Sunday, October 20

Time	CANYON FOYER
10:00 to 16:00	Sightseeing to nearby Sabino Canyon. Complimentary bus shuttles will run in both directions originating from the Westin La Paloma Hotel every 45 minutes. Circa 15-minute bus trip each way
13:00 to 19:00	Registration desk opens. Attendees pick up badges and conference materials
20:00 to 21:00	Welcome Reception for Attendees

Day 1: Monday, October 21

Time	CANYON CONFERENCE ROOM
08:00 to 13:00	Plenary Session Part 1
14:00 to 18:30	Plenary Session Part 2
18:30 to 20:00	Exhibitor Reception in Exhibition Area

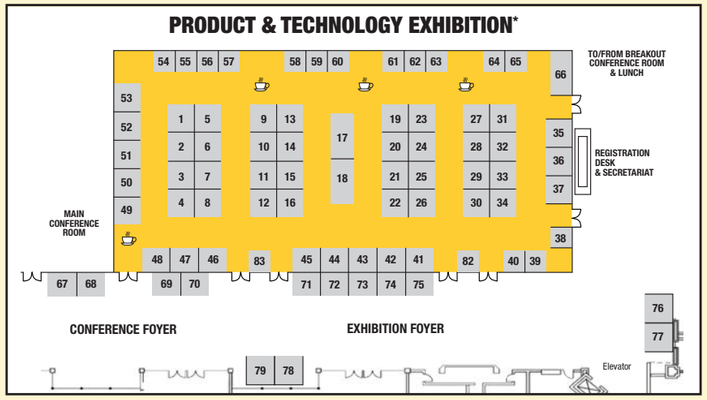
Day 2: Tuesday, October 22

Time	CANYON CONFERENCE ROOM	SONORAN 1 & 2 CONFERENCE ROOM
08:00 to 13:00	Plenary Session Part 3	Arrester Technologies & Applications Part 1
11:00 to 18:30	Insulator Technologies & Application Part 1	

Day 3: Wednesday, October 23

Time	CANYON CONFERENCE ROOM	SONORAN 1 & 2 CONFERENCE ROOM	MURPHEY CONFERENCE ROOM
08:00 to 13:00	Insulator Technologies & Applications Part 2	Arrester Technologies & Applications Part 2	Cable & Accessory Technologies & Applications
14:00 to 18:00	Insulator Technologies & Applications Part 3		

PRODUCT & TECHNOLOGY EXHIBITION*



*Subject to possible modification

EXHIBITOR	SPACE #
ABB Components	26
Agni Fiber Boards	64
BPG International	58 & 59
CESI	39 & 40
CIGRE	76
Dalian Sunrise Hardware	36
Dekuma Rubber & Plastic Technology	4
Desma Elastomertechnik	27 & 28
DKSH Korea	78
EDF Lab Les Renardières	50
EGU HV Laboratory	45
Electro Magnetic Works (EMWorks)	75
Electric Power Research Institute (EPRI)	77

EXHIBITOR	SPACE #
EPRECSA USA	1
Eximprod Power Systems	49
Global Insulator Group (GIG)	7
Gruppo Bonomi/EB Rebosio	54 - 55 - 56
Hebei Kangao	11
H-J Family of Companies	29
Hubbell Power Systems	17 & 18
Huphen Fabricators	65
Induron	83
Integrated Engineering Software	2
KEMA Laboratories	13
K-Line Insulators	47 & 48
La Granja Insulators	14

EXHIBITOR	SPACE #
MacLean Power Systems	21 & 22
Manitoba Hydro International	68
Nanju Polymer Material	60
NARI Group Corporation	70
Ofil	8
Pfisterer Holding	51
Pioneer Technology Solutions	71
PPC Insulators	9 & 10
Polyone - Glasforms Advanced Composites	37
Reinhausen Power Composites	43 & 44
RHM International	6
RNG Exports	79
Saver	23 & 24
Sediver	19 & 20
Shaanxi Taporel Electrical Insulation Technology	34
Shenzhen Square Silicone	25
Sichuan Yibin Global Group	3
Siemens AG	31 & 32
STRI	12
TÜV Rheinland (Shanghai)	66
Ugur Turkyurt	41
UMEK Group	33
Uniflex Hydraulik	38
Uvirco Technologies	52 & 53
Verfahrenstechnik Hübers	46
Victor Insulators	57
Vogel moulds and machines	69
Wacker Chemie	15 & 16
Wellwin Precision Mould	30
Xi'an Gaoqiang Insulation Electric	42
Yizumi Rubber Machinery	61 - 62 - 63
Zhengzhou Xianghe Group Electric	82
Zibo Taiguang Electrical Equipment	5

PLENARY SESSION: CANYON CONFERENCE ROOM

Monday, Oct. 21
08:00 to 09:15
Session Chairman:
Marvin L. Zimmerman, Publisher, INMR, Canada

08:00
Susan Gray
Senior Vice President & Chief Operating Officer, Tucson Electric Power, United States

Welcome Address

Ms. Gray holds a Bachelors in Electrical Engineering and an MBA from the University of Arizona. She came to TEP as a student engineer in 1994 and progressed through several leadership positions in Transmission and Distribution Operations. Her positive leadership style, analytical approach, team building and interpersonal skills were recognized in 2015 when she was named Vice President of Energy Delivery and later promoted again to her current position in January 2019. Susan motivates and inspires her team by encouraging inclusivity and diversity of thought, teamwork and creative problem solving to promote operational excellence. As founding member of TEP's Women in Energy Group, she strives to develop, mentor and inspire other women in the energy industry. She serves on the Advisory Boards for Eller College and the College of Engineering at University of Arizona as well as two professional association boards.

08:10
Konstantin Papailiou
Professor, Dresden Technical University, Switzerland/Germany

Overhead Lines: Back to the Future

Dr. Papailiou received his Doctorate Degree from the Swiss Federal Institute of Technology (ETH) Zürich and his post-doctoral qualification as lecturer (Dr.-Ing. habil.) from the Technical University of Dresden. Until his retirement at the end of 2011 he was CEO of the Pfisterer Group, a company he has served for more than 25 years. He is past Chairman of the CIGRE Study Committee 'Overhead Lines' and has published numerous papers and co-authored the EPRI Book 'Wind-Induced Conductor Motion' as well as a monography on 'Silicone Composite Insulators'. He is also the Editor of the first CIGRE 'Green Book on Overhead Lines'.

08:25
Jeff Butler
Business Unit Manager, Insulators, Hubbell Power Systems, United States

Optimizing Design & Materials for High Voltage Transmission Applications

Mr. Butler graduated from Georgia Tech (Georgia Institute of Technology) in Mechanical Engineering before entering the power utility industry in 2006. Since then, he has held various roles of international and U.S. domestic responsibilities in engineering, business development, sales and marketing. He is an internationally published author and presenter as well as a licensed professional engineer. In his current role, he is based in the manufacturing facility in Aiken, South Carolina.

SYNOPSIS

Various standards setting bodies have established requirements to test insulators but sometimes these have not been as well suited to assessing capabilities of materials themselves to function as outdoor high voltage insulation. In fact, continuous evolution and improvements in testing non-ceramic materials resulted in diverse methodologies to verify polymeric insulators. Originally, design testing evaluated an insulator as an entity for characteristics such as dielectric strength, environmental stability, resistance to tracking and erosion, UV resistance and thermal stability. However, the need for material-based testing expanded beyond this into testing capabilities such as resistance to corona cutting, hydrophobicity and flammability. Insulators, whatever their material type, are tested to predict behavior in the field over their expected service life. While the best measure is actual field experience, it is not practical to build credible field experience for every new insulator design or iteration. As such, it is critical to develop an understanding of factors influencing a transmission line and consequently transmission line materials so as to quickly verify the competence of an insulator. This paper and presentation review different aspects of any high voltage transmission line that must be considered to optimize line performance. The goal is to ensure that those responsible for design, construction, operation and maintenance of transmission lines fully understand the impact of insulator design and material selection.

08:50
Jens Seifert
Senior Expert, Reinhausen Power Composites, Germany

Application of Station Posts

Dr. Seifert obtained his Ph.D. degree from TU Braunschweig in 1998. He has had 20 years of experience in development of composite materials for high voltage insulating applications. In 2018 he joined the MR Group as Senior Expert for basic development. He serves as Chairman of IEC TC 36 Insulators and is also Convener of CIGRE Working Groups D1.58 and D1.59.

SYNOPSIS

Station post insulators are indispensable for HV substations and related apparatus. Porcelain station posts have been applied for more than 100 years, with voltages ranging from 1 to 765 (800) kV and maximum cantilever strengths from 20 to 30 kN. Single units can be manufactured to a length of 3000 mm while, for voltages over 245 kV, assemblies consist of 2 or more units connected by flanges. Modern production technologies offer high-strength designs optimized in shape, weight and shed profile. Glass station posts, by contrast, consist of individual units assembled by cement and complex profiles can be realized. For severe pollution conditions, RTV coatings improve electrical performance. The first composite station posts were introduced in the 1980s, consisting of solid core fiber reinforced polymeric core material with an elastomeric housing. Typical core diameters are 45 to 100 mm with maximum diameters rarely exceeding 130 mm. For voltage classes over 245 kV, given increased bending moment, much effort is needed to meet requirements with solid core designs. Composite hollow core station posts as well as hybrid station posts have begun filling these applications, with the former already realized up to 800 kV HVDC and 1100 kV UHV and with connection lengths of more than 10 m. This presentation reviews the state-of-the-art of these alternative technologies, related standards and ideal applications for each. An outlook is also made to future applications where use of composite station post insulators will be preferred.

PLENARY SESSION: CANYON CONFERENCE ROOM Monday, Oct. 21 09:15 to 10:50

09:15

Jean-Marie George

Scientific Director, Sediver, France

Specifying RTV Silicone Coatings for Overhead Transmission Lines

Mr. George received his Electrical Eng. Degree from the HEI School in France and joined Sediver as Research Engineer in 1986. After working as Production Manager for the Composite Insulator Division and Quality Mgr. and Technical Dir. for North America, he is now Scientific Director, with responsibilities covering R&D and technical assistance worldwide. His cross-functional positions with more than 30 years of experience have given him expertise in insulator performance as well as research and development. He has published and co-authored extensively on overhead lines, with 40 papers and articles and he is also author/co-author of patents and utility models. He is a member of CIGRE, IEEE, NEMA, ANSI and CSA as well as 2018 recipient of the Claude de Tourreil Memorial Award for Lifetime Achievement in Electrical Insulators.

SYNOPSIS

Silicone coatings to mitigate contamination problems on insulators have been used at substations for decades and more recentlly on a large scale on overhead lines as well. Over time, coating line insulators has moved progressively from application in the field to a more consistent process whereby insulators are coated in an industrial facility to take advantage of relatively clean and better controlled work environments. This presentation discusses two sets of parameters of interest to ensure long-term pollution mitigation performance. For one, selecting the most appropriate coating material is key to ensure long lasting hydrophobicity as well as a resistance to erosion under severe pollution and related corona activity. The second major point is the application process itself, which must be carefully considered to avoid accelerated degradation in pollution performance of coated insulators. CIGRE is currently working to provide a Technical Brochure that will offer guidelines for coatings and their applications through the activities of WG B2 69. Major insulator manufacturers can contribute to this process based on many years of experience monitoring and supplying coated insulators. For example, a variety of coating materials haved been screened at the Sediver Research Center in Saint Yorre. Moreover, continuous monitoring of coated insulators that have been installed across the globe has allowed validation of the choices made as part of the company's development programs while also continuously challenging findings from research as well as laboratory testing.

09:40

Ed Niedospial

Technical Sales Director – Transmission, MacLean Power Systems, United States

Longitudinal Loading: Fact Versus Myth

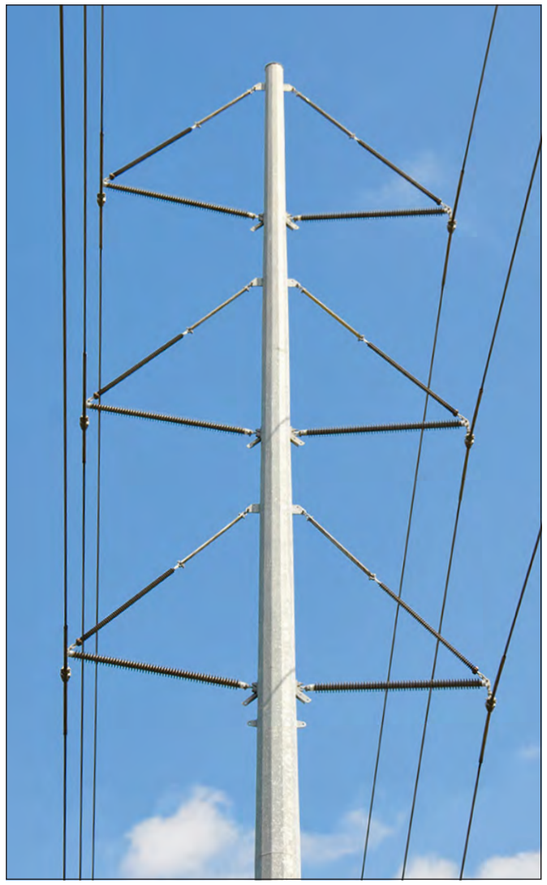
Mr. Niedospial holds a B.S. in Physics and Mathematics from Elmhurst College as well as an MBA in Project Management and Marketing from Keller Graduate School of Management at Devry University. He has worked for Maclean Power Systems since 1996 as part of the Technical Engineering Team where his focus is on high strength mechanical applications. This includes development of features for improved insulator performance and service life through product testing and validation. He is an active member of IEEE and other Technical Committees.

SYNOPSIS

Utilities have been moving more and more towards compact line designs for tangent structures. These typically use polymeric line post and braced post insulators due to the demand for lower project costs as well as growing limitations on land and right of way corridors. Line post and braced post insulators have been used for over 25 years and have performed well in this regard. Moreover, application of braced posts has now accelerated rapidly with new applications, such as at 345 kV, and this means that mechanical limitations are being extended to new levels. The key to meeting the requirements of these new applications is the need to better understand possible limitations as well as to establish safe working loads for each braced post design. This is typically accomplished using load curves, or interaction diagrams, to determine when an insulator is mechanically sound or when its limitations have been exceeded. Moreover, nothing complicates the design process more than longitudinal loads. This presentation aims to explore the 'Facts' and the 'Myths' pertaining to longitudinal loads.

