and two IEEE Transformers Committee meeting in the United States and have been able to go on several site visits around the world. These activities gave me some insight into the latest in transformers developments taking place around the world and allowed me to network with leading transformer experts. I hope to continue the collaboration and work to maintain the new relationships I have formed. Without the scholarship, these extra and highly beneficial opportunities would not have been possible.

It should be noted due to confidentiality, I am not able to include specific information relating to the customer or new technology and development projects.

Thank you, Edward Satchwell Cornwall and the scholarship committee for allowing me to do what I do best every day. This is just the beginning.

I welcome the committee's feedback on this report and the experience that I have gained throughout my scholarship tenure. I will continue to support this program wherever possible and hope to help future scholarship applicants with their E.S. Cornwall journey.

Regards,

Tara-lee MacArthur

CONTENTS

PROPOSED PLACEMENTS FOR THE SCHOLARSHIP

BACKGROUND

For the last four years, I have been involved in Substation Design Standards at Ergon Energy. I am responsible for standardising design strategies, standards and equipment specifications for substation assets, particularly on power transformers. Through my role, I have been an active member in Australia's CIGRE panel A2 and secretary for WG A2.49 Transformer Condition Assessment. The topics ("my niche") I enjoy most at work are analysing DGA samples, doing condition assessments, condition monitoring of assets and completing investigations on power transformer failures.

For this reason, my proposed placements for the E.S Cornwall Scholarship will aim to:

- Experience an overseas transformer factory as a Principle Engineer
- Gain an understanding of the design and manufacture of transformer components
- Acquire knowledge of established asset management systems and condition assessment
- Increase my involvement with CIGRE and IEEE

With guidance from the scholarship committee and a combination of the work placements below, the scholarship will provide me with a broad knowledge and understanding of the 'whole of life attributes' of a power transformer.

SUMMARY OF PRACTICAL EXPERIENCE

Period 1	
Name of Employer:	Maschinenfabrik Reinhausen
Starting date of employment: 2018	3rd September
Ending date of employment:	2nd October 2018
Position/job:	
Period 2	
Name of Employer:	HIGHVOLT Prüftechnik Dresden GmbH
Starting date of employment:	4th October 2018
Ending date of employment:	31st December 2018
Position/job:	
Period 3	
Name of Employer:	Dynamic Ratings
Starting date of employment:	3rd January 2019
Ending date of employment:	31st December 2019
Position/job:	Principal Engineer

KEY PROJECTS

<table>
<tr><th colspan="4">Monthly Progress</th></tr>
<tr><td>Month One</td><td rowspan="2">Comparison of JEC 2220-2007 with IEC 60214-1:2014.
(Technical findings below)</td><td>Hands-on training, fault finding and investigations</td><td>Difficult conversations: customer vs colleague</td></tr>
<tr><td>Month Two</td><td>DGA and OLTC classification</td><td>IEEE conference and US customer visit</td></tr>
<tr><td>Month Three</td><td>Testing of an impulse generator</td><td rowspan="2">Analog design and simulation using OrCAD Capture and PSpice</td><td></td></tr>
<tr><td>Month Four</td><td>Euro TechCon - paper and presentation</td><td></td></tr>
<tr><td>Month Five</td><td>OSHA training (the Occupational Safety and Health Administration</td><td>Attended the 2019 DISTRIBUTECH conference</td><td rowspan="6">Customer Requirement Documents (CRD)</td></tr>
<tr><td>Month Six</td><td rowspan="4">Customer visits, substation tours and site inspections.</td><td>NA TechCon – paper, panel and presentation</td></tr>
<tr><td>Month Seven</td><td>Doble conference and CIGRE</td></tr>
<tr><td>Month Eight</td><td>CIRED Spain tutorial</td></tr>
<tr><td>Month Nine</td><td>New monitoring technologies and cybersecurity</td></tr>
<tr><td>Month Ten</td><td>Monitoring proposals</td><td>CIGRE Canada, IREQ tour and CA A2 panel.</td></tr>
<tr><td>Month Eleven</td><td rowspan="2">Trial projects and evaluation criteria</td><td>IEEE TX meeting</td></tr>
<tr><td>Month Twelve</td><td>CIGRE India and A2 tutorial</td><td>Reflection</td></tr>
</table>

Comparison of JEC 2220-2007 with IEC 60214-1:2014	Date
Concerning their differences in the type test procedure for on-load tap-changers and motor-drive mechanisms for on-load tap-changers	Sep-Oct 2018

Background: JEC 2220 has not been reviewed since 2007 and at this stage the JEC committee has not adopted the international product standard IEC 60214-1 20:2014, which is mainly used by MR and other international tap-changer manufacturers. As a result, tap-changers are predominantly purchased meeting the JEC 2220 standard requirements. MR is responsible for meeting international standards for tap-changers, for example IEC, IEEE and JEC, but also to continually exceed requirements and keep developing the products to meet customers' needs.

It is well known that the JEC traditionally has high security needs but retype testing according to JEC 2220-2007 can be a significant cost to the customer and manufacturer over a lengthy period of time.

Project: To prepare a report comparing JEC 2220-2007 with IEC 60214-1:2014 and make a presentation concerning the differences in the type test procedure for on-load tap-changers and motor-drive mechanisms for on-load tap-changers. Currently there is no publicly available document detailing the exact differences between both standards. I also went a step further and I compared MR's testing practices to the JEC and IEC procedures.

I had to read the two existing standards and their previous versions, review MR's testing procedures and attend customer type testing to gain further experience in this area.

I was based in the 4,800 m^2 test Centre in Regensburg (Opened in 2008) which is the only one of its kind in the world. 'Everything under one roof', fully automated test rigs and test processes running in parallel to allow operation 365 days a year, 24 hours a day.

Based on the analysis results I created a document for the following applications:

- Summary document (e.g. presentation) which contains first general information.
- MR internal guide

It was challenging to define the differences in simple terms e.g. Does the IEC meet JEC "yes" or "no" so I developed my own set of parameters to compare the standards. This was reviewed by my supervisors and agreed upon that it was a more technical and accurate way to compare. In numerous cases that IEC test methodology is different to that described in JEC and could not be easily compared.

The main differences between the two type testing procedures were;

- Mechanical endurance test – The number of operations for IEC 60214-1 standard is 500K compared to 800K of the JEC. However, the IEC provides that the mechanical endurance test should be carried out, for the oil immersed on-load tap-changer, the half of the testing cycles at the temperature not below 75°C, and for both oil immersed and air type, 100 times should be tested below -25°C. The JEC specifies more operations but at normal temperature range and not to test the limits in extreme conditions.

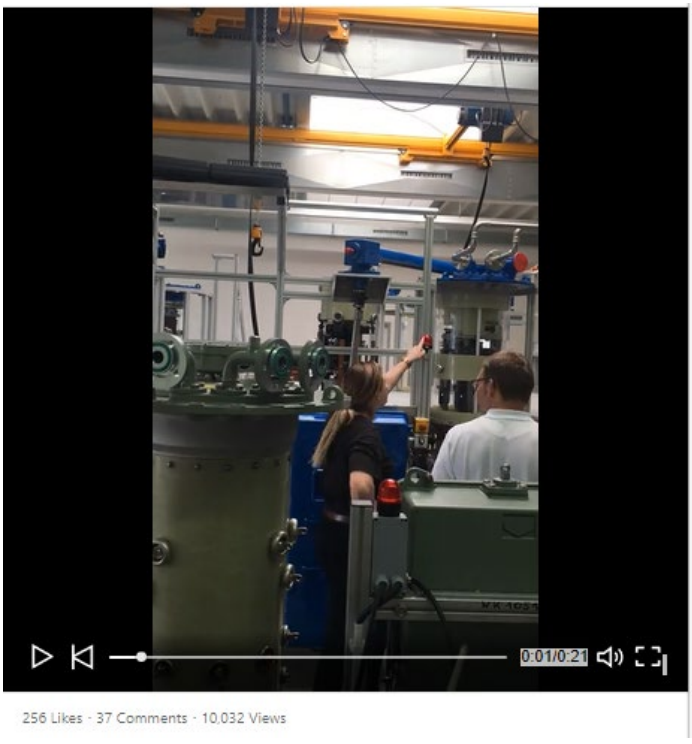
- Service duty test - Number of switching operations performed with max. rated through-current at relevant rated step voltage for vacuum type OLTCs: 1.2 * operations between maintenance of OLTC (min. 50K) and for Non vacuum-type OLTCs: 50K. However, the JEC 2220 specifies a blanket rule of 200K.

