

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 important 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 three months in an intensive development program in Germany. 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 up 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 IEEE Transformers Committee meeting in Jacksonville, USA and have been able to go on a number of site visits in Germany. These activities gave me some insight into the latest in transformers developments taking place around the world and gave me an opportunity 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 wouldn't have been possible.

It should be noted that due to confidentiality, I am not able to include specific information relating to 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 each and 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.

Regards,

Tara-lee MacArthur

COVER PAGE

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BACKGROUND

For the last 4 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've 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 manufacturing 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	3 rd September
Ending date of employment:	2 nd October 2018
Position/job:	
Period 2	
Name of Employer:	HIGHVOLT Prüftechnik Dresden GmbH
Starting date of employment:	4 th October 2018
Ending date of employment:	31 st December 2018
Position/job:	
Period 3	
Name of Employer:	Dynamic Ratings
Starting date of employment:	3 rd January 2019
Ending date of employment:	31 st December 2019
Position/job:	Principal Engineer

KEY PROJECTS

Monthly Progress			
Month One	Comparison of JEC 2220-2007 with IEC 60214-1:2014. (Technical findings below)	Hands-on training, fault finding and investigations	Difficult conversations: Customer vs Colleague
Month Two		DGA and OLTC classification	IEEE conference and US customer visit
Month Three	Testing of impulse generator	Analog Design and Simulation using OrCAD Capture and PSpice	
Month Four	Euro TechCon - Paper and Presentation		
Month Five			
Month Six			
Month Seven			
Month Eight			
Month Nine			
Month Ten			
Month Eleven			
Month Twelve			

KEY FINDINGS:

Comparison of JEC 2220-2007 with IEC 60214-1:2014	Date
<p>Concerning their differences in the type test procedure for on-load tap-changers and motor-drive mechanisms for on-load tap-changers</p>	<p>Sep-Oct 2018</p>
<p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>I was based in the 4,800 m² 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.</p> <p>Based on the analysis results I created a document for the following applications:</p> <ul style="list-style-type: none"> • Summary document (e.g. presentation) which contains first general information. • MR internal guide <p>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.</p> <p>Some of the main differences between the two type testing procedures were;</p> <ul style="list-style-type: none"> • 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 times 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. <p>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's my opinion that the sequence and the definition of</p>	

<p>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 necessary compromising on safety and quality of the product.</p> <p>I was also given the opportunity 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.</p>	
<p>Did it relate to my scholarship proposal? (Extract from my scholarship application)</p>	<p>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 bushings and tap-changers as these are commonly made overseas."</p>
<p>Was the project mission completed?</p>	<p>The document was completed before I left MR however the clarifications and questions I had sent to the subsidiary were still out for discussion.</p>
<p>Lessons learnt</p>	<p>This project helped me realise the importance of understanding that when we specify certain standards (e.g. 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.</p>
<p>Were the stakeholders satisfied?</p>	<p>Yes. I could bring a new perspective and challenge some of the assumptions on the JEC2220-1.</p>

OTHER PROJECTS

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 actually 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 a number of 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®. (TBC if I can release the footage of this OLTC exchange)

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 was 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 complement to offline monitoring and maintenance strategies.

My final task in Regensburg was to look into 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 was able to schedule a meeting, even with the time difference between Australia and Germany to help answer the questions that were arising out of our review. 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's how I can really 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,

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

Every two years, the world's number one global power system event is run by CIGRE in Paris, France. This event attracts members from across the whole CIGRE community and is the culmination of the previous two years of the CIGRE knowledge programme. 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 Ruomei 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 host this session.

I was fortunate enough to meet with Rob Stephens this year in NZ CIGRE 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. Efforts have been made to increase participation of women in

2017-18, including 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 can't" to the opportunity as I didn't want to stuff up the job.

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

At the start, it was breaking work down into smaller, more manageable tasks until I felt confident enough 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:

- It gives you a different 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. It expands your network and helps you make professional contacts.
- It gives you the chance to 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 largely be based on the work of a number of 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.

It was critical all stakeholders attended this kickoff 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 will be involved in an editing meeting in Cardiff once the document is reviewed by the SC.

IEEE

FALL TRANSFORMER COMMITTEE MEETING, JACKSONVILLE

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

I don't believe I can just 'keep up' by reading books and papers. The best way for me to learn about latest developments is to attend meetings, conferences and networking with others. I really 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 make 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 a 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.

FACTORY SURVEYS

During my time in Germany, I was able to complete a factory audit of a transformer and components manufacturing facility. This audit helps determine 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.

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.

With respect to immigration, the team at Dynamic Ratings and the American Immigration Council has been really 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. But 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

SUMMARY

It's still early days but equipped with this knowledge, upon my return I hope to continue my career as a transformer designer or transformer lifecycle maintenance subject matter expert for Ergon Energy. I would like to use this experience to identify opportunities in life cycle operation of transformers and their associated components.

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
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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 **first 1 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

TBC

ANNEX

PEER REVIEWS AND CERTIFICATES

NEWS ARTICLES

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!