10:05

Coffee Break & Visit to Exhibition



PLENARY SESSION: CANYON CONFERENCE ROOM Monday, Oct. 21 10:50 to 12:05

10:50

A.J. (Tony) Carreira

President, K-Line Insulators, Canada

Self-Cleaning Properties of Injection Molded Super-Hydrophobic Silicone Rubber for HV Insulators

Mr. Carreira received his Bachelor of Applied Science in Electrical Engineering from the University of Waterloo. Prior to that he worked at Ontario Hydro (now Hydro One) in areas encompassing distribution and transmission design, planning, construction and maintenance. He is a member of CIGRE, CSA, CEA and a Senior Member of IEEE. He has chaired the IEEE TF 15.09.04.01 "Guidelines for the In-service Classification of NCI Damage" as well as ESMOL TF on IEEE Std 957 "Guide for Cleaning Insulators". He has also been appointed an Associate Expert of WG 32 and an Associate Member of B2-AG-06. In addition, he sits on various committees, working groups and task forces within these organizations. Mr. Carreira is past recipient of the Claude de Tourreil Memorial Award for Lifetime Achievement in the Field of Insulators.

SYNOPSIS

Both electrical and mechanical issues have been reported as a result of pollution deposition on the surface of outdoor high voltage insulators. Although pollution accumulation is most severe in coastal areas, deserts, industrial regions and highly polluted cities, surfaces of insulators inevitably become contaminated after being operated for several years. When contaminated surfaces are exposed to wetting, the dissolved pollution creates a conductive layer, followed by dry-band arcing that can have pronounced impact on insulator pollution flashover. Hence, performance of insulation materials in polluted service areas must be addressed and the problem of flashover on the contaminated insulator surfaces needs to be resolved. High temperature vulcanized silicone insulators are known for their exceptional hydrophobic properties. Due to this hydrophobicity, water droplets stand separately over the surface and do not form a continuous film. Despite the excellent hydrophobic properties of HTV silicone insulators, the opportunity to further improve pollution flashover performance is clearly advantageous. This paper and presentation explains how super-hydrophobic surfaces that offer a water contact angle >150° and sliding angle <10° are attracting growing attention for applications that require anti-corrosive, ice-phobic, bio-fouling resistant, non-wetting and self-cleaning surfaces.

11:15

Florent Giraudet

Business Development Manager, Siemens, Germany

Benefits of Line Surge Arrester Application & Advantages of Externally Gapped Line Arresters

Mr. Giraudet received a Dipl.-Ing. Degree in Industrial and Electrical Engineering from CESI in Lyon, France in 2010. He worked 3 years for Siemens Grenoble where his focus was mainly on retrofit activities of GIS & AIS switchgear. He later joined Siemens AG, Germany as Application Engineer for surge arrester technologies and is currently responsible for business development of overhead line solutions that include different applications of transmission line arresters as well as polymeric insulators.

SYNOPSIS

Application of line surge arresters (LSAs) is a cost-effective means to achieve improved performance of overhead transmission lines by reducing outages due to lightning activity and poor grounding. Generally, LSAs are installed as a retrofit, in situations where other mitigation measures have not brought the improvements desired. Yet apart from improving lightning performance, they also offer additional benefits. Some users, for example, apply this technology to limit safety risk to the public, to control switching surge in order to optimize structures, to reduce clearances, to achieve line uprating and compaction and to assist in live-line work. Even though implementation of the externally gapped type line arrester (EGLA) allows outstanding results with minimal investment, this device is still realizing limited growth. Part of the reason is that users underestimate the benefits, even when facing issues with the alternative of non-gapped line arresters. Application of EGLAs not only improves performance of a power system but also lowers cost of construction and maintenance and savings become even greater if they are considered during the design stage. This paper and presentation offers technical knowledge, experience, customer feedback and latest innovations for compact and cost-efficient lightning-proof transmission lines.

11:40

Patrick Maloney

Chief Engineer, PPC Insulators, United States

Porcelain Insulators Under Cyclic Loading

Mr. Maloney holds a BS ME degree from Purdue University and has worked for PPC Insulators for the past 19 years, coordinating product testing, quality and application engineering. He is active in American Standards Committees, including NEMA and C29 Insulator Working Groups.

SYNOPSIS

Porcelain insulators have been used in electrical systems for over 120 years but designs have changed as these became proportionately greater in height with increased voltage requirements. Early station posts were comprised of stackable top-threaded caps and bottom pins with a flange but this design was vulnerable to bending loads due to the fragile porcelain being outside the steel pin. The soild core station post comprised of externally attached cast caps was therefore introduced in the 1960s. This paper and presentation explores the effects of repeated loading of such insulators. Typical ANSI and IEC mechanical testing differs greatly from the loading characteristics actually experienced in the field, e.g. laboratory testing consists of relatively slow loads over a 90s window whereas field loading is generally cyclic or static. Moreover, solid core porcelain insulators are comprised of several components, including the porcelain body, the cast iron end fittings and Portland cement grout. Each has a different reaction to loading.

PLENARY SESSION: CANYON CONFERENCE ROOM Monday, Oct. 21 12:05 to 14:00

12:05

Andrei Szabo

Marketing Manager, Wacker Chemie, Germany

Silicones In T & D: Advantages of This Versatile Material

Mr. Szabo received his M.Sc. in Electrical Engineering from the University of Oradea and his M.B.A. from the Budapest University of Technology and Economics. After several years spent at a leading chipmaker, he joined Wacker Chemie in 2005 and has since been fulfilling Sales and Marketing positions related to silicone rubber materials. In 2014, he was appointed Marketing Manager for Energy Applications in the Rubber Solutions Business Team at Wacker Silicones.

SYNOPSIS

Silicone polymers are a class of versatile inorganic materials suitable for the needs of a broad variety of industries and whose unique properties perfectly fit requirements in the T&D industry. Indeed, silicone rubbers, fluids and gels are increasingly used in power industry applications that pose different challenges for materials in regard to processing method as well as mechanical and electrical characteristics. Beneficial properties offered include hydrophobicity and hydrophobicity transfer, less or no need for maintenance, light weight of finished parts, resistance to weathering, ozone and radiation, flame retardant properties, high arcing, tracking and thermal resistance and excellent dielectric properties. Among the components that benefit from these properties are rod and hollow core composite insulators and arresters for medium, high and ultra high voltages, RTV-coated porcelain and glass insulators as well as high-tech cable accessories and fire safe cables. This paper and presentation reviews what has been learned from 100 years of experience as a manufacturer serving the needs of the T&D community with a growing portfolio of silicone solutions for reliable power supply.

12:30

Benjamin Baum

Development Engineer, Digitalization, DNV GL Energy, The Netherlands

Experience Testing Digital T&D Equipment

Mr. Baum received his diploma and doctoral degree in electrical power engineering from the Technische Universität Darmstadt, Germany. Until 2016, his research work was focosed on the development of test circuits to investigate late breakdown in high-voltage vacuum circuit breakers during capacitive load switching. During 2015/2016, he was guest researcher at Xi'an Jiaotong University, China, where he engaged in optimization of test circuits for medium voltage switchgear. He joined KEMA Laboratories in 2017 as Development Engineer in the field of digitalization of power systems and testing of switchgear and instrument transformers. He is a member of CIGRE WG A3.38 and IEC TC 38 WG 47.

SYNOPSIS

Digitalization is omnipresent these days and new technologies are arising rapidly. By contrast, while some digitalization exists in power generation, transport and distribution, it tends to be treated highly conservatively. Nevertheless, driven by the need to integrate volatile energy sources while also increasing efficiency and reliability, digital T&D equipment has been finding its way into substations. Items range from conventional instrument transformers featuring an additional A/D converter to new wireless, miniaturized temperature sensors. In parallel there is a trend to reduce footprint of substations and one possibility to achieve this is merging components. Part of this miniaturization is only possible with availability of digital equipment. While digital technologies have already been used for years on a station level, what has changed is expansion towards the process/bay level where instrument transformers, circuit breakers and protection relays are located. With such new digital equipment and operational methodologies, new dielectric stresses can be experienced, leading to need for a different approach when testing and evaluating such components. This paper and presentation reviews the type of digital equipment that has been tested in recent years. Special attention is given to traditional test procedures, such as lightning impulse, that have become more severe due to requirements from the digital side. Finally, projects are presented that demonstrate how digitalization provides both new opportunities and new challenges for insulating technologies.

12:55

Summary of Session/Questions

13:00

Lunch

PLENARY SESSION: CANYON CONFERENCE ROOM Monday, Oct. 21 14:00 to 14:50

Session Chairman: Aram Khalil-Pour, Director of Engineering & Asset Management, FortisBC, Canada

14:00

Alexander Zlakazov, Tatiana Symonova

Polymer Technology Director, Manager Polymer Technology, Global Insulator Group, Russia

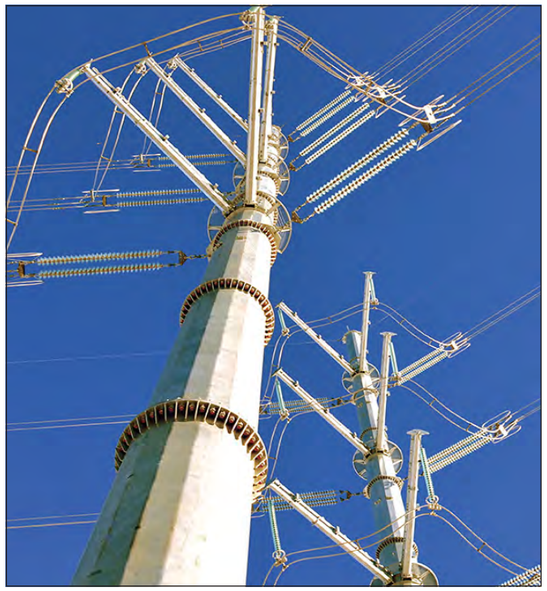
Polymeric Insulators: Problems & Ways to Improve Reliability & Service Life

Dr. Zlakazov completed his studies at Moscow Power Engineering University and began his career in 1975 as an engineer and later Senior Engineer and Head of the Engineering Department at the Special Design Bureau of the country's Power Grid. In 1992, he received his PhD on "Development of design techniques for power units of suspension insulators". Later, in 2000, he joined the High Voltage Research Institute as a Director. He has been with the Global Insulator Group since 2010, where his main responsibility has been to use years of practical experience to promote techniques for improved design and performance of polymeric insulators. He has more than 100 patents as well as 30 scientific articles and the technology he developed is already being successfully applied in the field.

Ms. Symonova received her Bachelor's Degree from Donbass Machinery Engineering Academy in 2004 and later her Master's Degree in Management from Kharkov State Economic University. Her work at Global Insulator Group includes: providing technical support to the sales team; overseeing technical project life cycles with emphasis on resource efficiency; developing statements of work, including estimates of time and cost; applying functional specifications to each project; collaborating with the design team to create accurate prototypes for customer approval; and meeting clients to refine and evaluate requirements, strategy and content.

SYNOPSIS

Polymeric insulators have advantages compared to traditional ceramic insulators and these have contributed to increasing use. However they can possess disadvantages as well, including insufficiently high reliability, relative complexity of visual inspection for internal breakdown and risk of mechanical fracture. Yet these weaknesses are not inherent drawbacks of polymers as a type of electrical insulation. Rather, they stem from weaknesses of any specific individual manufacturer and occur for reasons such as: deficiencies in production equipment or technology being applied; construction defects within insulators; low quality raw materials; or flaws in acceptance testing and quality control. While glass and porcelain insulators are produced by a relatively small number of long-term suppliers that have established good reputations, the comparative ease of manufacturing polymeric insulators has led to the rise of many suppliers, some of whose products are of questionable quality. This paper and presentation explains how a buyer can better distinguish between good and inferior units and analyzes typical types and causes of polymeric insulator failures based on service experience involving four million units installed on overhead lines from 110 to 750 kV.



14:25

Ruben Grund

Head, Corporate Technology, Pfisterer Holding, Germany

HV Cable Accessories: Enablers to Restore & Recover Cable Systems

Mr. Grund holds the Diploma of Electrical Engineer and started his career at Pfisterer as Manager for High Voltage Projects. In 2008, he became responsible for the high voltage pluggable cable accessories and since 2013 has been heading Research and Development as well as Product Management for the product portfolio covering medium and high voltage pluggable accessories as well as cable joints and terminations. In addition, since 2018 he is now also responsible for Corporate Technology.

SYNOPSIS

In recent years, the causes behind failures of cable systems have begun to shift. While incidence of material degradation, systematic defects and incorrect definitions and calculations has decreased, externally induced damage continues to be an issue. Damage caused by excavators continues due to lack of sufficient documentation, especially in the course of expanding cities into previously suburban areas. Repair of such damage is vital and failed components need to be replaced as quickly as possible to ensure service is restored. But this can prove a major challenge given that a range of variables needs to be taken into account. For example, is there sufficient excess length for the cable to be replaced or will an additional cable bridge be needed? What will be the requirements in regard to testing? This paper and presentation looks into the possibility to reduce the negative impact of these types of failure based on two case studies: the first sees utilization of a conventional joint for repair; the second discusses using a pluggable system, assuming the network in question is already flexible, meaning that transformers as well as switchgear are also equipped with pluggable systems. Moreover, this second case study is not limited only to incidence of repair but can also be applied for temporary set-up and bypassing of existing lines.

PLENARY SESSION: CANYON CONFERENCE ROOM Monday, Oct. 21 14:50 to 16:00

14:50

Dan Windmar

Vice President, STRI, Sweden

Cases of Non-Standardized Testing

Dr. Windmar received a Ph.D. degree in high voltage engineering from Uppsala University in Sweden. His professional experience includes extensive work in such areas as insulators (production, testing, materials), high power testing, high voltage testing and dielectric insulation. He has held several management positions at ABB and since 2009 has served as Vice President, Testing at STRI.

SYNOPSIS

Demand for high voltage testing has increased dramatically over the past few years and test objects now typically include HVDC valves, AC and DC cables, line insulators, cable accessories, wall and transformer bushings, optical instrument transformers and station post insulators for a variety of applications. Moreover, many of these requests coming both from manufacturers of high voltage equipment and from transmission system operators have highly specific requirements. Often, these involve non-standardized tests driven either by individual user requirements, such as specific environment and system, or the growing perception that several current standards may need to be updated to reflect more stringent service conditions. At the same time, power systems are becoming more complex and high voltage equipment installed in a network is increasingly exposed to conditions not covered by typical design and type tests. Conducting these types of non-standard tests place demanding requirements not only on test equipment but also on the competence of test engineers. For example, test equipment needs to be made more flexible and easier to move during installation, even though large and heavy. There is also increased test duration while many of the new test methods come with more stringent requirements. This paper and presentation provides examples of different types of non-standardized tests being encountered in recent years.

15:15

Robert Ross

Professor, Performance of HV Energy Systems, Technical University of Delft, The Netherlands

Asset Replacement Strategies in Ageing Grids: Periodic Maintenance vs. Condition Based

Professor Ross is Director at the Institute for Science & Development, Ede and Professor at HAN University of Applied Sciences. He is also Asset Management Research Strategist for the transmission grid operator in the Netherlands and parts of Germany. He worked in the past at KEMA in the area of reliability and post-failure forensic investigation and his present fields of specialization include reliability statistics, electro-technical materials, sustainable technology and superconductivity. He was granted a SenterNovem Annual Award, nominated Best Researcher by the World Technology Network and wrote 'Reliability Analysis for Asset Management of Electric Power Grids' based on his extensive experience with power utilities.