Although it was not clearly defined in the translated version of the standard, it was assumed that only one test sample could be used for type testing and in the test sequence stated by the JEC and not the tap-changer manufacturers. This became the critical difference between the two standards as it has biggest effect on type testing products in particular to the time to complete the testing. I agree that some tests are required to be completed in a sequence to guarantee service performance but some are not related, therefore could be done in parallel to others using other test samples. If there was a

revision to the JEC, it is my opinion that the sequence and the definition of test object should be change to, by agreement between manufacturer of on-load tap-changing equipment and user. This would allow new products to be designed and out to markets faster or older products in new markets using JEC standards and not necessarily compromise on safety and quality of the product. I was also allowed to ask a colleague in the subsidiary in Japan to clarify points I had about the project and if a review of JEC 2220 was planned.	
Did it relate to my scholarship proposal? (Extract from my scholarship application)	Yes. - "…experience technical design reviews from the other side of the offer and be involved with other standards aside from Australian Standards. I am also interested in working with a manufacturer of transformer components such as bushings and tap-changers as these are commonly made overseas."
Was the project mission completed?	The document was completed before I left MR, however, the clarifications and questions I had sent to the subsidiary were still out for discussion.
Lessons learnt	This project helped me realise the importance of understanding that when we specify certain standards. Specifing older versions, other national standards or if we specify higher requirements that we could impact testing, incur time delays and could have cost impacts on the product.
Were the stakeholders satisfied?	Yes. I could bring a new perspective and challenge some of the assumptions on the JEC2220-1.

HANDS-ON TRAINING

During my first month in Regensburg, I spent a week doing hands-on training with other technicians and with the expert trainer. In the hands-on training environment, I got to work with the products that are used at Ergon and learnt about the different switching principles and concepts. I was able to review all the different types of OLTC's at Ergon and learn about the models in detail. I was able to create my own training project and complete several challenges set by the trainer. One project I worked on, in particular, was an OLTC replacement where I completed a replacement of an OILTAP® M on-load tap-changers with a VACUTAP® VM®. See LinkedIn post - https://www.linkedin.com/feed/update/urn:li:activity:6492043830945161216



Following this I visited the Messko factory in Oberursel, Frankfurt and reviewed their current range of transformer accessories. (thermometers, oil level indicators, pressure relief devices, dehydrating breathers, flow indicators, sensor systems for oil analysis etc…). Here I was able to see how each component was made and tested at each stage and prepared for shipping. These components are critical to the safe operation on a power transformer, so I was impressed at how each component was hand crafted and inspected in detail along the production line.

Following on from my work in the test department, I carried out a complete product review on one of the latest products from MR. I spent a week learning about the concept and gave my feedback to my supervisor and the project team. I was able to switch 'hats' and use my experience as a customer to review and suggest improvements to the marketing campaigns and the product details. I used examples from my industry experiences to show how transformer assessment indices are now widely used and how users have developed their own or why they are looking for solutions. One of the biggest lessons I could share with the team was that, in my opinion, a condition monitoring system should include both offline and continuous monitoring techniques to form an optimal strategy. I believe that traditional monitoring techniques still have a place in the industry and have been proven with accuracy and maturity over time. I think continuous monitoring should be a complement to offline monitoring and maintenance strategies.

My final task in Regensburg was to investigate the benefits of using voltage regulating distribution transformers (VRDT) for grid integration of renewables. I reviewed several papers and trials looking for a solution to the voltage issues in Australia caused by renewables. Distribution planning and distribution transformers are not my area of expertise so I reached out to a colleague in Energy Queensland to help. I scheduled a meeting, even with the time difference between Australia and Germany to help answer the questions. We discussed the current regulatory environment, grid structure/assets, grid planning, metering, data and communication. I realised after that meeting, that one of my strengths is to connect people and projects and that is how I can make a difference during this scholarship. Since this project I have been thinking about applications of VRDT's at Ergon Energy and how they would help solve the capacity issues during peak loads and regulate the voltage imbalance in our low voltage networks. The development of this idea will be discussed further with my colleagues at Ergon Energy.

HIGHVOLT

- Analysis and interpretation of fault location measurements on a 131 km long DC-cable (250 kV)
- Simulation of cable faults with the software tool OrCAD Capture / PSPICE
- Hands-on testing during factory tests of an impulse generator

In my first month at HIGHVOLT, I completed several acceptance tests for an impulse generator (up to 2400 kV cumulative charging voltage). Impulse testing systems are designed to generate impulse voltages simulating lightning strikes and switching surges on cables, surge arresters and power transformers. I usually witness transformer factory acceptance tests, so it was fascinating to see how the test equipment itself is designed, manufactured and tested before it gets to an equipment factory.

The test system generally consists of an impulse voltage generator and three components (voltage divider, chopping sphere gap and overvoltage correction). For one customer we were testing a connection point (Items 4,5,6) which is an innovative patented solution combining all three in one device.

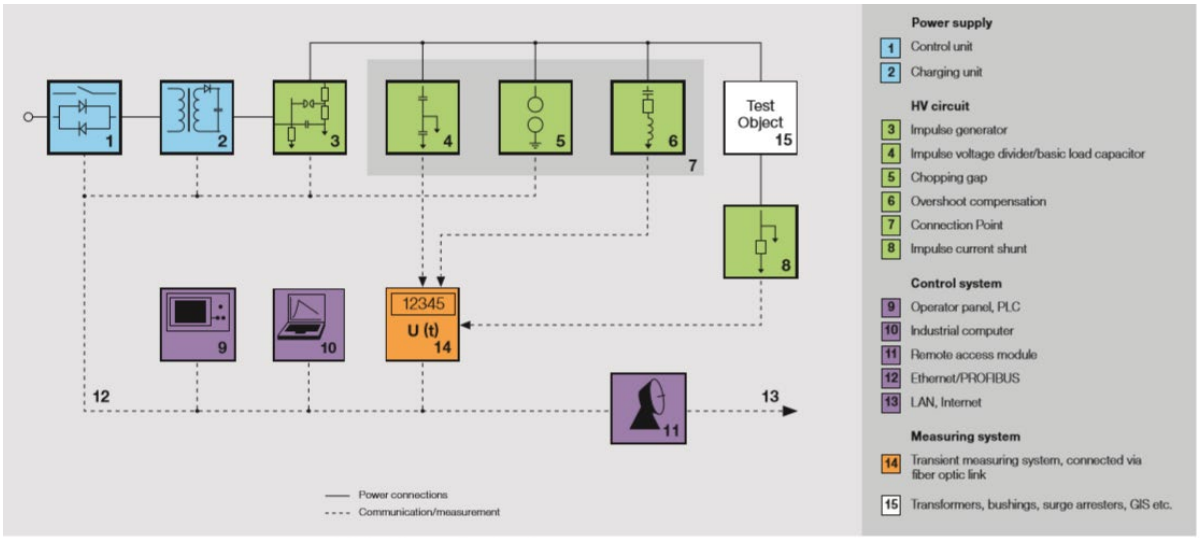


Fig. 3 **Block diagram of impulse voltage test system**

Safety was a priority in this test facility to ensure the health and safety of the testing engineers. The control of each test system had safety functions which included emergency off and a safety loop that fulfilled the requirements of the standard IEC 62061.