SYNOPSIS

In the 19th century, power supply began as separate installations and the first multi-client grids appeared by the early 1880s. By the 20th century, however, electricity grids in Europe and elsewhere had become state-owned and were regarded as a public service at almost whatever cost required. These grids tended to be overdesigned, over-serviced and often deployed in a national context. By the end of the 1990s, however, energy came to be recognized as strategic but no longer at any cost since energy became a significant part of production costs that had to reflect international competition. Therefore, in addition to reliability, demand for cost-efficiency became a priority. Components and connections in a grid must meet the requirements of power supply but, since most assets wear due to mechanisms driven by temperature, electro-magnetic field, mechanical forces and ambient conditions, preventive and corrective maintenance actions are necessary. Ultimately replacement will be required. Costs, human resources, materials as well as planned outages together form efforts and risks for utilities. Not undertaking efforts also contributes to risk. As such, maintenance requires due consideration. This paper and presentation discusses alternative maintenance strategies as well as which conditions favor which approach. It leans on statistical techniques but, even when data is lacking, these principles still apply and can be used in planning to repair or replace assets.

15:40

Coffee Break & Visit to Exhibition

PLENARY SESSION: CANYON CONFERENCE ROOM Monday, Oct. 21 16:00 to 17:05

Session Chairman: Aram Khalil-Pour, Director of Engineering & Asset Management, FortisBC, Canada

16:00

Steve Aubertin

Managing Director, Goulden Reports, United Kingdom

Funding the Next Global T&D Investment Cycle 2020-2040: How Much It Will Cost

Mr. Aubertin specializes in market research and data collection for the electrical power industry. Reports on the world markets for T&D equipment, including HV insulators and bushings, have been issued for over 25 years.

SYNOPSIS

Global investment in transmission and distribution systems in 2019 was a little over $240 billion and by 2020 will have reached $250 billion. Estimated compound annual growth over the next 10 year period is expected to be 4.15% meaning that investment by 2030 will be some $386 billion (measured in 2019 US$). Total investment between 2020 and 2030 will be on the order of US$3.5 trillion and between 2030 and 2040 will total $4.7 trillion. These sums are so large as to equal to the entire GDP of Germany but growth will not be evenly distributed across the globe. Rather, the drivers in each region will vary according to local development cycles and grid development, enhancement, reinforcement, changes in generating facilities and new interconnections. Who will fund that investment is a major question. Among the most important aspects for the future will be how T&D development is organized and how investment spikes are smoothed out in order to provide a continuous stream of business for the manufacturing sector. The number of companies capable of supplying the equipment necessary to support future growth in the power industry has been declining for decades. The demand and supply equation will therefore have to be carefully managed to ensure future security of electricity supply. This paper and presentation examines these types of issues.

16:20

Masoud Farzaneh

Professor Emeritus, Université de Québec à Chicoutimi, Canada

Impact & Mitigation of Icing on Power Network Equipment

Professor Farzaneh is an IEEE Fellow, IET Fellow, EIC Fellow and CAE Fellow. A specialist in the effects of icing and pollution on power network equipment, he has been President of IEEE DEIS (2013), contributor to IEEE 1783, P1820 and author of 10 position papers related to insulator icing and pollution. He is Convenor of CIGRE WG B2.44, B2.29 and B2.69 as well as contributor to TB 179, TB 256, TB 291, TB 322, TB 438, TB 631 and TB 645. He has authored 700 technical papers, 3 books and chapter lead of 14 others. He has served as Professor at the University of Quebec in Chicoutimi, teaching courses related to power engineering, high-voltage and physics of discharges and is currently Editor-in-Chief of IET High Voltage Journal.

SYNOPSIS

Ice and snow accretion on power equipment such as conductors, ground wires and insulators are a concern to engineers in many regions The disruptive effects result mainly from excessive ice and snow accumulation, combined with wind forces as well as the subsequent jumping of cables and conductors following sudden ice shedding. Other potential sources of failure are dynamic phenomena such as galloping, often involving extensive dynamic forces. Electrical flashover along iced or snow-covered insulators is another problem affecting reliability of overhead lines and outdoor substations. Substantial collaborative R&D projects between academia and industry have advanced the knowledge in many areas of atmospheric icing and lead to improvements in overhead power network design, construction and operation. However, despite this progress, knowledge on this complex and unpredictable phenomenon is still lacking - all the more so when considering increasing extreme meteorological events from climate change. Continued growth in energy consumption and the need to upgrade existing networks, and construct more reliable transmission lines together call for innovative solutions to icing issues. This presentation will review impact of icing on conductors, ground wires and outdoor insulators as well as mitigation options to improve their reliability under such conditions.

16:45

Alberto Pigini

T&D Consultant, Italy

Optimal Insulator Type & Dimensioning in Harsh Service Environments

Mr. Pigini received a Doctoral Degree in Electrical Engineering from the University of Milan. Heworked for more than 35 years at CESI, first as a researcher, then as Research Manager and finallyas Division Director, responsible for a number of aspects of HV electrical system, includingenvironmental impact and generation. He is a Distinguished Member of CIGRE, Fellow of IEEE andactive in various WG and Committees at these bodies. Recipient of the 2015 Claude de TourreilMemorial Award for Lifetime Achievement in the Field of Electrical Insulators, he acts as consultant tointernational clients and has also served as expert Contributor to INMR for more than 10 years.

SYNOPSIS

Harsh service environments such as deserts and coastal areas are highly demanding from the viewpoint of insulation selection and dimensioning. After analyzing general design criteria to be adopted in such environments, alternatives are analyzed and typically sub-divided into two main categories: non hydrophobic transfer material insulators, i.e. porcelain and glass, and HTM insulators, which include RTV-coated and composite types. Specifications for selecting insulators with regards to pollution in AC are already available and work is in progress towards their revision. These specifications are simplified to make their application easy yet they can offer sufficient information for preliminary design in cases where pollution does not determine insulator design, e.g. design of insulators for EHV and UHV AC systems with only moderate pollution constraints and where design and arcing distance are dominated by performance requirements under switching overvoltage. This paper and presentation explains why the situation is much different when pollution dominates design. In this case, it is fundamental to select the proper insulator type and establish an accurate design under pollution since this will have great impact on overall system cost - either in terms of high investment costs or excessive operating costs.

17:05

Dennis Schlender

Principal, DBS Energy Services, Canada

Practical Field Inspection & Condition Assessment of Transmission Insulators

Mr. Schlender has offered high voltage professional consulting and engineering services across Canada for almost three decades, covering issues from fibre optics to 500 kV. He previously held positions at TransAlta Utilities, West Kootenay Power and Aquila Networks Canada, with responsibilities in Senior Management, Project Management, Engineering, Line Construction & Maintenance, Substations, Telecommunications, Metering and Material Services. Over the last 16 years he has been Principal at DBS Energy Services, a firm providing consulting services in transmission design, standards development, line rehabilitation, fiber optic communication, asset management, maintenance, submarine cable installation, estimating & planning and owner engineering. He has also been involved in safety, life cycle evaluations, training and facility inspections.

SYNOPSIS

Most utilities and large industrials with transmission networks have varying degrees of Condition Assessment Programs. Reviewing the condition of insulation constitutes an important part of such inspections since it is key to the reliable operation of the system. There are a range of options available to complete a detailed review of insulation performance, including removing samples from a line and testing them in a laboratory, infrared thermal imaging, daylight corona inspection and visual inspection. Since budget limitations invariably influence the extent of testing that will take place, coordinating and consolidating what goes into a condition assessment program can help reduce costs and ensure more effective use of capital. During any inspection and life assessment of insulation, it is important to understand what to watch for, how and where to look for signs of damage and why any damage may be starting. This paper and presentation provides a practical approach to visual field inspection and related condition assessment, as needed for various insulation components. Such an approach can help minimize the financial and management burdens related to completing condition assessments in a timely and efficient manner. While this approach does not eliminate possible need for more rigorous additional testing and inspection, it can be used to help prioritize its implementation.

17:25

Jan Lachman

Director, EGU-HV Laboratory, Czech Republic

Lessons from 25 Years' Experience Testing Polymeric Insulators

Dr. Lachman graduated from the Czech Technical University in Prague, Faculty of Electrical Engineering where he later received his PhD degree. After graduation, he joined EGU-HV Laboratory as a test engineer. He has also had experience as a design engineer when working abroad. He is active in IEC/CIGRE Working Groups and represents the Czech Republic in SC D1.

SYNOPSIS

Several decades of application of polymeric insulators to overhead lines worldwide has allowed the opportunity to accurately assess service performance as well as test experience for this technology. Before installation, insulator quality is always verified through design as well as type testing. Moreover, manufacturers are responsible to perform required sample and routine tests as well. Still, in many cases purchasers require additional acceptance tests and independent laboratories have for years been offering a range of design, type and special tests conducted on polymeric insulators. Such laboratory test experience has demonstrated that polymeric insulators generally fail during interface testing and emphasis is therefore being devoted to interfacial issues that are not being well addressed by the current standards. For example, although IEC 62217 specifies tests on interfaces to verify quality, service as well as laboratory test experience has shown that composite insulators with poor adhesion of housing to core rod sometimes still pass. As such, the standard is now in the process of being revised by IEC TC 36/MT 19. The goal is to specify stricter criteria to ensure improved capability to detect insulators with defective interfaces during testing. This presentation summarizes long-term service experience with polymeric insulators on the transmission grid in the Czech Republic and discusses key aspects of what has been learned from design and type testing them over more than 25 years.

17:45

Michele de Nigris

Director, Sustainable Development & Energy Sources, Ricerca sul Sistema Energetico (RSE), Italy

Research & Experience with Coatings on Glass Insulators & Conductors

Mr. de Nigris received his degree in Electric Engineering from the University of Genoa in 1983 and now serves as Director of Sustainable Development & Energy Sources Department at RSE. He was elected Chairman, IEA Technology Collaboration Program ISGAN (International Smart Grids Action Network) at the first Executive Committee Meeting in Seoul. An international leader in the study, research and testing of electrical components for more than 30 years, he represents Italy at international forums such as the former European Electricity Grids Initiative and the IEA End-Use Working Party. He is author or co-author of nearly 100 scientific papers and has been coordinator of the GRID+ project.

SYNOPSIS

Environmental stresses on overhead lines can heavily impact overall system performance. For example, high levels of surface contamination due to salt deposits and other types of pollutants can cause surface discharges on insulators with consequent possible service interruptions. Severe pollution conditions are detected in several regions of the globe and, if anything, only seem to be occurring with increasing frequency and intensity due to progressive climate change. For this reason, pollution considerations have great impact on long-term power system strategy, overhead line design, maintenance planning, daily operation and, eventually, emergency and resilience management. The first part of this presentation is dedicated to application of RTV silicone coatings to limit the effects of pollution on line insulators. Two alternative approaches are addressed: partial coating of insulators to enhance pollution performance through hydrophobic properties that inhibit formation of a continuous wet pollution layer; and super-hydrophilic coatings and treatments to facilitate permanent natural insulator washing, thereby impeding build-up of a pollution layer. The second part of the presentation is devoted to line conductors and ground wires and their behaviour under conditions of wet snow conditions. Different solutions to mitigate formation of snow sleeves are addressed through identification of the most influential parameters and materials based on tests conducted both in the laboratory and in the field.

18:05

Lars Jonsson

Senior Specialist, ABB Components

Impact of Biofouling on Performance of Outdoor Bushing Insulation

Mr. Jonsson has been closely involved with bushings and other transformer components as well as their applications for 30 years. His experience includes design, product development and a large number of field investigations. He is Chairman of IEC TC 36A - Insulated Bushings and he has presented many technical papers on bushings and tap changers at major international conferences such as CIGRE, IEEE, INMR WORLD CONGRESS, CEPSI and TechCon.

SYNOPSIS

There is growing interest among asset managers worldwide in the potential impact of biofilm formation on HV outdoor insulation, whether ceramic or polymeric. The most commonly reported effect is reduction in hydrophobicity, which also reduces wet flashover voltage. While this reduction is generally higher for ceramic insulators than for polymeric insulators, there are several ways microorganisms can influence the structure and function of the synthetic polymers used in composite insulators, including bio-fouling, degradation of leaching components, corrosion, hydration, penetration and discoloration. Moreover, a surface does not even need to support growth to be affected since the mere presence of biofilm risks interfering with material functionality. Results from previous studies suggest that silicone rubber is highly resistant to corrosion induced by microorganisms. Nevertheless, it may contain organisms that produce pigments causing serious discoloration that is not removable by cleaning. This paper and presentation reviews findings of a recent project where 20 different material samples were studied. The surface of all specimens was inoculated with a mixed suspension of different fungi and incubated under optimal conditions. After the test period, hydrophobicity and hydrophobicity recovery after cleaning were both evaluated.

18:25

Summary / Questions & Answers

18:30

Reception in Exhibition Area

(until 20:00)

PLENARY SESSION: CANYON CONFERENCE ROOM

Tuesday, Oct. 22
08:00 to 09:15
Session Chairman:
Igor Gutman, Sr. Expert, Independent Insulation Group, Sweden

08:00

Iryani Mohamed Rawi

Head, Product Certification, Research Div., Tenaga Nasional Berhad, Malaysia

Quality Evaluation of MV/HV Network Components at TNB: Past Experience with Failures & Lessons Learned

Dr. Rawi (P.Eng) received her bachelor degree in Electrical Engineering from Universiti Teknologi Malaysia, Johor in 2002. She was an electrical engineer in the Engineering Department of Tenaga Nasional Berhad Transmission Division, responsible for the design, testing and specification of HV transmission lines equipment. Her main interest includes Transmission and Distribution HV switchgear, overhead lines performance, design and application of surge arresters and environmental impact on power system performance and renewable energy.

SYNOPSIS

Tenaga Nasional Berhad (TNB) is Malaysia's largest electricity supplier and also the largest publicly listed power company in Southeast Asia, serving of over 8.4 million customers and with core activities in generation, transmission and distribution. Quality as well as product certification and inspection are seen as critical to ensure products are always fit-for-use. In this regard and to ensure continuous monitoring of the quality of new and existing assets, a subsidiary was established under TNB Labs with the mission to conduct rigorous certification and approvals for both critical and less-critical products. For example, after certifying any product, a quality audit is conducted annually at the manufacturer's location for surveillance and once every 3-years for re-certification. Product inspection and factory acceptance testing is also conducted to ensure every batch delivered meets required specifications and standards. This paper and presentation discusses the process involved under product certification conducted by TNB Labs. Process flow is explained, showing three major activities: technical evaluation, field trial and verification of quality issues. Case studies and examples of recent failures and product rejections during field trials and factory inspections are also presented, together with lessons learned in ensuring no recurrence in the future. Finally, statistics are shown to represent the product categories with the most common failure modes.

08:25

Daniel McCullough

Principal Engineer, San Diego Gas & Electric, United States

Optimizing Insulator Selection with Regard to Performance, Installation, Stocking & Maintenance

Mr. McCullough received his BS Degree in Electrical Engineering from San Diego State University in San Diego, California. His current position is in the Apparatus Group of Substation Engineering where he is responsible for specifying and ordering porcelain and polymer insulators for substation applications. He has been involved with development of substation plans and designs, protection systems, cost estimating, equipment specifications, technical support for field personnel, engineering studies, materials, and electric system operations during his career at SDG&E.

SYNOPSIS

Insulators may appear relatively simple in design but can actually prove complex in terms of practical application. In fact, choosing proper insulators for the application is one of the most commonly overlooked design considerations. For example, factors relevant when selecting porcelain post insulators include BIL, cantilever strength, tapered or uniform stacks, shed diameter, vertical or under hung, end cap diameter and standard versus semi-conducting glaze. Moreover, selection from among all the possible different polymeric post and suspension insulator types can be daunting. Some of the variables to consider are rod diameter, shed pattern, number of sheds, dry arc distance, end fittings as well as corona ring diameter and quantity. Moreover, all these characteristics have to be optimized to find the best insulator for each voltage class that will perform well in each of the four different climatic zones within San Diego County. This paper and presentation reviews key factors in proper selection, handling and maintenance of insulators for substation applications. These include: contamination performance; minimizing insulator selection for each voltage class; minimizing types of insulators for each installation; ensuring insulators are designed and installed properly for the application; establishing controlled storage to ensure insulator inventory is always current and available to construction and maintenance personnel.

08:50

Samuel Arturo Asto Soto

Transmission Line Coordinator, Red de Energía, Peru

Performance of RTV-Coated Toughened Glass Insulators in Zones of High Contamination: Peruvian Experience

Mr. Asto Soto is an Electrical Engineer graduated in 2000 from the National University of the Center of Peru (UNCP 2000) with further studies in Masters of Business Administration at the University Ricardo Palma. He has detailed experience in management, planning and supervision of electrical maintenance and projects in mining, concentrating plants and high voltage electrical transmission systems. He is a member of the Working Group with Tension of the Regional Energy Integration Commission (TcT CIER). His work experience also includes high voltage maintenance in transmission lines, hot line work, corrosion protection in transmission electrical systems and insulation.

SYNOPSIS

To reduce maintenance costs from frequent washing of insulators on transmission lines in coastal areas with heavy salt pollution, high humidity and scarce rainfall, glass and porcelain insulators were replaced by 12,000 polymeric units between 1996 and 2004. However, after only a few years, 17 failures occurred due to breakage of the core of insulators installed in extreme contamination areas. After investigation, it was decided to replace polymeric insulators installed on coastal transmission lines by RTV silicone coated glass insulators. The coating would allow maintaining reliability of the line, eliminate failures due to core fracture and result in savings by significantly reducing fines as well as need for frequent cleaning. Regarding frequency of replacement or change of coated insulators, this was initially set at 10 years based on manufacturer recommendation and experience elsewhere. However, since 2015, there were cases of failure of the coated insulation, causing disconnection of the lines. This resulted in revision of the strategy and start of a program of cleaning such insulators in areas of extreme pollution once every 4 years and once every 6 years in areas of high pollution. Subsequent experience showed that, in areas of extra high pollution, coated glass insulators did not recover their hydrophobic properties after cleaning, leading to the need for cleaning in a shorter time frame than before. This paper and presentation reviews experience with regard to application of RTV coated glass insulators on transmission lines along the coastline of Peru. It discusses performance and outlines decisions in regard to the best replacement strategy as well as proper maintenance needs.

09:15

Glenn Stapleton,

Powerlink Queensland, Australia

Tony Gillespie

Gillespie Power, Australia

Lessons from 20 Years' Experience with Composite Insulators on Transmission Lines

Mr. Stapleton has more than two decades of experience at Powerlink Queensland – the transmission network owner, operator and maintainer in Queensland, Australia. During this time, he has held a number of senior engineering roles across a portfolio of transmission projects, with primary responsibilities including project electrical design and transmission line construction management. Presently, he is responsible for electrical design standards, including overhead and underground cable primary procurement standards, including those for transmission line insulators. He is a Fellow of Engineers Australia and presently chairs the Standards Australia Committee EL-010 Overhead Lines. He also serves a post-graduate lecturing role at Queensland University of Technology, specializing in overhead and underground cable ratings.

Mr. Gillespie has 30 years' experience with Powerlink – the transmission utility in Queens-land, Australia – and is now an independent consultant specializing in insulation, lightning, earthing and transmission lines. His experience as line designer includes 1400 km of 110 to 330 kV HVAC transmission lines. He serves on National Committees, is a Fellow of Engineers Aus-tralia and member of CIGRE, IEEE and IET. He has written numerous technical papers, is co-author of several EPRI books and serves part time as lecturer on transmission line electrical design at Queensland University of Technology.

SYNOPSIS

Powerlink is a government-owned network service provider that builds, owns and operates the extensive transmission network in Queensland, Australia, where some 30,000 non-ceramic insulators (NCIs) are in service and operate at 110, 132, 275 and 330 kV. This experience began about 20 years ago, when prevailing thinking and drivers were to install NCIs in large quantities on transmission lines. Back then, their service life was estimated to be 25 years in relatively clean environments, although insulators on certain lines were damaged shortly after installation due to bird pecking and chewing. Over the years, field inspection and laboratory testing were performed on NCIs removed from service to monitor for possible degradation over time. This testing was intended to estimate end-of-life so that replacements could be prioritized, scheduled and resourced for replacement before failure. An important consideration in this process was retaining the option to safely undertake replacement using live working methods. Over time, technical drivers and management strategy changed such that asset managers are now considering replacement strategies for whole NCI populations as well as managing them using fleet management approaches. This paper and presentation discusses Powerlink's experience across the whole life cycle of 3rd generation NCIs that are approaching projected end of life. Desktop models, with calibration using field inspection and laboratory investigation, are also presented as is a case study using three sub-populations of NCIs on transmission lines.

09:40

Karl Emil Steenholt-Eliasson

Power Lines Engineer, Energinet, Denmark

Transmission Structures for Reduced Cost & Increased Public Acceptance

Mr. Steenholt-Eliasson received a B.Sc. degree in 2015 before starting his career at Energinet's Power Lines Department, where he has been involved in various retro-fit projects. In parallel, he has conducted a strategic cost optimization project for overhead lines where the goal has been to reduce cost of new towers while keeping a focus on visual aspect of the final design. This has resulted in an optimized version of the Eagle Tower as well as a new even more cost-effective portfolio of towers to be used on future 400 kV lines across Denmark.

SYNOPSIS

Denmark plans to have a 100% emission free energy sector by 2050 and all electricity production must qualify as 'environmentally friendly' by 2030. As a result, a major effort is underway in more wind power production, both onshore and offshore. This policy has also resulted in a total re-think of all power infrastructure and how to cope with an ever-growing share of basically unforeseeable production input. One of the strategic goals of the country's TSO, Energinet, is therefore to become an Energy Hub through more interconnections to other countries: during periods of calm winds, energy can be imported while, when there is a large wind production, excess power can be exported. But such new interconnectors will place huge requirements on transmission grids given the amounts of power that will need to be transferred. To ensure enough grid capacity, building new overhead lines is required and indeed two new OHLs are in planning although these face public opposition. To help overcome such resistance in the past, the latest transmission line in Denmark was established using a new design of towers and the project was deemed a success. The new towers, however, came with increased cost compared to traditional lattice towers even though the only real alternative would have been underground cables. This paper and presentation discusses a new project aimed at development of special transmission structures using an updated tower design where the focus is not only on aesthetics but also on cost.

10:05
Coffee Break & Visit to Exhibition

PLENARY SESSION: CANYON CONFERENCE ROOM Tuesday, Oct. 22 11:00 to 12:10

11:00

John Schonewolf

Design Engineering Supervisor, Hubbell Power Systems, United States

Braced Line Post Testing Considerations

Mr. Schonewolf received his B.S. in Mechanical Engineering from Lehigh University in 2004. He has worked in product design, manufacturing and leadership positions over a 15-year engineering career and been involved professionally with insulators at Hubbell Power Systems for two years, leading the Insulator Design Engineering Team.

SYNOPSIS

Braced line posts (BLP) have become widely accepted to create compact high and extra-high voltage transmission lines. This design includes a combination of two distinctly different types of insulators - a horizontal line post and a suspension insulator - in a triangular configuration with the supporting structure acting as vertical member. There are no standardized test protocols for braced line post assemblies and it is therefore usually left to the manufacturer to determine the most appropriate means of testing. From a mechanical standpoint, there is no firm definition for onset of elastic buckling of the line post member and testing for this is time-consuming. As such, one area for exploration is using Finite Element Analysis (FEA) to design the BLP assembly. A similar issue exists involves electrical testing of BLPs. While test standards exist for the suspension and line post insulator as individual units, no standard exists for the combined assembly. Should electrical testing be performed on the overall assembly? Since electrical flashover tests represent averages, if the suspension and post had equal flashover values, would the value of the assembly be lower than that of the individual units? Or, should the individual units be sized to assure sufficiently different flashover values to eliminate statistical flashover reduction? This paper and presentation details comparisons of actual mechanical test data for a BLP design with analytical results obtained through FEA. It also explores the effect on electrical values for line post and suspension insulators within the BLP assembly with unequal and approximately equal strike distances.

11:20

Milan Radosavljevic

Sr. Engineer & Asset Manager, Svenska Kraftnät, Sweden

Selection of Optimal Outdoor Insulation for Refurbishment of 400 kV Substation Under Coastal Pollution

Mr. Radosavljevic obtained his Masters of Science in Electrical Engineering from the University of Belgrade and, after working in different positions in the former Yugoslavia, has spent the past 15 years within the Swedish power industry. He worked as a consultant both at SwedPower and at Vattenfall Power Consultants before joining Svenska Kraftnät in 2011. His broad industry experience covers more than two decades and has made him an expert in both substations and cables, covering all aspects from design to installation to commissioning to refurbishment. This also includes writing technical guidelines for components such as post insulators, insulator sets, surge arresters and connectors.

SYNOPSIS

Substations and overhead lines located near coastal areas can be affected by high levels of maritime pollution. For example, two particularly exposed Swedish substations, constructed in 1970s, are equipped with relatively short porcelain insulators - the only option available at time of construction. As such, there soon evolved the need to provide better pollution performance such that installation of live line washing equipment became mandatory. When it was recently decided to refurbish these substations, engineers wanted to forego this type of expensive washing system that was not operating fail-free - sometimes activating washing more often than needed while other times activating it too late. Also, there were cases where the washing system actually initiated flashovers instead of preventing them. This paper and presentation describes the historical background and why the decision was made to select RTV-coatings for such applications in spite of the fact that the technical policy in Sweden is now to use superior pollution performing composite insulated apparatus at all new substations and also for refurbishment of existing substations. Moreover, a non-standard matrix of tests intended to help identify the optimal RTV-coating material is presented together with test results.

11:45

Fabio Bologna

Sr. Program Manager, Electric Power Research Institute (EPRI), United States

Development of Small-Scale Test to Verify Corona Performance of Polymeric Insulators

Mr. Bologna joined EPRI in Dec. 2006 and is now Senior Program Manager of Transmission and Substations, based in Charlotte, North Carolina. His duties cover the areas of overhead and underground lines as well as substations and his main fields of interest include inspection and assessment, lightning & grounding as well as insulators.

SYNOPSIS

Polymeric transmission line insulators mechanically support the conductor above ground and electrically the conductor from the grounded structure and if they fail either a transmission outage results. Most reported failures of polymeric suspension insulators are from brittle fracture or flashunder, with both occurring if moisture ingresses past the rubber weathershed or end fitting sealant and contacts the fiber reinforced plastic core. Such in-service damage is usually associated with electrical stressors such as leakage current, corona and flashover while other types of damage can be due to handling and in some cases wildlife. EPRI performed full-scale multi-stress accelerated ageing on polymeric insulators to understand modes of weathershed degradation and results have correlated with failures observed in the field. Primary stressors are corona discharges from end fittings as well as from water drops. While it is recommended to keep E-field magnitudes below corona discharge extinction levels, discharges still occur due to uncontrollable factors and, in these cases, the weathershed must be able to endure them. Testing insulators under full-scale conditions is costly, time-consuming and difficult to use during selection and procurement. As such, representative, repeatable and cost effective tests to evaluate performance need to be developed to enable selecting and procuring polymeric insulators that provide optimum life expectancy and performance. This paper and presentation discusses a small-scale, corona-ageing test on an insulator sheath that meets this need and can be included in utility specifications.

PLENARY SESSION: CANYON CONFERENCE ROOM Tuesday, Oct. 22 12:10 to 14:00

12:10

Christian Pons

Research Engineer, EDF Lab les Renardières, France

Operating a Test Station in a Polluted Environment

Mr. Pons joined the Electrical Equipment Laboratory at EDF Lab Les Renardières in 2001, where he has worked in the fields of software data processing as well as metrology management for high voltage and high current equipment. His current position is Research Engineer on external insulation. For more than a decade now, he has dealt with studies and tests on insulators for both overhead line and substation applications, with the main research focus being on insulator performance, behavior under pollution, monitoring and diagnostics. He is a member of IEC TC 36 'Insulators'.

SYNOPSIS

With a view to better understanding the impact of relatively high pollution on the performance of electrical insulation, Electricité de France R&D Department installed different pieces of equipment in the south of the country over 50 years ago. Located close to the seacoast as well as a heavy concentration of petrochemical complexes, the purpose of this test facility was to study the behavior and limits of a range of insulator devices. With growing interest in the results of these types of tests, the site expanded and capacity increased along with voltage levels available. While factories have been under pressure for years to reduce emissions, localized industrial pollutants can still reach significant levels , depending on atmospheric conditions. That is why this location is still particularly appropriate for a natural ageing testing station and also why the Martigues Test Station ranks today among the world's most important in terms of numbers of samples being tested. This paper and presentation offers an overview of the site's assessment tools dedicated to monitoring performance of grid components in a polluted environment.

12:35

Alison Meredith

Engineering Manager (Electric), FortisBC, Canada

Replacing Insulators on Ageing Long Span Lake Crossing

Ms. Meredith holds a Bachelors Degree in Electrical Engineering from the University of Newcastle in Australia. She worked for Energy Australia before emigrating to Canada and for the past 11 years has worked at FortisBC – a utility in south-central British Columbia, where she leads the Transmission Lines Engineering Group. Her responsibilities include over-sight of transmission line design and refurbishment, fiber optic projects, transmission planning studies and estimates, engineering investigations, providing input to development of internal transmission standards as well as engineering support to Operations and System Control. She also coordinates the FortisBC Engineers in Training (EIT) program.