Additionally, during the tests we had:

- Guard fence with door and signal lamps
- An audible alarm which indicated 3 seconds to impulse

- Loud “Achtung” verbal warnings before each test
- Testing was completed during employee breaks or after hours when the test bay was not as populated
- Appropriate PPE was worn, including hearing protection

It was a fantastic experience to set up and operate the equipment especially at voltage levels around 1900 kV. Under instruction and supervision, I followed the test plans and adjusted the chopping gap distances to the required amount for each test and reported the results.

During my second month at HIGHVOLT, I learnt how to use the software tool OrCAD Capture / PSPICE. I also learnt how to analyse fault location measurements on HVAC and HVDC cables and online and offline fault location monitoring techniques. I think the case below and my visual notes page is an excellent summary of my experience in Dresden.

Case 1 - High voltage direct current (HVDC) link built to transmit offshore wind power to the power grid on mainland Germany. Power rating 576 MW, AC voltage 155 kV (offshore side), DC voltage ±250 kV. The project was completed in 2015. Three years later, during maintenance, reference measurements were carried out on the ~100 km DC cable. This cable was an underwater section which connects the offshore platform with the HVDC station.

Testing the cable: To perform these measurements, a special spark gap was made in advance and brought to the offshore platform. A local employee installed this spark gap. The recording of the travelling waves took place with a small universal divider directly connected to the cable termination.

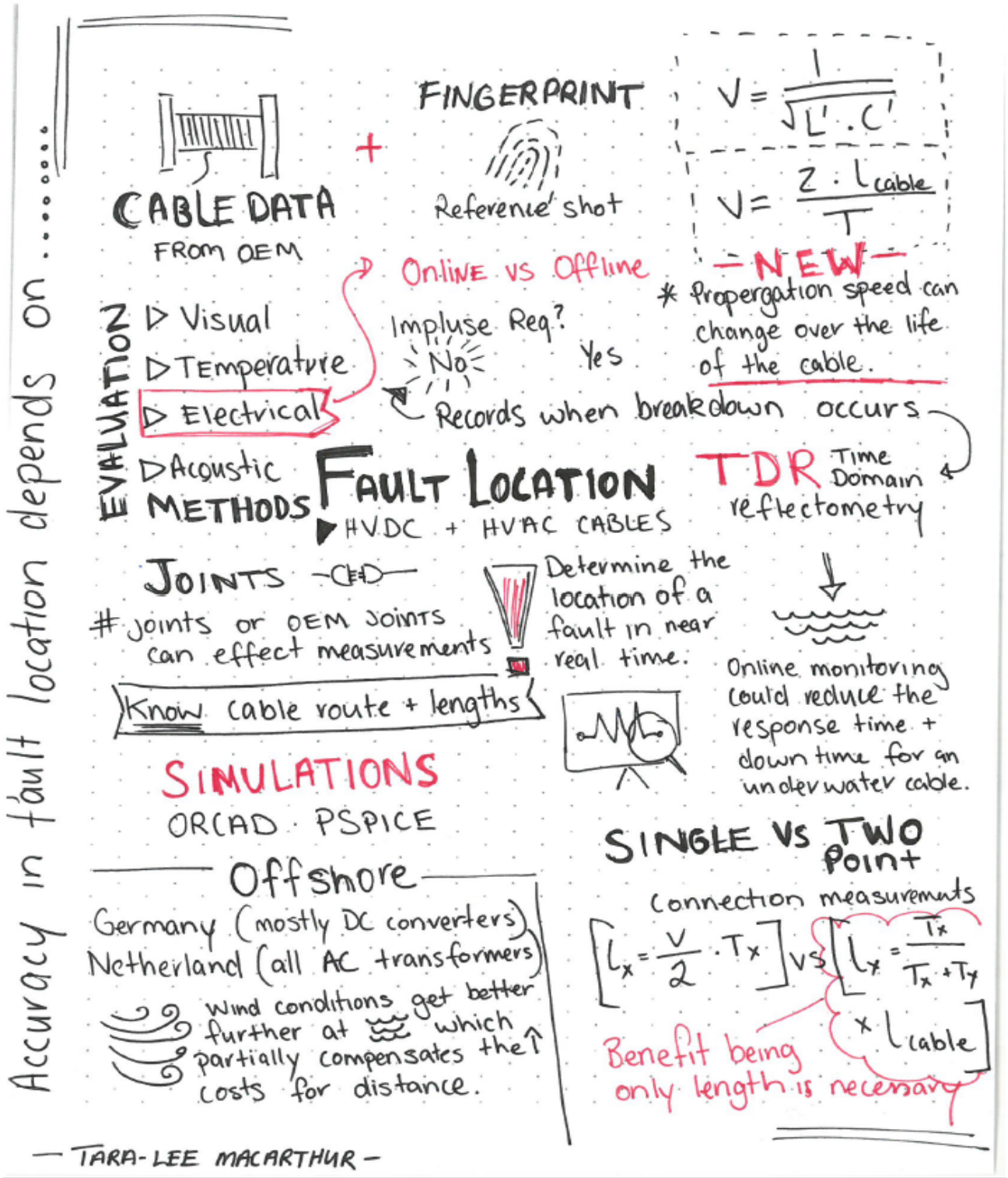
After reading the initial project reports, I noticed a mention of an ‘unbekannte muffe’ (meaning unknown joint as the reports were written in Deutsch). Finding the ‘unbekannte muffe’ had not been done before or investigated. I looked further into this unknown joint by translating the existing reports, studying the calculations and reviewing existing knowledge on this topic. I used the OrCAD Capture / PSPICE measurement file and analysed the reflection from this point. I recalculated the location of all of the known joints and then the distance into the cable where the unknown joint would be located. I had the cable lengths and joint data from the customer and there was nothing to indicate why we would see a reflection at this point.

After completing my calculations, I believed that there could be an anomaly at {e.g. beginning of a fault, cable stress or undocumented joint} ~23km into the underwater cable worth looking at.

To my supervisor I suggested,

- To see if the customer has had any indication of trouble with the cable so far
- If there is a joint not provided in the information supplied to us or a joint unspecified by the OEM during manufacture.

A retest during next maintenance could confirm whether there is an anomaly showing at that location on the cable.



After four months working in Germany it was time for me to say goodbye to MR.

I am truthfully thankful for my mentors who taught me more than I could have ever imagined and having managers who let me learn and grow. I will miss my new work colleagues and the customers who went with me on this journey. I am looking forward now to new experiences, new perspectives and a new culture! My journey continues!

DYNAMIC RATINGS (DR)

In 2019, I moved to Wisconsin to start work with DR as a Principle Engineer. My role was to work with different utility customers to learn about their asset management strategies and requirements. Some of the utilities I was working with have well-established condition monitoring programs for their transformer fleet while others are just developing a monitoring strategy. My task was to document the customer's technical requirements for different projects and look at how improvements can be made from both sides (customer and supplier). I was able to see a range of projects from concept to design and to commissioning. I worked on this project for the duration of my time at DR and was excited to be able to help customers solve some of their most significant transformer issues.

My task is to;

- Review the current customer requirement document process and documentation
- Share my own experiences from Ergon and the power industry

FIELD EXPERIENCE

Condition monitoring strategy for power transformers

Like many utilities, asset data exists in one database and test data in multiple other databases. This information was not tied together for reporting or monitoring and relied on subject matter experts (SMEs) to review and trend results to consider equipment condition. The data grew stale quickly in these snapshots in time. Now technology has made it easy to trend the health of the assets and investigate what risk these assets may hold. In the U.S, I found each utility had different priorities, variances in strategies and approaches to condition monitoring.

My daily activities involved preparing for and conducting interviews with senior Strategic Managers at major utilities and documenting how they utilise monitoring technology to achieve their business objectives. I was fortunate enough to travel to various utilities in the U.S to visit and interact with their business cultures.