SYNOPSIS

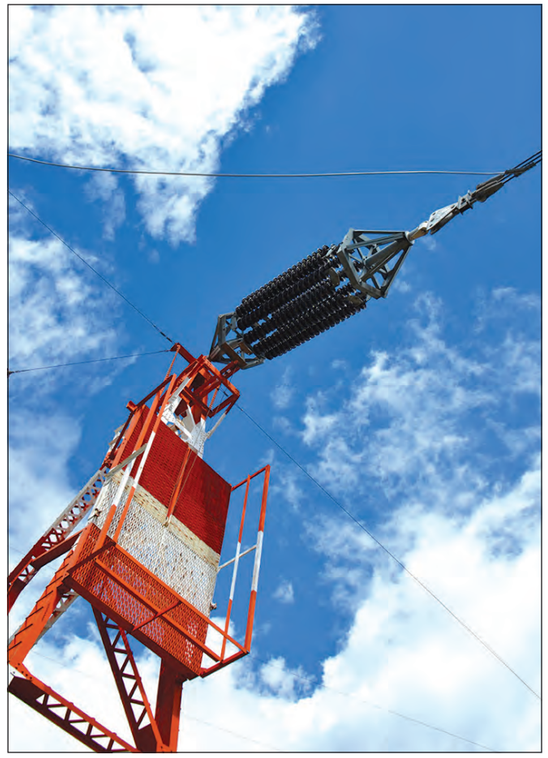
The Kootenay Lake Crossing still ranks among the world's remarkable transmission line projects. Commissioned in 1952 and designed for 170 kV, it was constructed to supply power to nearby mines. In spite of challenges that came with erecting huge towers in the steep forested terrain, a 3.4 km span across the lake – a record at the time – was deemed preferable to building 120 kilometers of line to go around the lake. Among the project's notable engineering achievements was the dead insulator arrangement that still carries the typical 75,000 to 79,000 lb. load of the high tensile steel wire used for each phase. Maximum design load for the crossing under wind and winter conditions is 237,000 lbs. Composed of 6 double strings of 18 bells, each assembly contains a total of 216 x 25,000 lb. short-shank, tongue and clevis porcelain bells, connected in a pattern to reinforce strength. One of the challenges has been monitoring the condition of these critical insulator assemblies, where inspection has revealed signs of ongoing cement growth and cracking as well as cases of fracture between pin and hub. There has also been evidence of rotation of the porcelain body inside the cement of the iron cap in some bells. This presentation reviews the challenges and processes during maintenance work to identify and replace damaged insulators and also the marker balls on this long span crossing.

12:55

Summary of Session/Questions

13:00

Lunch



ARRESTER TECHNOLOGIES & APPLICATIONS PART 1: SONORAN 1 & 2 CONFERENCE ROOM

Tuesday, Oct. 22
10:40 to 12:05
Session Chairman: Jonathan Woodworth,
ArresterWorks, United States

10:40

Mazana Armstrong

Powertech Labs, Canada

Methodology & Mitigation of Lightning Induced Arcing to Pipeline Hazard

Dr. Armstrong holds a degree in Electrical Engineering from the University of Zagreb, Croatia as well as a Masters and PhD from the University of British Columbia. In her last role as Lead Engineer at BC Hydro Engineering, prior to joining Powertech Labs in 2019, she had responsibilities that included electrical aspects of the overhead transmission network, line design, operation and maintenance. A registered professional engineer in British Columbia, she is also a Senior Member of IEEE and participates in the development of BC Hydro, Canadian and IEEE standards as well as being an IEEE PES Distinguished Lecturer.

SYNOPSIS

In recent years, BC Hydro has been receiving requests from proponents of pipeline projects from 30 to 600 km long to both cross and run parallel with existing transmission lines rights-of-way. Running a new pipeline in an existing right-of-way is beneficial to the pipeline proponent since it maximizes limited space in urban areas, minimizes environmental impact and footprint and potentially eases negotiations with other stakeholders. However, co-location of pipelines with unshielded transmission lines requires advanced modeling techniques to characterize and limit the arcing hazard to pipelines that could follow any lightning strike. The overall safety hazard to a pipeline having a large number of towers in close proximity is many times higher than for a pipeline with a single crossing point along the transmission line. For this reason, there has been a need to carefully model the safety hazard associated with such proposed pipelines. BC Hydro's safety hazard assessment is done based on a probabilistic approach with the specific concentration of population, frequency of lightning as well as variations in soil resistivity and structural grounding relative to the location of the proposed pipeline. This paper and presentation describes details of this new methodology and how it has already been applied to several large pipeline projects in British Columbia, Canada.

11:10

Volker Hinrichsen

Professor, Technical University of Darmstadt, Germany

Arrester Technology Today: Lessons Learned & Developments to Watch

Dr. Hinrichsen worked with Siemens from 1989 to 2001, where he held the position of Director R&D of the Surge Arrester Division. Since 2001, he is full professor in highvoltage engineering at Technische Universität Darmstadt, Germany. He is a member of several Committees and Working Groups within IEC, IEEE, Cigré and VDE/DKE. He is Chairman of IEC TC37 (Surge Arresters) and Convenor of IEC TC37 MT4, responsible for all high-voltage arrester test standards. His most recent research activities in the field of surge arresters have been on energy handling capability and on optimization of external grading systems of UHV arresters.

SYNOPSIS

Gapless metal oxide (MO) arresters are relatively new devices with only a short history but have nonetheless undergone rapid development during the past 30 years. For example, they were among the first electrical apparatus with polymeric insulation, now state-of-the-art in distribution and increasingly applied in transmission. Progress has also been achieved in MO varistor performance, making arresters among the most reliable components in power systems. New applications beyond overvoltage protection have also become possible, such as UHV arresters, HVDC arresters in converter stations, line arresters, arrester banks in FACTS and, most recently, as energy absorbers in HVDC circuit breakers. Energy handling and potential degradation have been concerns from the start, since a gapless MO arrester can suffer thermal runaway after excess energy input and/or due to deterioration of its nonlinear voltage-current-characteristic. Modern applications have thus required different approaches specifying and verifying energy handling capability. These days, simulation tools have become powerful enough to e.g. optimize EHV and UHV arrester designs with respect to external grading and thermal stability limits. This paper and presentation addresses challenges during ongoing development of arresters, reviews the current state of standards and offers an outlook on future requirements.

11:40

Jesse Hoffman

Electrical Engineering Manager, Power, Stantec Consulting Services, United States

Surge Arrester Considerations in Microgrids

Mr. Hoffman's expertise spans from design and implementation to management and development of power generation, critical power and renewable energy projects for federal, municipal, and private clients. His professional design experience centers on design and implementation of EPC assignments for low voltage and medium voltage electrical power generation projects, spanning the project's life cycle from initial concepts to construction and support during start.

SYNOPSIS

Addition of distributed generation sources as well as implementation of islanding microgrid capability introduce new insulation coordination challenges within existing power systems. If not properly designed, each new generator can present a new source of temporary overvoltages (TOV) during line-to-ground faults that stress distribution surge arresters, component insulation and, if present, single-phase loads. Proper application of system components and consideration of existing system grounding can reduce the impact of any new distribution source on existing components. Most existing distribution systems were originally intended to supply loads from solidly or effectively grounded sources and follow typical utility distribution system design guidelines. Therefore, surge arresters encountered within these systems are designed for TOV levels traditionally limited to 125% of phase voltage. Many utility systems maintain this design requirement and generation interconnections are designed to limit TOV to less than 125% of nominal. However, microgrid applications can pose a challenge to the system developer in that utility requirements often end at the utility interface point and do not extend into the customer owned distribution system. When considering interconnection of an additional generation source to privately owned medium voltage distribution systems, there are several options to address the new TOV levels. This paper and presentation reviews common strategies to address TOV levels in microgrid applications.

ARRESTER TECHNOLOGIES & APPLICATIONS PART 1: SONORAN 1 & 2 CONFERENCE ROOM Tuesday, Oct. 22 12:05 to 14:00

12:05

William Chisholm

Consultant, Canada

Arrester Protection of Lower Voltage Circuits on Multi-Voltage Towers: Issues & Opportunities

Dr. Chisholm is an expert in the effects of adverse weather on overhead power lines, including icing on insulators, lightning and grounding and thermal rating. He has been an IEEE Fellow for a decade - a distinction given after his long career at Ontario Hydro and Kinectrics. He combines his consulting worldwide with teaching and writing for INMR as well as Wiley & McGraw Hill and also volunteers in the IEEE executive rotation as Chair and Past Chair of the PES T&D Committee. In 2017, he received the Claude de Tourreil Memorial Award for Lifetime Achievement in the Field of Electrical Insulators.

SYNOPSIS

Distribution system engineers sometimes take advantage of existing transmission right-of-way to route medium voltage circuits when standards show there is adequate vertical clearance to high voltage transmission circuits above. Often, while the lightning performance of the HV circuit improves, the tripout rate of the MV circuit is disappointing. For example, in the case of one particular line configuration lightning protection is provided by a single overhead groundwire mounted at the top of the pole. Each steel pole is grounded but soil resistivity varies considerably from tower to tower so each pole will have a different value of footing resistance. The lightning performance of such a structure with four circuits helps to visualize the concept of electromagnetic surge impedance coupling. Depending on distance from the single OHGW, each phase will take up a voltage wave that is a faithful but reduced amplitude copy of what appears on the tower top. The voltage stress on each insulator is the difference between the local tower voltage rise and this 'coupled' voltage. Line surge arresters offer an opportunity to retain the benefits of improved electromagnetic coupling of lightning to the HV circuit above while also mitigating induced and back-flashover overvoltages on the MV circuit below. This paper and presentation offers a tutorial approach using surge impedance matrix calculations to support the analysis, which confirms that, with appropriate selection, arresters on the lower circuit can also mitigate cross-system contact faults.

12:30

Tim Rastall

Senior Electrical Engineer, Enspec Power, United Kingdom

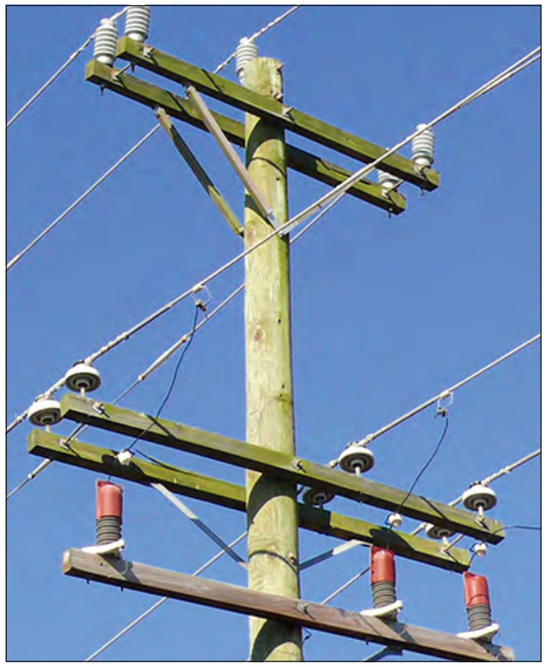
Arresters in MV/HV Capacitor Bank Protection

Mr. Rastall received his M.Eng. in Electrical Engineering from the University of Sheffield. He specializes in Grid Code compliance solutions for large-scale industry and renewables and has had extensive experience and knowledge in the modeling as well as application of surge arresters for protection of MV/HV capacitor banks and harmonic filters.

SYNOPSIS

Increased penetration of distributed generation (DG) from solar or wind brings challenges to network operators in terms of power quality issues such as voltage regulation, power factor and harmonics. For example, if DG sites do not comply with grid connection requirements they may need to install power quality improvement equipment. Should DG sites require reactive power and voltage support, capacitor banks are the most cost-effective solution. However, the switching of capacitor banks can introduce voltage disturbances at the connection point due to the possibility of high magnitude inrush currents. In recent years, improvements such as controlled switching technologies have allowed for inrush currents during energization to be minimized and also for fast switching of capacitor banks. Capacitor bank switching requires special attention because of the possibility of a restrike after current interruption. Many high voltage SF6 or vacuum breakers are designed for capacitive current switching. However, unpredictable restrike phenomena can still occur. If a restrike occurs, it leads to high frequency, high magnitude overvoltages, large inrush currents and large outrush currents in the case of back-to-back capacitor bank switching. Consequently, any restrike can induce additional stress on capacitors, de-tuning reactors and breakers, possibly leading to catastrophic damage. This paper and presentation discusses application of surge arresters for mitigation of overvoltages on capacitors based upon single restrike occurrence phenomena. Two particular capacitor bank designs are investigated: a 33 kV, 50 Hz ungrounded double wye connected bank and a same size de-tuned bank.

13:00
Lunch



ARRESTER TECHNOLOGIES & APPLICATIONS PART 1:
SONORAN 1 & 2 CONFERENCE ROOM Tuesday, Oct. 22 14:00 to 16:00

14:00

Martin Hughes

Sr. Technical Leader, Electric Power Research Institute (EPRI), United States

Mechanical Testing of Connection Leads for Transmission Line Arresters

Mr. Hughes is a Senior Technical Leader in the Transmissions and Substations Area of the Power Delivery & Utilization Sector at the Electric Power Research Institute. A mechanical engineer with special areas of interest in component testing, robotic mechanisms, composite structures, mechanical design and stress analysis, he has years of experience in the engineering industry in both international and domestic environments.

SYNOPSIS

Transmission line surge arresters are applied on overhead lines to improve outage performance and, particularly in cases of some EHV lines, to limit magnitude of switching overvoltages. There are basically two types: Externally gapped line arresters (EGLAs) and non-gapped line arresters (NGLAs). In places such as the United States, most are NGLA type, comprised of a column of metal oxide varistors packaged in a polymeric housing reinforced with fiberglass. The arrester is installed between phase conductor and tower with connection leads. One end is typically fitted with a disconnector to break the electrical connection in the event of arrester failure. Previous EPRI reports have described the various possible NGLA installation configurations as well as associated problems found during line inspections. While service experience shows that application of NGLAs often improves line performance with relatively few failures, many utilities have reported that installations are often compromised by mechanical issues such as connection lead or disconnector failures. Current arrester standards do not include mechanical tests or requirements for arrester connections, however, IEC 60099-5 suggests an arrester life expectancy of at least 25 years. This paper and presentation summarizes results of a multi-year EPRI research project to identify and understand causes of lead breakages with a view to formulating functional requirements that could eventually be included in user technical specifications.

14:30

Bastian Robben

Design Engineer/R&D Project Manager, Siemens AG, Germany

Innovative Compact Line Design: Reducing Clearances by Integrating EGLAs on HV Transmission Lines

Mr. Robben, an expert in design of composite insulators and surge arresters, received his Dipl.-Ing. degree in mechanical engineering from the Technical University of Berlin in Germany in 2010. He has been working for Siemens AG since 2011 and is currently responsible for development and engineering of composite insulators, transmission line arresters and overhead line solutions. He is a member of international Insulator Working Groups in IEC TCs 18 &19 as well as German Insulator Working Group AK451.0.2.

SYNOPSIS

Growing demand for power has resulted in need for increased transmission capacity and power quality. These days, developed countries encounter growing difficulties building new transmission lines due to public opposition and environmental considerations and it becomes necessary instead to 'uprate' existing power systems. Moreover, even if public approvals are obtained, line designers are often requested to create new concepts and structures to reduce footprint and visual impact. Line compaction and uprating involve the need to review conventional ratings and standard designs used for decades. Fortunately, the latest developments in composite insulators and surge arresters make compact line design a realistic alternative to traditional designs. For example, taking surge arrester functionality into consideration, structure clearances and insulator arcing distances can be reduced and power availabilities improved simultaneously. Conventional ratings such as lightning and switching impulse withstand values of insulator assemblies can also be coordinated with application of transmission line arresters to achieve advanced insulation coordination. This paper and presentation describes principles of transmission line surge arresters and reviews opportunities to optimize transmission line capacity and power quality. It also explains the technical challenges that have to be considered when implementing compact power system solutions.

15:00

Jon Leman

Sr. Project Engineer, POWER Engineers, United States

Assessing Sheath Voltage Limiter Failure Caused by Improper Bonding of Cable Sheaths

Mr. Leman earned his Master's Degree from the University of Idaho and is currently pursuing a PhD at Washington State University. As Senior Project Engineer in the Analytical Services Group at POWER Engineers, his responsibilities include leading engineering teams and performing studies for design and analysis of energy infrastructure. His technical interests are electromagnetics, power system transients, equipment failure investigation, numerical methods, insulation coordination and power system planning while his research emphasis is in high voltage transmission line electromagnetics and design. He is a member of CIGRE and a Senior Member of IEEE.

SYNOPSIS

A sheath voltage limiter (SVL) is an arrester that reduces risk of damage to cable insulation by limiting overvoltage levels on cable sheaths during a short circuit event. Typical sheath voltages are calculated for normal as well as short circuit conditions, given a properly bonded sheath. However, if a cable sheath is not correctly bonded to ground at the end opposite the SVL, a floating potential condition can result. SVLs can then be exposed to steady-state voltages that exceed their rating and allowing low-magnitude currents to flow. The amount of current will depend on the capacitance between cable core and sheath and between cable sheath and external ground planes. Such steady-state current can eventually lead to SVL failure. This paper and presentation summarizes proper application of SVLs, including their relationship to cross bonding of underground cable sheaths, and explains basic electrical specifications. Analysis is then made for the case of an improperly bonded cable sheath. Examples of cable installations are also examined using electrostatic finite element analysis to calculate capacitance between sheath and external ground planes. Sheath voltages are then calculated for floating potential conditions and current magnitudes are estimated for SLVs connected to an unbonded sheath.

15:30
Coffee Break & Visit to Exhibition

ARRESTER TECHNOLOGIES & APPLICATIONS PART 1:
SONORAN 1 & 2 CONFERENCE ROOM Tuesday, Oct. 22 16:00 to 17:30

16:00

Jody Levine

Asset Manager, Transmission Stations, Hydro One Networks, Canada

Experience Applying Surge Protection at Hydro One

Ms. Levine spent 16 years in the high voltage and high current laboratories at Kinectrics and learned how things break. In 2007, she joined Hydro One's Stations Technical Services group as the team lead for ancillary equipment and saw which things break. She moved to Asset Management in 2016 to get some things fixed. She is the chair of IEEE 400.3 on cable partial discharge testing, a member of CIGRE B1.60, and holds B.A.Sc. and M.A.Sc. degrees from the University of Waterloo.

SYNOPSIS

Hydro One owns and operates most of the power transmission grid in the province of Ontario, Canada, with the main corridors at 500 kV and 230 kV, and regionally at 115 kV. Overvoltages on this network occur in a wide variety of waveforms and situations. Metal oxide surge arresters serve in most applications, but protective gaps of various designs are still required. Some voltage transients are controlled with capacitors and even shunt reactors. Hydro One's surge environment and application philosophy puts relatively little stress on surge arresters, so they tend to last a long time. As a result, the surge arrester population has a broad demographic, and service life is determined mostly by housing integrity. This paper and presentation discusses Hydro One's approach to overvoltage protection and the various mitigation strategies employed, from the mundane to the highly creative. Surge arrester inspection, failure analysis and replacement strategy are discussed, and failures of particular interest are presented.

16:30

John M. Schneider

Principal, Complex Energy Solutions, United States

Development of 765 kV Externally Gapped Line Arresters

Dr. Schneider received his Doctor of Engineering Degree in Electric Power (Computational Electromagnetics) from Rensselaer Polytechnic Institute, Troy, New York. He was employed by AEP (American Electric Power) from 1980 to 2010 and held technical positions in business units including Transmission, Corporate Engineering, Generation and Distribution while also providing consultancy services. His responsibilities included: high-level technical support; complex problem solving; technical assessment of emerging technologies; corporate technology planning and execution. Currently, he is an Independent Utility Technology Consultant providing services in power system transient modeling and analysis, insulation coordination, equipment failure analysis, AC interference on railway and pipeline facilities, emerging power electronics and renewables technologies, electrical accident investigation as well as grounding, bonding, shielding and surge protection of facilities.

SYNOPSIS

Line surge arresters (LSAs) to improve lightning flashover rate of distribution and transmission lines are generally not automatically applied due to concerns over cost, reliability and maintenance. Rather, investigation of a line's grounding, shielding and proper insulation coordination typically remain the initial focus and LSAs are resorted to only when conventional mitigation methods are seen as either too costly or relatively ineffective. Yet application of LSAs has become a reliable solution these days thanks to the advanced design of their polymeric housings combined with the performance of metal oxide technology. LSAs are now also comparatively low in acquisition cost while also providing a variety of benefits. Non-gapped line arresters are often the type selected in most countries based on previous experience and the comfort of using applicable IEC/IEEE standards, which are identical to those for substation arresters. Externally gapped line arresters (EGLAs), by contrast, have been gaining popularity as a viable alternative and are already standard components in countries such as Japan, South Korea, France and Mexico. This is because they offer unique advantages in comparison to NGLAs. This paper and presentation provides technical knowledge to assist in correctly specifying EGLAs and also reviews the applicable testing standard intended to verify proper application.

17:00

Chenyang Wang

Transmission Line Design, Manitoba Hydro, Canada

Optimizing Structure Design on 500 kV Lines Using Transmission Line Arresters

Mr. Wang received his B.Sc. degree from McMaster University in Hamilton in 2007 and his M. Eng. Degree from University of Alberta in 2009, both in electrical engineering. His current position is in the Transmission & Civil Design Department of Manitoba Hydro where he is the lead transmission line design engineer of the new 500 kV AC Manitoba-Minnesota transmission project. His professional experience includes designing new/refurbished transmission lines, grounding and lightning protection and AC interference of lines.

SYNOPSIS

Manitoba Hydro's system depends on power generated by northern hydraulic generating stations whose output is transferred south on HVDC lines that carry about 70% of Manitoba's supply. In case of drought or an HVDC outage, supply would be restricted to generation connected to the AC system in addition to imports on AC interconnections with the U.S. and other provinces. Such a restricted supply of power would be inadequate to meet demand and therefore a new HVAC transmission line - Manitoba-Minnesota Transmission Project (MMTP) - is the second 500 kV line in Manitoba to connect to the U.S. grid and link Dorsey Station to Iron Range Station using a 575 km line. The geometry of the line's towers must accommodate different electrical clearances under various weather conditions, as provided for in standards or codes. Substantial consideration must be given to switching surge clearance and minimum approach distance, which depend greatly on switching surge overvoltage level of the line. Therefore, lower switching surge overvoltage level can lead to more compact tower top geometry that could reduce project cost as well as environmental impact. This paper and presentation introduce the novel means to optimize structure design for MMTP using transmission line surge arresters. MMTP will have 60% series compensation to maintain a 2000 A continuous current rating. Once completed, this 1440 MVar series capacitor would become the latest in the world at 500 kV and its large size and long line length would result in high switching surge voltage, thereby affecting tower design and live line maintenance. To address this issue, Manitoba Hydro conducted a detailed switching surge study to help optimize design of MMTP towers.

ARRESTER TECHNOLOGIES & APPLICATIONS PART 1: SONORAN 1 & 2 CONFERENCE ROOM

Tuesday, Oct. 22 17:30 to 18:00

17:30

Xuan Wu

Sr. Engineer, Station Design, American Electric Power, United States

Surge Arrester Sizing for Sub-Transmission Systems Using Grounding Transformers

Dr. Wu is from Nanjing, China and received his M.S. degree in Electrical Engineering from Arizona State University and a Ph.D. in Electrical & Computer Engineering from Ohio State University in Columbus. His research interests include applying optimization techniques in transmission & distribution system planning, operation and market designs, electromagnetic & electrostatic coupling effects, substation fault analysis and grounding design as well as transient analysis and surge arrester applications. He has contributed to several AEP substation design guidelines and published 6 journal and more than 10 conference papers in power engineering. He is an IEEE member and Chair of IEEE PES Columbus Chapter.

SYNOPSIS

A sub-transmission system is considered effectively grounded at a particular location if the ratio between its zero-sequence reactance (X_0) and its positive-sequence reactance (X_1) satisfies $0 < X_0/X_1 < 3$. A grounding transformer would lower the overall zero-sequence impedance of the power system at the grounding transformer location, X_0, to a desired value. Lowering the X_0/X_1 ratio at a particular system location will result in higher line-to-ground fault current at that location. The higher fault current will allow for easier and better relay protection coordination with protective equipment downstream. However, even if grounding transformers improve relay protection coordination, the decision to install grounding transformers and the selection of their impedance to increase line-to-ground fault current at a particular system location must be evaluated case-by-case. This paper and presentation deals with selecting and applying an appropriate surge arrester to protect corresponding equipment and focuses on temporary overvoltage evaluation, which governs the selection process for arresters for ungrounded sub-transmission systems. The specific case involves the Appalachian Power Region of AEP's service territory, which includes substations that have autotransformers with ungrounded delta tertiary windings. Use of the tertiary winding varies from station to station but, whatever the specific scenario, grounding transformers are used to detect line-to-ground faults and stabilize the neutral during system 'unbalanced' situations, such as fault conditions.

17:55

Summary / Questions & Answers

INSULATOR TECHNOLOGIES & APPLICATIONS PART 1: CANYON CONFERENCE ROOM

Tuesday, Oct 22
14:00 to 15:40
Session Chairman:
Alberto Pigini, T&D Consultant, Italy

14:00

Markku Ruokanen

Group R&D Director, PPC Insulators, Austria

Adding Intelligence to Ceramic Insulators

Mr. Ruokanen has an M.Sc. degree in Materials Science from the University of Technology in Helsinki, Finland. Before joining PPC in 2014, he held several leading technical positions at Maxwell Technologies in both the Ultra-Capacitor and HV Capacitor Divisions. He is a member of Cigré Switzerland.

SYNOPSIS

The move toward digitalization of substations brings with it several challenges when it comes to data capture and transmission. Fibre optic technology is one of the solutions possible since it is immune to EMI/RFI and has also achieved a high level of maturity that has helped drive down cost. Moreover, optical sensor technology does not need a power source at the measuring point and the light source can be hundreds of meters away and outside the substation itself. Installing fibre optic cable at a substation is another challenge since it must pass through the insulators. Fortunately, manufacture of fibre optic post insulators has become possible in an industrial, cost-effective manner using isostatic technology. The fiber optic hole is located on the neutral axis and as such does not affect mechanical performance while making it possible to measure acoustic waves and vibrations inside the ceramic post. The stress level of the insulator does not affect acoustic signal frequency or propagation within the material itself. Data collected, once filtered and analysed, can then be used for substation monitoring and in this sense is a first step toward an 'intelligent' insulator that senses its environment and provides important system data needed for substation management. This presentation explains the method of manufacturing ceramic insulators containing a fibre optic hole. It also explores potential future applications in monitoring forces, movements and vibrations of ceramic insulators as part of the digital substation.

14:20

Igor Gutman

Sr. Expert, Independent Insulation Group, Sweden

Rod to Housing Adhesion in Composite Insulators: Practical Evaluation in Collaboration with Utilities

Dr. Gutman received his MSc and PhD in high voltage engineering from Leningrad Polytechnic Institute and has developed his professional experience over more than 37 years – starting at the Leningrad HVDC Power Transmission Research Institute where he worked as Senior Researcher. His subsequent work became closely connected with outdoor line and station insulation, particularly composite insulators. In 1994 he joined STRI where his main areas of activity WEre optimal dimensioning and maintenance of outdoor insulation intended to operate in clean and polluted environments; ageing characteristics and accelerated ageing tests. Now with the Independent Insulation Group, he has published extensively on such topics with more than 200 papers and is a Senior Member of IEEE since 2005. At present he is also a member of Swedish IEC TC 36 "Insulators", Distinguished Member of CIGRE and active in working groups within CIGRE/IEC/IEEE. In 2011, he became Honorary Professor at St. Petersburg Power Engineering Institute of Professional Development (PEIPK) and was also the 2012 recipient of the Claude de Tourreil Memorial Award for Lifetime Achievement in the Field of Electrical Insulators. He is 2013 recipient of IEC 1906 Awards in recognition of his services to international technical standards.

SYNOPSIS

According to industry bodies, worldwide service experience with composite insulators is now considered on par with that of glass cap & pin insulators, with a population in service on overhead lines exceeding 20 million pieces and comprised of insulators of different generations. Initial lack of knowledge in 1st and the 2nd generation insulators from the early 1980s led to service issues that included sealing problems, interface issues between fiberglass rod and housing, flashunder, rod tracking and brittle fracture. These were investigated and overcome in successive generations. However, numerous new suppliers have since entered the market and composite insulators these days can again be of much different quality. For example, forensic investigations have confirmed that the root cause of many service failures is poor adhesion at the key interface between the fiberglass rod and silicone rubber housing. This was clearly revealed from non-standard adhesion tests but not by existing IEC-based tests intended to verify integrity of interfaces. Thus, the issue of quality is considered as not being fully covered by existing standards that may need to be reviewed in the light of this latest reported field experience. This paper and presentation describes the methodology and findings of a research project, sponsored by 9 European TSOs and DSOs, intended to develop a robust, effective test to evaluate level of adhesion.

14:45

Paolo Cardano

Sr. Expert for Bushings, GE Grid, Italy

External Insulation Alternatives for EHV & UHV Bushings

Mr. Cardano received his Doctoral Degree in Electrical Engineering from the Milano Polytechnic University. After graduation, he joined Passoni & Villa and has been working in various positions in the technical area. He is presently R&D senior expert for OIP, HVDC and gas bushings and also in charge of development of UHV AC bushings. He has been president of the Italian Committee 36A - Bushings and is active in several CEI/IEC working groups. He has published numerous papers at international conferences.