Notes from the interview were compiled and written into a technical document for each utility. This customer requirements document was adopted as the new standard. I had the opportunity to discuss these topics in more detail then what would be possible for a vendor or supplier due to the scholarship opportunity and background. My background as a fellow asset manager allowed me also to share my opinions and experience. I gained insight from multiple subject matter experts in the transformer industry and was a witness to the strengths, weaknesses and challenges of the various approaches. I was lucky to be able to deep dive into the various sensing technologies available in the market technology, review trending and review transformer faults.

Through the first three months, I learnt how to develop an asset management plan, what business benefits can be derived and how to manage the human element as needed to ensure the program will be successful. I learnt about the business drivers within the U.S concerning their deployment of monitoring. I learnt about the different techniques the utilities use to deploy and maintain monitoring equipment and the methods used to securely manage data across an extensive network, providing access to industry experts as needed to support the system without creating security vulnerabilities.

Some utilities have the strategy of 'run to failure' and they utilise equipment redundancy to maintain grid reliability; others leverage technology to detect equipment problems and they utilise corrective and

preventative actions to maintain the equipment and its reliability. I also observed the cultural resistance to change, “the way it has always been” attitude and appetite for risk/reward.

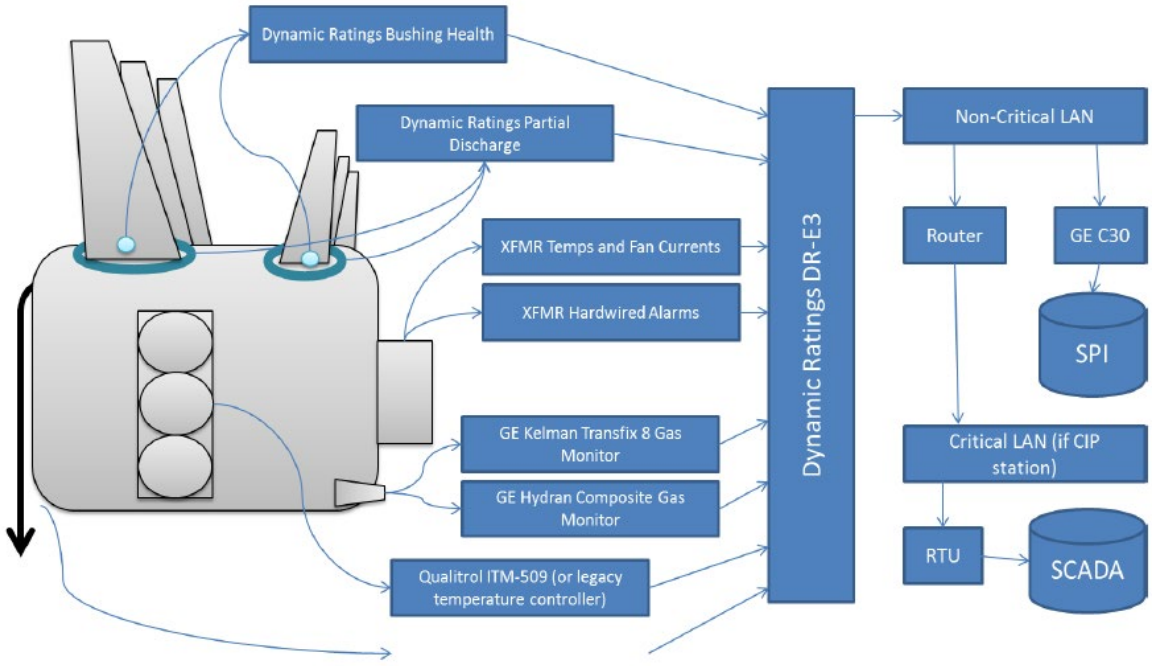
Utilities would use various monitoring on their transformers, 69,000 to 765,00 volts substations (a little different from home), which included;

- Dissolved gas analysis monitoring systems (sometimes both main and OLTC)
- Winding hot spot monitors, both direct sensing via fibre optics and simulation systems utilising thermal modelling
- Bushing health monitors (popular in U.S)
- Partial discharge monitoring and
- Geomagnetic induced current monitoring (see the section below)

Each application had various sensors or requirements that I would specify to the OEM or customer and I made sure that the application met their needs, did not interfere with the operation of the equipment, or introduce new maintenance issues or failure modes. Some of the sensors and fittings must be included in the specification and during manufacture, whereas other sensors could be retrofitted later. I also gained experience with various communication methods and protocols involved with bring the data back into each utility.

Example from one utility (Shown below)

Data is collected at a data concentrator on the transformer and sent across the non-critical LAN to a C30 relay in the control house. The traditional legacy data is sent via a critical LAN through the RTU to SCADA, and then is connected via a PI to PI connection to the Station PI data repository. The Station PI allows multiple departments to utilise the data for various analyses.



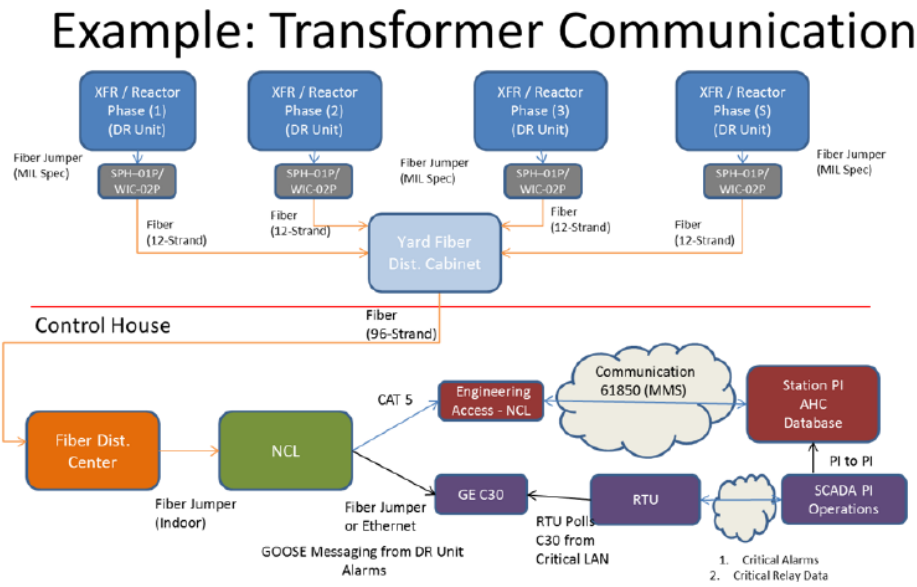


Figure 1 Schneider, C, "Lessons Learned at AEP Transmission in Failure Prevention", TechCon conference 2019

It was an excellent opportunity to learn from other utilities about their maintenance and real-time monitoring strategies. This experience will help me with details to include in future scopes and specifications. My goal is to look at our latest specifications for monitoring and the documentation on transformer monitoring devices we currently have on our network.

INTRODUCING NEW TECHNOLOGY / PROJECTS / PRODUCTS

Develop the systems and framework required to effectively and securely integrate new trial projects / new equipment into the existing substations.

Before I left Ergon Energy, I was involved in several trials and pilots of new technologies. I was involved in replacing the mineral oil in a transformer with an ester alternate and a project to do on the online condition monitoring of transformers (4). The lessons learned and outcomes from these pilots and trials will help us make evidence-based changes and improve asset management practices at Ergon Energy. In the U.S, I was fortunate enough to work with other utilities, also testing and venturing into online monitoring for the first time. It was interesting to see the different processes that each company had when it came to pilot installations and verifying new technology. One utility's practice/process stood out and it made me realise ways I could improve the way I had looked previous at trials. This project applied to transformers and batteries monitoring projects, but the methodology could be applied to any new product.

I had the opportunity to lead the project, prepare the scope of work and technical specifications for the customer. I had to interpret their technical requirements and documents according to the utility's internal procedures.