SYNOPSIS

Different housings are available these days for the external insulation of EHV and UHV bushings. These include: porcelain, which may or may not also be coated with RTV silicone material to improve pollution performance; hybrid housings consisting of a porcelain core with a polymeric housing; and a composite housing based on an internal FRP tube over which a polymeric housing has been molded. Each of these alternatives offers different benefits in terms of factors such as safety, pollution performance, seismic performance, icing performance, etc. For example, in regard to electrical performance, different housing solutions can be broadly grouped into two categories: hydrophobicity transfer material insulators and non-HTM solutions. This paper and presentation analyses the relative advantages of these different alternatives when considering the full range of design aspects and requirements. The analysis will focus on EHV and UHV applications and is based on tests performed at laboratories worldwide.

15:10

Coffee Break & Visit to Exhibition

INSULATOR TECHNOLOGIES & APPLICATIONS PART 1:
CANYON CONFERENCE ROOM Tuesday, Oct 22 15:40 to 16:40

15:40

Arturo Del Rio

Product Manager for Transformer Bushings, Siemens, United States

Synthetic Dry-Type Bushings Applied to HV Power Transformers

Mr. Del Rio holds a Bachelor's Degree in Electrical Engineering from the Universidad Industrial de Santander, Colombia and an MASc Degree in Power Devices and Systems from the University of Toronto in Canada. He started his professional career as a Field Engineer in Colombia and later worked as an Electrical Engineer for Hatch Associates consultants before joining Trench Canada where he held posiitons in design and engineering for instrument transformers, power electronics, HV transformer bushings and air-core reactors. In 2018, he joined Siemens in Wendell, North Carolina. He has been an IEEE member since 1988 as well as a registered Professional Engineer in Ontario since 1993 and is presently a member of the IEEE PES Transformer Committee where he participates in development of industry standards.

SYNOPSIS

Bushings on power transformers provide a central passage for a conductor for the purpose of insulating it from the grounded tank and conducting current from the air side to the liquid immersed side. While transformer bushings are well-established devices, investigation of transformer failures point to bushings and their operating conditions as causing a high percent of unplanned outages and transformer failures. New developments in bushing technologies and materials aim to address these issues. Bushings for transformers and other applications evolved from simple hollow insulators made of porcelain to more elaborate engineered designs. For example, when voltage levels increased, technologies such as capacitance grading and resin-bonded paper bushings were developed. When RBP technology reached its limits, other technologies such as oil-impregnated paper and resin-impregnated paper emerged. As RIP technology becomes more widespread and its reliability better demonstrated, utilities in the U.S. and IEEE market continue to adopt this dry-type bushing technology as a preferred solution, especially for high and extra high voltages. Most recently, the crepe paper used in RIP cores is being replaced by a polyester synthetic material. This paper and presentation focuses on air-to-oil bushings using resin-impregnated synthetic as the main insulation and applied in power transformer and shunt reactor applications up to 550 kV systems.

16:00

Ed Niedospial

Sr. Product Manager, Transmission Insulators, MacLean Power Systems, United States

Manufacturing Quality of Toughened Glass Insulators

Mr. Niedospial holds a B.S. in Physics and Mathematics from Elmhurst College as well as an MBA in Project Management and Marketing from Keller Graduate School of Management at Devry University. He has worked for Maclean Power Systems since 1996 as part of the Technical Engineering Team where his focus is on high strength mechanical applications. This includes development of features for improved insulator performance and service life through product testing and validation. He is an active member of IEEE and other Technical Committees.

SYNOPSIS

Quality can be defined as a measure of the relative superiority of a particular product when compared to similar products and also as a degree of excellence. In the case of the electric power industry, quality is benchmarked using defined national and international standards, including ANSI, IEEE, ASTM or similar. While meeting such standards is mandatory, most engineers have come to recognize that standards actually represent minimum performance requirements for a component or material to function properly in its application. For this reason, many users and also manufacturers look to further differentiate product quality with enhanced specifications. Manufacturers use continuous process improvement methodologies, with focus placed on process controls, repeatability and zero defects. Ultimately, the goal is that quality represents product capability and longevity as well as compliance with industry standards and customer specifications. This paper and presentation discusses quality in relation to toughened glass insulators, which are manufactured in two steps: production of the glass shell; and assembly of metal fittings to that shell. The focus is on what comprises quality when manufacturing the toughened glass shell and later when finally assembling the insulator as a separate step.

16:20

Eric Moal

Technical Expert, Reinhausen France SAS, France

Pollution Performance of Composite Hollow Core Insulators with HTV/LSR Housings

Mr. Moal received his Engineering Degree from l'Ecole Nationale Supérieure d'Electricité et de Mécanique in Nancy in 1990. He has worked for over 25 years in development of hollow core composite insulators for high voltage apparatus as well as composite insulators for overhead lines. He is an electrical & mechanical design specialist and a member in IEC TC 36 as well as CIGRE D1 Working Groups dealing with composite insulators.

SYNOPSIS

Silicone rubber materials exhibit distinct properties that are advantageous for application in HV outdoor insulation. These include stability against UV and ozone, good dielectric properties, resistance against high temperatures, excellent hydrophobic properties as well as resistance to arcing and tracking. High temperature vulcanizing and liquid silicone rubbers have been successfully applied for over 30 years as elastomeric housings for composite insulators. Moreover, process technology and formulations have been developed to meet the high quality requirements needed for HV outdoor applications. HTV rubbers are typically applied in housings of large composite hollow insulators, usually manufactured with extrusion technology, and also for hollow and solid core insulators made by injection moulding. LSR rubbers, by contrast, are typically applied in housings of large composite hollow insulators manufactured using injection moulding technology. This paper and presentation reviews the long-term performance of grades of HTV and LSR rubber materials that have been specially adapted for HV outdoor applications. Evaluation of relative performance is based on long-term service experience in the field, which is then compared to results obtained from material tests in the laboratory.

INSULATOR TECHNOLOGIES & APPLICATIONS PART 1:
CANYON CONFERENCE ROOM Tuesday, Oct 22 16:40 to 17:40

16:40

Marco Nosilati

Technology Leader, GE Grid Solutions, Italy

Optimal Selection of Post Insulators for AIS Disconnectors & Other Substation Applications

Mr. Nosilati is an Electrical Engineer, graduated at the University of Padova with a Masters thesis in collaboration with the Helsinki University of Technology. He started his work experience in 2009 as R&D Test Engineer in Areva and he is currently the Technology Leader of air-insulated disconnectors in GE Grid Solutions. He is holder of several patent applications linked mainly to HV equipment and technological solutions for HVDC applications. He has served as a member of IEC as well as ad hoc Working Groups for DC switchgear

SYNOPSIS

Many varieties of post insulator can be used at substations and converter stations depending on application, whether as bus supports, smoothing reactor supports, or for switchgear such as disconnectors. The diverse requirements for open-air type disconnectors can be divided into three classes: functional and electrical requirements; mechanical requirements; and environmental requirements. All these requirements link closely to insulator performance. Moreover, the general trend in design of open-air substations is being driven by the need to arrive at compact and cost-effective solutions. Selection of station post insulators can contribute to this goal by limiting arcing distances necessary for busbars, disconnectors and other station apparatus through proper design, including ideal materials, improved mechanical strength and stiffness, reduced number of stacks and intermediate flanges as well as by optimal shed profile and creepage factor. In regard to UHV, the main challenge for post insulator design relates to height, particularly if the pollution environment requires extra long creepage distances. Mechanical requirements from bending and torsion loads only increase the challenge and also increase the difficulty in manufacturing such units. This paper and presentation provides qualitative comparison of the five main station post design options, noting that final selection from among these will in each case be influenced not only by technical performance but also by local costs and other economic factors.

17:00

Derek Oliver

Director, Manitoba Institute for Materials, University of Manitoba, Canada

Insulator Performance & Characteristics Required of Innovative Materials from Renewable Sources

Prof. Oliver's research interests include developing insulation materials and characterization techniques for electrical infrastructure, in addition to materials for solar energy conversion. A Professor in Electrical & Computer Engineering, he is Director of the Manitoba Institute for Materials, coordinating interdisciplinary research across 5 faculties. He serves as Canadian representative to CIGRÉ SC D1 and the Advisory Group AG D1.03 (Solid Materials).

SYNOPSIS

A growing number of different insulation material options are available these days, with key ingredients that vary from different metallic particles to various inorganic oxide particles to graphene. In most cases, the additional costs associated with testing and manufacturing these new materials can be justified based on potential demonstrable improvements in performance. Setting aside manufacturing validation tests that are application or client-specific, candidate new materials for insulation applications must meet or exceed benchmarks set within the standards and associated tests used by the insulation community. These represent a performance roadmap, a subset of which can be used to pre-screen potential materials for further study. For example, interest in bio-polymers goes beyond proposing alternative materials for future insulation needs. Bio-polymers are also attractive because, as 'designer' materials, a chemical process can be designed to fully recycle the material when it is removed from service. As such, bio-polymers can be considered relatively carbon-neutral and highly recyclable. This paper and presentation surveys broad physical and electrical characteristics of 10 bio-polymers and compares these with key petrochemical-sourced materials used incable insulation. The screening process also identifies candidate bio-polymers that merit additional study in terms of benchmarks provided by existing standards.

17:20

Ron Duckstein

Sales Director, Sediver, United States

Evaluation of Field Returned Insulators from U.S. Grid Through Laboratory Tests

Mr. Duckstein received his Electrical Engineering Degree from the University of Pittsburgh in 1986. His experience spans design and product support for distribution, substation and transmission systems from 5 kV through 765 kV. He began his career in the electric utility industry as a large power transformer design engineer for Cooper Power and then moved to technical sales with investor-owned utility, Duquesne Light Co., and eventually to Hubbell Power Systems. He joined Sediver in February 2014. He is a member of CIGRE and IEEE and participates in American standards committees including NEMA and ANSI C29 Insulator Working Groups.

SYNOPSIS

The age of the transmission grid in the United States and elsewhere has required increased focus on the condition of old insulators still in service. Indeed, many utilities have already started testing some of their oldest lines to forecast and plan for refurbishment and capex expenditure. Evaluating the condition of such assets can be done using different methodologies. For example, CIGRE TB 306 offers a statistical approach based mostly on mechanical performance of insulators removed from service. Additionally, flashover, M&E, thermo-mechanical and steep front wave evaluations also provide valuable information. Today, an increasing number of utilities are looking at laboratories offering the full scope of ANSI, IEC or CSA test programs for such investigations. Quantities of units tested clearly help in establishing a statistical diagnostic of the condition of insulators but utilities are often not able to dismantle large sections of lines for such work. Therefore, the most pertinent test program should be designed using customized approach to best fit the environment or the type and age of test samples as well as their application. This paper and presentation offers an example of what can be offered in this regard based on a new U.S. factory for glass insulators established in 2017. This facility offers a laboratory capable of performing all tests required by international standards and test campaigns have already been conducted for North American utilities from the east to the west coast.

INSULATOR TECHNOLOGIES & APPLICATIONS PART 1: CANYON CONFERENCE ROOM

Tuesday, Oct 22 17:40 to 18:50

17:40

Robert Middleton

Chief of Technology & Engineering, RHM International, United States

Dry Type Paperless Bushings for T&D Power Systems

Mr. Middleton received a degree in Electrical Engineering from the University of Manitoba in 1971 and is a registered professional engineer in the Province of British Columbia. He has an extensive background in generation and transmission engineering including quality assurance and has served on several CSA, CIGRE and IEC Working Groups. Author of numerous technical papers, he is presently Chief of Technology and Engineering for RHM International, a manufacturer of high voltage dry type current transformers, bushings and cable terminations. Prior to joining RHM International he worked over 40 years at two Western Canadian provincial electric utilities.

SYNOPSIS

A transformer bushing functions to safely transfer power through the earthed transformer tank. Oil-impregnated and resin-impregnated paper type bushings have been the industry standard for decades and have generally performed satisfactorily. However, as transformer assets age, deterioration of the paper in originally supplied bushings can cause failure, sometimes even catastrophic. As a result, there is increasing movement these days toward silicone insulated, dry type, paperless condenser bushings that can offer improved safety, no risk of leaking oil, optional maintenance requirements and lower installation weight. Indeed, several suppliers now offer this new bushing technology, which is referred to as resin-impregnated synthetic (RIS) - the common generic terminology for dry, paperless bushings. Resin-impregnated fiberglass (RIF) is the registered trademark of a dry, paperless insulation style of bushing that broadly falls within the RIS category yet is itself a distinctive technology. Introduced in 2003 and with more than 22,000 units installed worldwide, it has greater service experience than the RIS bushing, first launched in 2014. This paper and presentation reviews differences between RIS and RIF type bushings in terms of technology and also how the condenser core is manufactured.

18:00

Cristian Gutiérrez Aguirre

Corpoelec (retired), Venezuela

Brittle Fracture Failure of Polymeric Insulator on 400 kV Transmission Line

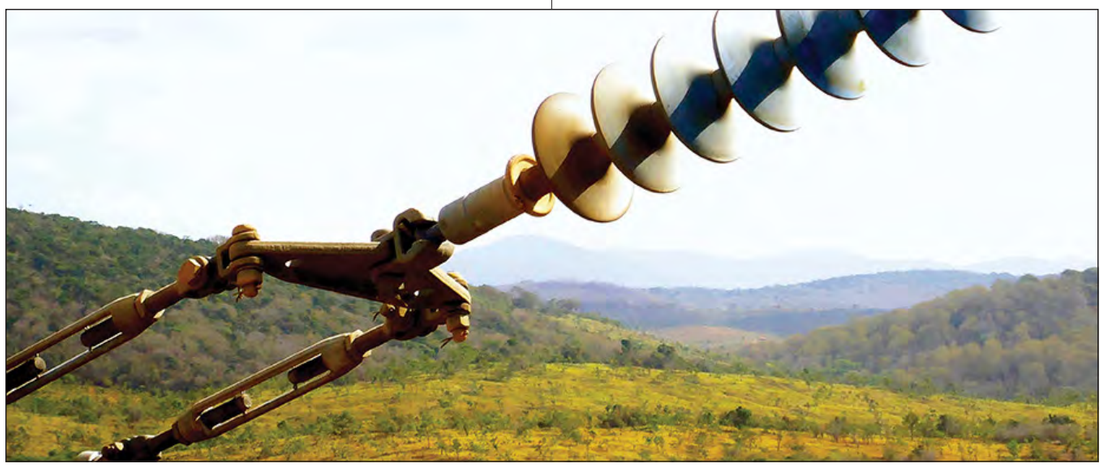
Mr. Gutiérrez graduated in Electrical Technology from Simón Bolívar University in Caracas. Since 1991, he has worked in preventive and corrective maintenance as well as in planning, inspection and supervision of maintenance on transmission lines from 115 kV to 765 kV. He has also had extensive experience in thermographic and UV corona inspection of lines and substation equipment, gained while working for Venezuela's largest utility in generation and transmission.