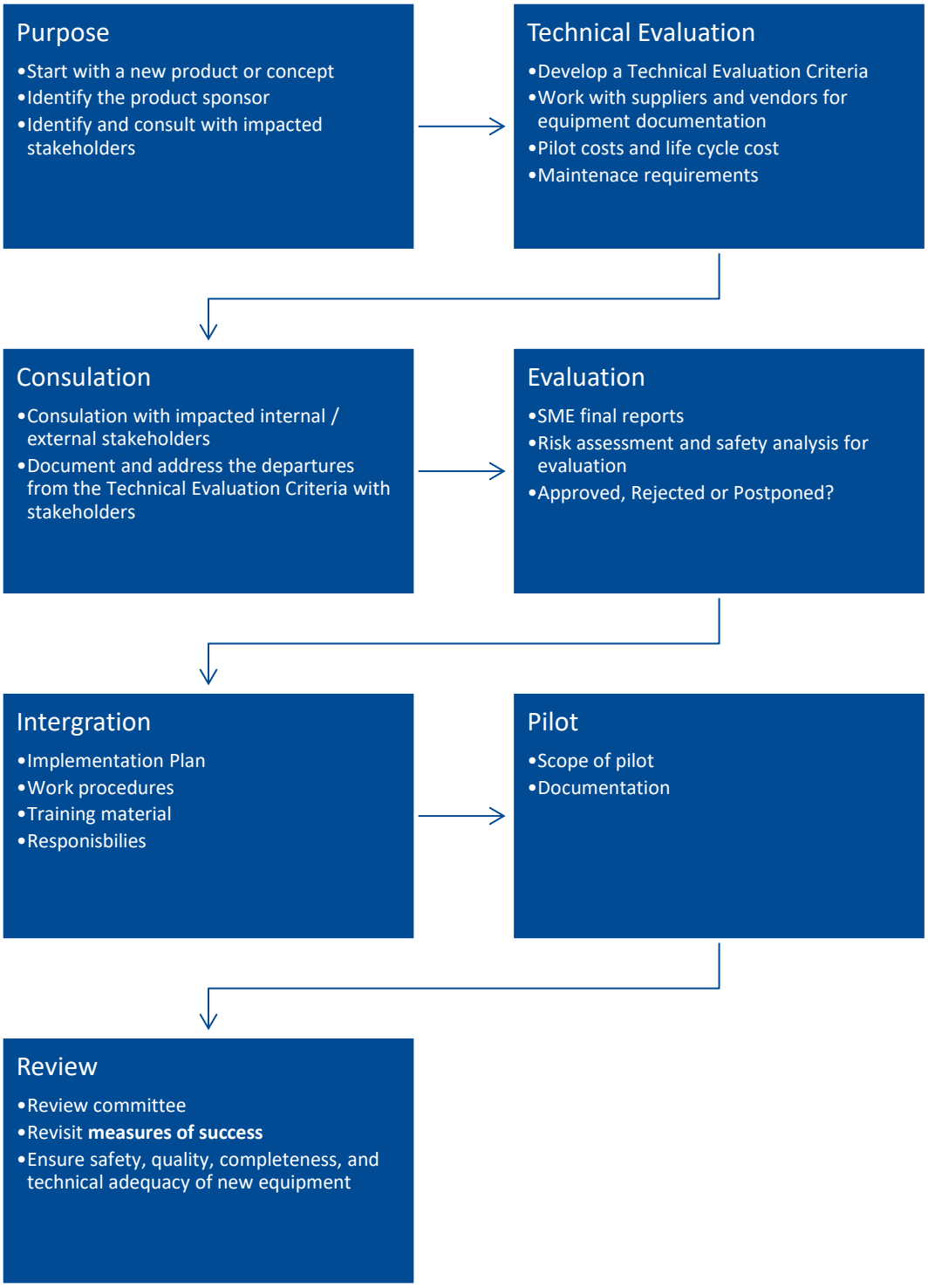
The key lessons learnt from this project;

New Product (equipment or material) is introduced, evaluated and considered for approval.

Is it for?

- Proof of concept or new technology – benefits to both utility and supplier, opportunity to share costs/data.
- Testing in-house or external testing e.g., other utility references, bench testing, Electric Power Research Institute (EPRI) etc.
- Required to solve an issue – benefit the utility

The pilot stage should be one of the last stages to complete.



The last stage was of interest to me after commencing trials of my own – what makes a trial successful? For this utility, I was able to share my experience from my work. Then together, we were able to come up with the following list, which could be applied to any online monitoring equipment evaluation criteria.

- Safety incidents
- False/nuisance alarms
- Refining setpoints/move to evidence-based condition monitoring
- Cost estimate vs actual pilot costs
- Increased or decreased frequency of maintenance activities
- Any catches saves or equipment failures.

What I found interesting when reviewing scope documentation, the focus was always on technologies chosen and the implementation schedule but often what was forgotten was the deployment allocated and system sustainability from staff support and consistency of design standpoint. How can we standardize and make it sustainable if every installation different? Is there a system validation plan and ongoing system verification? This was the most challenging but most relatable phase of my training as it merges the various technical issues, real-life schedule challenges, personal coordination and financial business decisions.

I now appreciate asset managers/management and many other aspects of business, creating business efficiency by leveraging continuous monitoring data to revise maintenance practices, optimise asset replacement plans and improve reliability. This is something my work with CIGRE has also helped me realise. For future projects, I want to avoid 'new technology being underutilised', or just ordering with the specification, I want to have everyone on board with the technology.

MONITORING GIC (GEOMAGNETICALLY INDUCED CURRENTS)

Effects of Solar Geomagnetic Disturbances on power transformers and power systems have been observed for many decades and in several parts of the world. These events had created a certain level of concern in the electric power industry. In December, while in the U.S. I heard that Townsville's Local Disaster Management Group (TLDMG) got together to talk about a response plan in case of a GIC event.

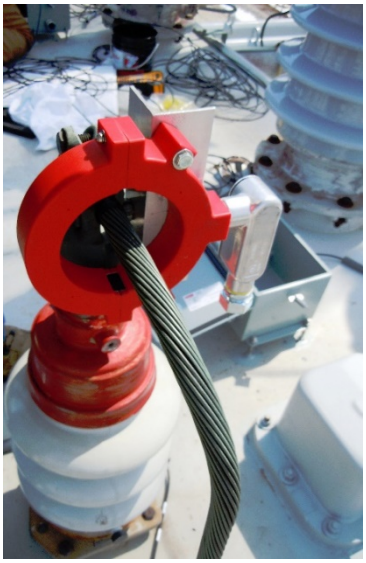
Townsville Disaster Information
9 December at 02:00 ·

Townsville's Local Disaster Management Group (TLDMG) has been put through its paces at a mock disaster response exercise simulating a significant solar flare event.

The Group and supporting agencies had to navigate their way through a scenario where a massive eruption of plasma and magnetic field from the sun affected communications on earth.

Known as a geomagnetic storm, these events have disabled power networks and key communications services in other parts of the globe.

Members of the Local Disaster Management Group were called to the Townsville Local Disaster Coordination Centre to deal with a "for exercise only" Severe Space Weather Watch following a significant solar flare event.



This made me reflect on my time in the U.S, where many utilities were investigating the implications of GIC currents flowing into the neutrals of large power transformers. New requirements from North

American Electric Reliability Corporation (NERC) [1] have been introduced that require utilities to assess and verify the potential impact of geomagnetic induced currents. During my time with DR I leant about the following two techniques;

1. DC Current on the transformer neutral: DR supplies a custom-designed split-core CT for this specific application. This GIC sensor is designed to filter out the primary system frequency and detect only DC and near DC currents. The sensor can detect DC current flowing into the transformer during geomagnetic storms and determine whether the transformer is at risk.
2. Harmonics: During GIC events, the DC current flow can cause the transformer core to go into part cycle saturation. If this occurs, the transformer will begin to generate harmonics.

At Ergon, we are currently looking into the effects of harmonics. GIC/harmonics method is currently being trialled at a site in Queensland. On my return, I will follow up to ensure that we are in line with NERC and IEEE C57.163 recommendations and an alarm if the sum of the even harmonics exceeds the sum of the odd harmonics and review the action plan so if the even harmonics have exceeded the odd harmonics appropriate action is taken.

CYBERSECURITY

Review of U.S. practices and examples. Please note; Not all this information is readily available to the public, so I have not listed the utility names for privacy reasons.

Utility (1) Documentation

Special Quality Assurance Documents that applied to suppliers, OEM, distributors when providing digital assets (hardware, firmware, operating systems, or application software)

Documentation that acknowledges and certifies that they have cybersecurity protection controls and measures in place to protect against supply chain cybersecurity threats in order to maintain the integrity of the digital asset during the design, manufacturing and distribution processes.

1. Tamper-proof seal requirement
2. Maintain cognizance of evolving cybersecurity threats and vulnerabilities
3. Maintain cybersecurity protective strategies and security controls
4. Configuration management of computers (venders/suppliers/contractors)
5. Secure transfer and storage of information and code
6. Duty to protect confidentiality

Utility (2) Requirements for control room entry

NERC CIP (North American Electric Reliability Corporation critical infrastructure protection) is a set of requirements designed to secure the assets required for operating North America's bulk electric system. The NERC CIP plan consists of 9 standards and 45 requirements covering the security of electronic perimeters and the protection of critical cyber assets as well as personnel and training, security management and disaster recovery planning. The purpose of Reliability Standard CIP-014-1 is to protect transmission substations and their associated primary control centers that if rendered inoperable or damaged as a result of a physical attack, could result in a widespread outage. What is NERC CIP (critical infrastructure protection .... https://searchcompliance.techtarget.com/definition/NERC-CIP-critical-infrastructure-protection

[1] The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority whose mission is to ensure the reliability of the Bulk-Power System (BPS) in North America. NERC develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the BPS through system awareness; and educates, trains, and certifies industry personnel. NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico.

To enter ‘critical’ sites control rooms, they required everyone on-site to sign and were continually monitored.

Commonly these sites hard swipe cards or e-keys

Utility (3) Chain of custody

As cyberattacks increase in number and sophistication, we’re proactively identifying and mitigating cybersecurity threats — not simply reacting to them. This unity has its own testing facility where devices are sent before being received at the site. Therefore, in some cases e.g. transformer monitoring devices will have to be duplicated and a set sent to the OEM and a sent for testing by the utility.

Other cybersecurity efforts include;

- Deploying devices that provide physical and electronic protections, logging and monitoring
- Increasing the use of data analytics to help predict, prepare for and mitigate threats
- Implementing third-party tests that use “friendly” hackers to attack the network to validate technical cybersecurity control effectiveness and any deficiencies
- Enhancing the security and reliability of transmission-related cyber assets by deploying Critical Infrastructure Protection (CIP) standards and planning an on-site CIP audit of utility operations to demonstrate compliance
- Conducting an independent assessment of every aspect of cybersecurity programs to identify improvements

Examples 1 and 3 are things that I should look to include in any new equipment purchases. Also, while in the U.S, the new California Privacy Laws were announced. This will affect passwords on electronic devices and system access as default passwords are no longer accepted.

Prepare for the California Privacy Laws Hitting Jan 2020

It is not just the EU that is putting customer data protection legislation into place. New California privacy laws are emerging -- how should your company prepare as these laws get stricter and stricter?

OTHER ACTIVITIES

CIGRE

https://www.cigre.org/

CIGRE is home to the worlds' most comprehensive collection of technical publications and reference information, standing alone for their unbiased, rigorous, real-world technical orientation and excellence.

The scholarship helped me to move to Europe earlier than my start time, which allowed me to attend the Paris Session.

2018 PARIS SESSION

CIGRE Paris runs every two years, the world's number one global power system event. The Session is unlike any other conference. It offers an in-depth interactive conference, following a rigorous process where, rather than being presented, hundreds of papers are collaboratively debated.

Engineering in Women" session - CIGRE Paris - 30 August

The 3rd CIGRE Women in Engineering (WIE) Forum was successfully held on 30th August 2018 in Paris, France. "Inspire, Motivate and Empower Women Engineers" was the theme for this year. The event was organised by the WIE Taskforce led by Roomie Li from CSEE and the CIGRE Central Office. More than 220 participants from power utilities, manufacturers and universities all over the world attended the event. There were not only female participants but also many male participants in the event. The forum consisted of five sessions: Welcoming Address, Keynote Speech, Dialogue, Interactive Session and Interview.

The event started with the welcoming addresses from Rob Stephen the CIGRE President, Rovani Sigamoney the UNESCO Engineering Programme Specialist, Mark Waldron the CIGRE Vice President and Technical Committee Chairman and John Mcdonald the IEEE PES Past President and CIGRE USNC Vice President. The moderator of this session was Ruomei Li.

I was one of five young females in the Interactive Session. The topic of this session was "Engineering in Women". Amanda Olson from Burns & McDonnell talked "Future challenges of engineering organizations". Louise Preedy from OMNETRIC talked "Agile content generation @CIGRE--Advancement and Empowerment of Women Engineers". Myself, (Tara-lee Macarthur) from Ergon Energy talked "Diversity and Inclusion Strategy". Veronique Beghin from Tractebel and Claire Chevalier from Siemens talked "Challenges & Opportunities for Women in the new paradigm: Perspectives from Belgium". Biljana Stojkovska from National Grid UK hosted this session.

I was fortunate enough to meet with Rob Stephens this year in NZ CIRGE and EEA and in Paris where we continued to talk about gendered language used in CIGRE brochures and announcements.

A2 Poster Session

The new strategic goals and mission for A2 is to encourage more diversity on the A2 Committee.

No. 298 - June 2018 ELECTRA "Specific actions for the recruitment of young experts, Place of Women in the SC

Some working group Convenors have had good success at integrating young members, e.g A2-49 and A2-59. To date, the place of women in SC A2 still remains a challenge; however further efforts will be made to increase participation with new WGs launched in 2018-19. The only woman Regular Member retired after the 2016 Paris session, and following the completion of certain WGs, there remains only one woman Convenor. Initiatives have been made to increase the participation of women

in 2017-18, including the naming of women as special reporters in both years. SC A2 is also supporting the CIGRE Women's Network.

An experience of where our Chairman is working towards a more diverse and inclusive A2 and CIGRE was when I was asked by the Chairman to co-chair the A2 poster session. Had I have been asked to do this on my own, I would probably have said, "no sorry I cannot" to the opportunity as I did not want to stuff up the job.

However, through job shadowing, I had the opportunity to work alongside a colleague and gain experience and insight into the role.

At the start, it was breaking work down into smaller, more manageable tasks until I felt confident to do it on my own. If I was to be asked to do it on my own again next time, I would say yes, now that I've built up my confidence and experience. I would, however, like to see another young engineer be involved like I was. From this experience, I would encourage everyone to job shadow with a young engineer.

Key learnings:

- Gives you perspective on your work by learning from others' experiences. I learnt so much by observing the interaction and communication between paper authors and the poster session chair.
- I had read a lot from these authors and it gave me a chance to connect and put faces to names and expand my professional network.
- Reflect on your own professional practice.

GREEN BOOK PARTICIPATION

The possibility of writing a Green Book on the transformer procurement process was discussed at the Study Committee meeting at Cracow in October 2017. If approved by the study committee, the contents would primarily be based on the work of several current and recent WGs (A2.36, A2.42, A2.56, A2.58, and A2.59). I volunteered to be a part of this group as I have been using a number of the technical brochures in my day to day work and I could contribute to the review of these documents.

The Green Book (GB) team scheduled a kick-off meeting on the last day of the Session. During this half-day meeting, the team worked together discussing:

- Outlining the next steps and critical success factors
- Gather information and priorities
- Confirm roles and responsibilities.

All stakeholders needed to attend this kick-off meeting as the GB deadline is Paris Session 2020.

This meeting gave me ideas on how we can achieve a successful publication and tight timeframe by using new WG's, the AP A2 panel members and NGN members from EQL.

This progress will be documented here over the next reports.

TECHNICAL BROCHURE WG A2.49

Publication plan for the coming year TB from A2.49 - “Condition assessment of power transformers” - Convener: Peter Cole (AU). I was the secretary and co-editor for this technical brochure.

I will be involved in an editing meeting in Cardiff once the SC reviews the document.

While the document is going to be published in March 2019, I will continue to work on this body of work. I am putting together some additional case studies using data from three different utilities. I will have the opportunity to present the new material at two upcoming events, CIRED Madrid and CIGRE A2 Colloquium in India. I specifically asked to give the tutorial to gain more experience writing technical papers and giving presentations.

CIGRE INDIA

This conference was great exposure to other failure modes other countries are facing and helps to stay up to date with new technology.

From the installations I was doing in the U.S., a massive priority for customers was the use of online DGA main and OLTC and bushing monitoring. This was due to catastrophic failures of these components and one happened just 1 hour from my house. They had two transformers failures resulting in fires within a matter of minutes apart. This occurred on the hottest day of the year, causing a dangerous fire and lengthy power outage. The utility was aware of a problem with one transformer (On-Load Tap-Changer) and was monitoring it in the lead up to the fire with plans for a detailed internal inspection schedules days after the failure had occurred. This has me thinking about the latest statistic for transformer failures and how we report / record failures.

In India, I got to talk with the local utility about their practices and where they want to head in the future. I was amazed at the different techniques they were using to monitor bushing (offline) as they struggled in the early stages of online bushing monitoring.

At the conference, I presented a tutorial on Condition Assessment, which was a new topic but helped start the conversation of condition indices within their departments.

IEEE

2018 FALL TRANSFORMER COMMITTEE MEETING, JACKSONVILLE

http://www.transformerscommittee.org/homepage.htm

I do not believe I can ‘keep up’ by reading books and papers. The best way for me to learn about the latest developments is to attend meetings, conferences and networking with others. I enjoy learning by listening to others and connecting with them (or connecting them with others). I will be working in the United States next year so I took the opportunity to network and made some new connections that I could use in the new year.

I was able to attend my first IEEE Fall Transformer Committee Meeting as I could combine it with an MR customer visit in the US. I used the scholarship to pay for my travel to and from the conference.

Before I left Australia, one of my projects was to investigate the retro-filling of power transformers with alternate insulating liquids. I have an interest in joining the new WG on retro-filling power transformers, which was proposed at this meeting. I noted that I would struggle to attend all the meetings when I get back to Australia, but I could contribute remotely to this topic based on my own experience.

What experiences I can share from this IEEE meeting;

- There is a new standard for transformer (main tank) DGA going to be released and that a review of the existing documents will need to take place.
- IEEE and IEC work together on joint standards and that Australian Standards and other independent country standards could adopt these joint standards in the future.

2019 FALL TRANSFORMER COMMITTEE MEETING, COLUMBUS

In my second IEEE transformer meeting, I took a more active participation role in the development of a new standard. My working group has actively made arrangements so I can attend the video conference calls when I am back working in Australia.

What struck me the most about my second meeting was how standards get developed. During the week-long meeting, I thought about how I could use the same format to develop Standards back at Ergon in my old role. What I did not appreciate at first was the enormous collaborative effort that goes into the development of industry standards and guides. The collaboration is not just between OEM's, customers, consultants and experts across different states in the U.S but other countries as well.

DISTRIBUTECH

I recently attended the DistribuTECH conference and exhibition in New Orleans. Overall it was a great conference and one of the largest events I have ever attended. I highly recommend those working in transmission and distribution space to attend.

The 2019 theme was the collection, integration and analysis of grid data and its applications for grid performance improvement or commonly known as "grid edge". Each year approximately 12,000 utility professionals gather for the week to learn and discuss products and trends in the industry.

It was the latest industry event that I have attended to demonstrate the importance of data and how to make informed decisions out of it. Data collection through various sensors and monitoring devices has been growing over the past few years. In my opinion, we need to continue collecting data but should also prioritise investments in data analytics. I am interested in the concept of transforming data from numbers on a screen into informed decisions, especially in the power transformer space. Some of the larger manufacturers displayed this "Digital Twin" concept in the exhibition. Digital Twin refers to a digital replica of physical assets. Early days yet, but I think this is something we will see take off over the next couple of years and an area I would like to explore more.

Another one of the challenges that took centre stage at the conference was being able to manage Distributed Energy Resources (DER) effectively. We discussed creating a smart grid that can handle conventional power sources while integrating utility-scale renewable energy sources.

Fun fact: For anyone organising a conference, 'When the Saints Go Marching In' and 'Ready to Go' by Republica are excellent songs to get people seated and prepared for the keynote.

TECHCON NORTH AMERICA

I had a great time presenting and hosting the panel at NA TechCon earlier this year. The TechCon event held in San Diego showcased the journey towards new technologies and asset life extensions. Brian Sparling and I presented on situational and operational awareness, calling on our own experiences to share case studies on reducing risks on substation power transformers. During both the presentation and panel discussion, we had great engagement and questions from the audience.

I was fortunate to catch up with some familiar faces and fellow Aussie engineers, Chris Shaw, Stuart Nell and Kevin Chong who also presented at TechCon in San Diego. It's great to see Australians contributing in this field.

Future ideas to explore: This idea comes from a paper authored by a US utility where they started using a Telsa Battery for effectively managing life support customers. I think there is an opportunity for EQL to do something similar to this and they would have an interest in learning more about this project.

I am looking forward to connecting the two organisations to have a conversation about it.

FACTORY VISITS

During my time in Germany, I was able to complete a factory audit of a transformer and components manufacturing facility. This audit helps determine the capability of the manufacturer and gives some indication of the probable future performance and reliability. Some of the aspects I looked at were the safety records of the facility, cleanliness, technical competency and manufacturing processes.

I was also able to share information about Ergon and our asset base. I will continue to develop the presentation used to showcase Ergon for future meetings and opportunities.

During my time in the U.S, I was able to visit more transformer factories and component manufacturers making solid insulation and ester fluids. The component factories were fascinating as I had never been into one and witnessed the production of transformer paper and esters.

UNEXPECTED EVENTS

Below are some details about some unexpected events that occurred during my program:

Description	Impact	Actions
Visa for the US	Loss of time at work	This is part of working and travelling overseas. It is out of my control, but my visa interview coincides with a conference so I can use the travel time on the way home to complete the interview.

Concerning immigration, the team at Dynamic Ratings and the American Immigration Council has been helpful with assisting me and ensuring that the Visa and Work Permits are organised and ready for January 2019.

POST-PROJECT LESSONS LIST

- Learn from real-world experiences, lessons and successes
- Collaborate with different companies and solve local challenges
- Actively encourage women to take more chances and go for opportunities they desire. However, not only encourage but share your experiences and stand by them. External support like this is great for confidence-building and will help anyone succeed.

POST PROJECT GOALS AND FUTURE WORK

1) Condition monitoring
    a) Evaluate condition monitoring and ester trial based on frame work discussed above
    b) Write a paper on measures of success and progress to date on the trial
2) Esters
    a) Communication refresher to field, commissioning and operations staff on the use of esters.
3) Review maintenance on tap-changers (OLTC) and bushings
    a) OLTC DGA to be reviewed
    b) OLTC classifications
    c) Maintenance and condition assessment of OLTC and bushings
    d) OIP vs RIS/RIP

SUMMARY

It's still early days but equipped with this knowledge, upon my return I hope to continue my career as a transformer specialist or move into a role where I can combine transformer lifecycle maintenance matters for Ergon Energy. I would like to use this experience to identify opportunities in the life cycle operation of transformers and their associated components.

I will present at a conference later this year on my journey and I hope to share what I have done since with the scholarship committee, past, present and future ESC students and the transformer industry.

I didn't want this to end and I don't believe it needs too. These opportunities were invaluable, and I will try to do something like this again in the near future.

ABOUT THE COMPANIES

MASCHINENFABRIK REINHAUSEN

https://www.reinhausen.com/en/

Our company is active in power engineering and consists of Maschinenfabrik Reinhausen GmbH (MR) and 42 subsidiaries and 7 affiliated companies globally. In the past financial year, 3.550 employees produced a turnover of 750 million euros.
Our core business is the regulation of power transformers. This is done above all with the aid of tap changers, which adapt the transmission ratio of the primary to secondary winding to changing load ratios and, together with additional, innovative products and services, ensure an interruption-free power supply.

Today, over 50% of global electricity flows through our products. As an innovative company with decades of experience in voltage regulation, we are present in every area that deals with the flow of energy.

Regensburg, a Bavarian city on the Danube River in southeast Germany, is known for its well-preserved medieval core.

MASCHINENFABRIK REINHAUSEN GMBH	MESSKO GMBH
Falkensteinstr. 8 93059 Regensburg Germany Tel.: +49 (0)941/4090-0 Fax: +49 (0)941/4090-7001	Gewerbegebiet An den Drei Hasen Messko-Platz 1 61440 Oberursel Germany Tel.: +49 (0)6171/6398-0 Fax: +49 (0)6171/6398-98

MY POSITION IN THE COMPANY

Job title: Intern Engineer

Tasks:

CTTP Product Approval Testing (6 weeks): Analysis of Japanese tap-changer product standard JEC 2220-2007 and comparison with international tap-changer product standard IEC 60214-1:2014 with focus type & routine testing.

CTC Engineering / OEM Systems (2 weeks): Latest product review and learn about voltage regulated distribution transformers.

HIGHVOLT PRÜFTECHNIK DRESDEN GMBH

www.highvolt.de/en

High voltage is our specialty. HIGHVOLT Prüftechnik Dresden GmbH is a global leader in high voltage test systems and measurement equipment with an export share of about 90 percent. At our factory in Dresden, Germany, we develop and manufacture systems and equipment for testing devices used to transfer electrical energy, such as transformers, cables, and switchgears. We also furnish research and educational institutions with our systems and equipment.

Milestones:

- One of the outstanding achievements of Koch & Sterzel has been the world's **first1 MV cascade transformer** (1923) for the high voltage hall of TH (today TU Dresden). Further Highlights have been the development of impulse voltage generators up to 2.5 MV (1929, according to the multiplier circuit of Marx) and direct voltage generators up to 1 MV, mainly for research in nuclear physics.
- TuR produced the largest **HV test systems of the world** (1990) with up to 3 MV alternating (AC) and 7.2 MV impulse voltages as well as very powerful direct (DC) voltage sources 1.35 MV.
- HIGHVOLT has been the first company developing a **mobile AC test system (type WRV) based on the static frequency converter to test high voltage cables and gas-insulated switchgears** in the late 1990s.
- The market introduction of the first **onsite test system for induced voltage testing of transformers (type WV)** based on **the technology of the static frequency converter** in 2006 was another milestone in HIGHVOLT's corporate history.

Dresden, capital of the eastern German state of Saxony, is distinguished by the celebrated art museums and classic architecture of its reconstructed old town. Completed in 1743 and rebuilt after WWII, the baroque church Frauenkirche is famed for its grand dome.

HIGHVOLT Prüftechnik Dresden GmbH
Marie-Curie-Straße 10
D-01139 Dresden
Germany
Phone +49 351 8425 700
Fax +49 351 8425 679
E-mail sales@highvolt.de

MY POSITION IN THE COMPANY

Job title: Intern Engineer

Tasks: Analysis of test specifications and simulations regarding cable DC HV, development of recommendations for a future project.

DYNAMIC RATINGS

https://www.dynamicratings.com/

Dynamic Ratings (DR) is an Asset Management Solutions provider. Using end-to-end comprehensive products and services to improve customers' business performance. Helping utilities address the various challenges associated with successfully deploying and managing their Condition Based Monitoring programs. They offer transformer and other asset monitoring solutions, support and customer service in the global marketplace.

Dynamic Ratings is a wholly owned subsidiary of Wilson Transformer Company (WTC). WTC was founded in 1933 and has multiple transformer manufacturing plants. In the early 1980's, WTC started a joint development with one of the largest utilities in Australia to provide a transformer monitoring system. This evolved into the Dynamic Ratings division of WTC. In 2002, the U.S office was opened and is now the headquarters.

DR's U.S. office is in Milwaukee which is the largest city in the state of Wisconsin.

Americas Headquarters N56 W24879 N. Corporate Circle, Sussex, WI, 53089, USA Phone +1 262 746 1230

MY POSITION IN THE COMPANY

Job title: Principle Engineer

Tasks: To understand the needs of the market in great technical detail and to then utilize this detailed knowledge to guide experimentation and research into new analytics, sensors, product formulations and approaches.

Manage key customer projects to ensure technical accuracy in supply and on time delivery of products and services.

Act as the liaison between the end user (customer) and the various departments within DR and/or 3rd party (transformer manufactures, strategic partners, consultants, contractors, etc.)

Provide input to the Application Engineering team as needed to ensure system designs meet customer requirements.

October

BRINGING KNOWLEDGE FROM REGENSBURG OUT INTO THE WORLD

One or two of you may have run into Tara-Lee MacArthur, a trainee at MR since September, in the cafeteria or on the way to the Engineering department. The young Australian received an E.S. Cornwall Memorial Scholarship from the University of Queensland and is currently spending two months observing different technical departments at MR in Regensburg before spending two months at HighVolt in Dresden.

After completing a degree in electrical engineering, multiple years of experience at Australian electricity supplier Ergon Energy and winning a number of awards for her outstanding achievements, MacArthur was selected as the latest candidate for the renowned E.S. Cornwall Memorial Scholarship. This scholarship program offers engineers who have demonstrated exceptional achievements the opportunity to spend between 6 and 18 months as a trainee at various companies abroad.

MacArthur came into contact with RA Managing Director Dr. Thomas Smolka through her work on the CIGRE A2 Transformer committee. Thanks to this connection and MR's excellent reputation in Australia, she quickly decided that Regensburg would be one of the stops on her journey, and soon found a suitable trainee position here. Here in Regensburg, the Australia native draws on her comprehensive knowledge of power transformers to help in the various CT departments and Sales as both a colleague and client. She also works with her mentor Marc Foata (CST), also a CIGRE member, on a wide variety of tasks and projects. At the end of the scholarship, MacArthur, who is a CIGRE junior member, plans to return to her previous employer in order to take on a management position with the company and use the experience she has gained abroad to improve the Australian power grid. Since MR has a long-standing business relationship with Ergon Energy, the trainee program presents an excellent opportunity for everyone involved to exchange knowledge, deepen existing connections and further strengthen MR's position on the Australian market.

What is MacArthur's favorite thing about MR? "The super friendly colleagues, the highly technical work and the great food in the cafeteria," she said, smiling. When asked about the city of Regensburg, MacArthur gushes about the beautiful, historic city center, the rich cultural scene and the many festivals and celebrations. "Going to the Regensburg Fall Festival was one of the highlights of my time here!"

MacArthur will be in Regensburg until the end of October, when she will join HighVolt in Dresden and work there until the end of the year learning more about high-voltage transformers. After her time in Germany, she has chosen to spend time in the US for the second leg of her scholarship in order to learn more about the power grid and energy supply there. We wish MacArthur all the best, and a great deal of success in her future endeavors and the rest of her time with the Reinhausen Group!

Dynamic Ratings
682 followers
1w •

Over the past year, we had the pleasure of hosting an E.S. Cornwall Memorial Scholarship recipient, **Tara-lee MacArthur** of **Ergon Energy** at our US office. She spent a lot of time working directly with our customers to help make them successful. We want to extend our sincerest thanks to all her hard work and dedication to the team. Tara, we wish you well in all your future endeavors!