SYNOPSIS

Corpoelec's 400 kV transmission system consists of 4300 km of overhead lines and more than 10,350 towers. Venezuela's first transmission lines were built using glass and porcelain string insulators but application of polymeric insulators at 400 kV began in 1998. Currently, these types of insulators are installed on over 2500 towers along some 980 km of lines and represent about 23% of the total transmission system. In late 2016 a situation occurred involving non-ceramic insulators installed for 14 years on a 400 kV overhead transmission line. The problem occurred when there was a single-phase fault resulting from a brittle fracture process linked directly with not having installed corona rings on insulators during construction. The experience highlighted the importance of corona rings at this voltage level and also the need for proper visual inspection to be performed by linemen and technicians. This paper and presentation shows what can actually happen on transmission lines once equipment is put into commercial operation. The failure due to brittle fracture is carefully described, with the goal of documenting contributing factors, including period in service as well as external factors and environmental pollution that can reduce life expectancy.

18:20

Summary of Session/Questions



INSULATOR TECHNOLOGIES & APPLICATIONS PART 2: CANYON CONFERENCE ROOM

Wednesday, Oct. 23
08:00 to 09:05
Session Chairman:
William Chisholm, Consultant Canada

08:00

Ed Niedospial

Technical Sales Director - Transmission, MacLean Power Systems, United States

Maximizing & Validating Ultimate Capacity in High Strength Applications

Mr. Niedospial holds a B.S. in Physics and Mathematics from Elmhurst College as well as an MBA in Project Management and Marketing from Keller Graduate School of Management at Devry University. He has worked for Maclean Power Systems since 1996 as part of the Technical Engineering Team where his focus is on high strength mechanical applications. This includes development of features for improved insulator performance and service life through product testing and validation. He is an active member of IEEE and other Technical Committees.

SYNOPSIS

High strength insulators can improve efficiency of a project, which can then be measured in shorter project duration and also lower total cost. But gaining such added efficiency is a function of going beyond what has typically been done and finding new solutions. The challenge is to demonstrate that the new solutions will work. Mechanical loading of suspension insulators is comparatively simple since both specified mechanical load (SML) and rated tensile load (RTL) are both easily understood and quantifiable. Regardless of application, the primary load applied to the insulator is tensile and for any SML an insulator is not limited by section length. Maximizing tensile performance of a suspension insulator is a function of increasing the rod diameter, upgrading end fittings and getting the most tensile output from the crimping process. Where 30klb and 50klb have typically been the most used ultimate strengths for polymeric insulators, suspension applications can now go to 120klb SML and beyond, if required. This paper and presentation discusses how current insulator applications can be improved for higher mechanical capabilities and how these can be tested and validated.

08:20

Isaac Bohlken

Engineering & Technology Manager - Hardware, Pfisterer Lapp, United States

Design Rules for Long-Term Reliability of Composite Insulator Strings

Mr. Bohlken received his BSc in Mechanical Engineering from the University of KwaZulu-Natal in Durban South Africa. He worked for the Pfisterer Group in locations around the world, starting out in Pietermaritzburg, South Africa where he served as Production & Development Engineer re-sponsible for line and string fittings. He spent two years in China as Technical Director at Pfisterer's factory producing polymeric insulators and fittings and is now based at the Pfisterer Lapp facility in LeRoy N.Y. where he is responsible for insulator strings and fittings. He is a participating member in the IEEE OHL Sub-Committee.

SYNOPSIS

Long-term reliability of composite insulator strings is achieved by taking a holistic design approach with proper consideration of all the determining factors. Insulator strings are mechanical links between structures and conductors and also commonly the shortest path between energized and grounded elements of the line. Therefore, they are where electrical field gradients are highest and where power arcs are most likely to occur. One of the keys to longevity of composite insulator strings is avoiding continuous corona discharges on hardware as well as water droplet corona on insulator housings. Since both can have damaging long-term effects, electric field stress limits for both must always be controlled. This is achieved through appropriate design of hardware and use of field grading devices such as corona rings. Simulation is one way to evaluate electric field stresses but care must be taken to consider the larger context in which a string will operate in order to create a truly representative model. Moreover, it also has to be considered that corona rings are most exposed to power arcs due to their positioning. This paper and presentation explains how understanding the current and duration of possible short circuit events is important when designing suitable corona rings and arcing protection for a string as well as in specifying the current carrying capacity of load bearing hardware.

08:40

Daniel Luder

Materials Laboratory, Israel Electric, Israel

Research Findings Linking Corona to Brittle Fracture

Mr. Luder received his B.Sc. in materials engineering, B.A. in Chemistry and M.Sc. in energy engineering from the Technion - Israeli Institute of Technology. In 2013, he joined Israel Electric Corporation and has since worked as an engineer at the company's main materials laboratory. He specializes in failure analysis, metallurgical analysis, microscopy and standards compliance and has published papers on these topics. In addition, he sits on various Committees and Task Forces dealing with insulator failures as well as innovative maintenance methods.

SYNOPSIS

Application of composite non-ceramic insulators has increased among transmission companies worldwide due to advantages such as low weight and cost, high mechanical strength-to-weight ratio, high damage tolerance, flexibility, excellent impact resistance and relative ease of installation. While already successfully applied on lines up to 1000 kV, it has also become apparent that such insulators have unique weaknesses that can make them relatively susceptible to certain types of failure over time. Common failure mechanisms in this regard include brittle fracture and damage to the core rod from over-crimping. Composite insulator failures in regard to the brittle fracture mechanism have been researched for 25 years. A number of notable studies established that nitric acid was the main corrosive medium that formed on insulators as a result of corona discharge activity and eventually caused the FRP rod to corrode and fail through stress corrosion. A specific formation process of nitric acid was suggested and, in certain cases, it was even possible to pinpoint areas along an insulator where acid was at its highest concentration during and after failure. This paper and presentation presents results of the forensic investigation of a failed composite suspension insulator installed on a 400 kV transmission line along the humid southern coast of Israel. Although this insulator had a declared life expectancy of 30 years, it failed after only 15 years in service, triggering a temporary local outage with a high cost.

09:05

Jean-Marie George

Scientific Director, Sediver, France

Digital Solution for Transmission Line Risk Assessment

Mr. George received his Electrical Eng. Degree from the HEI School in France and joined Sediver as Research Engineer in 1986. After working as Production Manager for the Composite Insulator Division and Quality Mgr. and Technical Dir. for North America, he is now Scientific Director, with responsibilities covering R&D and technical assistance worldwide. His cross-functional positions with more than 30 years of experience have given him expertise in insulator performance as well as research and development. He has published and co-authored extensively on overhead lines, with 40 papers and articles and he is also author/co-author of patents and utility models. He is a member of CIGRE, IEEE, NEMA, ANSI and CSA as well as 2018 recipient of the Claude de Tourreil Memorial Award for Lifetime Achievement in Electrical Insulators.

SYNOPSIS

Dust and coastal salt contamination of overhead line insulators can seriously compromise the performance of a transmission line, generating potentially heavy losses and additional maintenance costs. Classical evaluation and mitigation of this problem usually requires an outage during which samples are taken down to measure pollution level and decide future action. Alternatively, preventive line washing is performed at defined intervals. Ideally, information on the surface condition of insulator strings would be more useful if provided on a real time basis without disturbing the system. This would allow maintenance actions at the proper time without risk of facing a flashover or unnecessary premature spending from making the wrong guess on the actual pollution situation of the line. Innovative techniques for real time evaluation of the condition of insulator strings are now possible thanks to 'smart' insulators able to communicate their pollution condition in real time. This paper and presentation describes this technology where the insulator itself produces a diagnostic. Instead of measuring level of contaminants through physical sampling on a string, this developmentconcentrates on the impact of the environment on string performance by measuring leakage current. Using wireless communication technologies, data is transferred to a dedicated server where it is analyzed and presented to the user with a diagnostic of the real risk of having a pollution related flashover. Such processes imply detailed knowledge of the signature of each different type of insulator in terms of leakage current since threshold values depend on shape and profile.

09:25

Andrew Phillips

Vice President T&D Infrastructure, EPRI, United States

EPRI Sensor Suite: A Step Towards an Intelligent Electrical Power System

Dr. Phillips is Vice President of Transmission and Distribution Infrastructure for EPRI's Power Delivery and Utilization research sector. In this role, he has overall management and technical responsibility for more than $48 million in annual research activities conducted by EPRI's T&D programs in collaboration with its global membership. Over the course of his career, he has been intimately involved in development of advanced inspection techniques and technologies, including radio frequency sensors, robotics and data analytics.

SYNOPSIS

Among the challenges faced by power utilities these days is their ability to meet expected reliability performance targets in the face of ageing equipment that typically operates at the highest possible level of utilization while oftentimes also exposed to severe service conditions. In the United States alone, the Department of Energy has estimated that the total asset value of power infrastructure exceeds $800 billion. It is therefore obvious that existing grid components cannot simply be changed out for new technologies. Instead, the focus needs to be placed on gradual replacement of assets that have reached the end of their operating life while also developing and installing technologies that can assess the condition of components and provide decision support mechanisms to prioritize both maintenance and replacement. Existing as well as new sensors are one of the important sets of enabling technologies that will aid in such decision-making. This paper and presentation reviews modern sensor technologies and offers an overview of the EPRI RF Sensor Suite. It also discusses opportunities to facilitate grid modernization through accelerated development and deployment of the RF Sensor Suite.

09:45

Alexander Zlakazov, Tatiana Symonova

Polymer Technology Director,
Global Insulator Group, Russia

New Technology for Coated Glass Suspension Insulators

Manager Polymer Technology,
Global Insulator Group, Russia

Dr. Zlakazov completed his studies at Moscow Power Engineering University and began his career in 1975 as an engineer and later Senior Engineer and Head of the Engineering Department at the Special Design Bureau of the country's Power Grid. In 1992, he received his PhD on "Development of design techniques for power units of suspension insulators". Later, in 2000, he joined the High Voltage Research Institute as a Director. He has been with the Global Insulator Group since 2010, where his main responsibility has been to use years of practical experience to promote techniques for improved design and performance of polymeric insulators. He has more than 100 patents as well as 30 scientific articles and the technology he developed is already being successfully applied in the field.

Ms. Symonova received her Bachelor's Degree from Donbass Machinery Engineering Academy in 2004 and later her Master's Degree in Management from Kharkov State Economic University. Her work at Global Insulator Group includes: providing technical support to the sales team; overseeing technical project life cycles with emphasis on resource efficiency; developing statements of work, including estimates of time and cost; applying functional specifications to each project; collaborating with the design team to create accurate prototypes for customer approval; and meeting clients to refine and evaluate requirements, strategy and content.

SYNOPSIS

Among the major problems when operating power equipment is maintaining the required level of external electrical strength of insulating structures, thereby reducing risk of flashover. This can be particularly difficult in the case of equipment in service in areas with a high degree of pollution from industry, dust, coastal salt deposits, etc. Globally, there are three main ways to resolve this problem: increasing

creepage distance by using additional insulating elements, which would have the disadvantage of also increasing overall dimensions of insulating structures; periodic manual or automated cleaning of insulation which is costly; or application of a hydrophobic coating to the insulator surface. Currently, the last of these options, i.e. waterproofing insulators with silicone-cold-cure RTV compounds, is regarded as the most effective way to enhance insulation performance. An RTV coating is typically applied to the insulator using a compressed air source and spray. After that, a thin elastic film is formed on the surface. While this film has good hydrophobic properties as well as high resistance to the influence of external pollution, it is relatively easily damaged during transport and handling in the field. This paper and presentation review a new hot-cure technology for applying coatings with thickness that allows the service life of the coating to be comparable to that of the ceramic insulator on which it is applied due to significantly higher strength and adhesion.

10:05

Coffee Break & Visit to Exhibition

INSULATOR TECHNOLOGIES & APPLICATIONS PART 2: CANYON CONFERENCE ROOM

Wednesday, Oct. 23
10:40 to 11:55
Session Chairman:
William Chisholm, Consultant Canada

10:40

William Chisholm

Consultant, Canada

Dust & Sea Salt Pollution Mapping: Satellite versus Ground Truth Results

Dr. Chisholm is an expert in the effects of adverse weather on overhead power lines, including icing on insolators, lightning and grounding and thermal rating. He has been an IEEE Fellow for a decade - a distinction given after his long career at Ontario Hydro and Kinectrics. He combines his consulting worldwide with teaching and writing for INMR as well as Wiley & McGraw Hill and also volunteers in the IEEE executive rotation as Chair and Past Chair of the PES T&D Committee. In 2017, he received the Claude de Tourreil Memorial Award for Lifetime Achievement in the Field of Electrical Insulators.

SYNOPSIS

The atmosphere contains fine aerosol particles that have the potential to negatively impact reliable operation of power networks. While ash and dust are large enough to be seen by the unaided eye, aerosols such as salt-spray and many types of pollutants are microscopic, with a distribution of diameters in the range 0.1 to 10 µm. All sizes of aerosols scatter and absorb light and degree of scattering is a function of particle size, pollution type and concentration as well as wavelength. Water vapor and aerosols absorb infrared energy whereas dust, NO2 and O3 scatter visible and UV light. Optical observations can therefore infer total volume of specific pollutants in a column cross-section. Even for cloudless conditions, the sun's rays will attenuate as they travel through the atmosphere. Best results are obtained when looking directly downward from space or vertically upward from the ground. Moreover, small corrections are made for seasonal variation in distance from earth to sun during long-term measurements from the ground. This paper and presentation discusses how man-made and natural pollution can be monitored using optical measurements found in satellites. Indeed, several studies have shown that wide area estimates of particulate matter density, such as PM2.5 and PM10, can help fill in gaps between sparse and costly ground-based air quality or insulator pollution measurement sites. It is even feasible to identify natural dust and sea-salt aerosol fractions that are heavily weighted respectively in accumulation of non-soluble (NSDD) and soluble (ESDD) deposits onto outdoor insulator surfaces.

11:05

A.J. Carreira

President, K-Line Insulators, Canada

Thermally Diffused Galvanizing & Application to Insulators

Mr. Carreira received his Bachelor of Applied Science in Electrical Engineering from the University of Waterloo. Prior to that he worked at Ontario Hydro (now Hydro One) in areas encompassing distribution and transmission design, planning, construction and maintenance. He is a member of CIGRE, CSA, CEA and a Senior Member of IEEE. He has chaired the IEEE TF 15.09.04.01 "Guidelines for the In-service Classification of NCI Damage" as well as ESMOL TF on IEEE Std 957 "Guide for Cleaning Insulators". He has also been appointed an Associate Expert of WG 32 and an Associate Member of B2-AG-06. In addition, he sits on various committees, working groups and task forces within these organizations. Mr. Carreira is past recipient of the Claude de Tourreil Memorial Award for Lifetime Achievement in the Field of Insulators.

SYNOPSIS

Existing corrosion control systems often do not provide enough of the long-term protection required for power infrastructure and other applications. The most effective solutions, at present, involve alloying zinc and steel. Hot dipped galvanizing (HDG) is a well known process and the only corrosion resistance protection allowed within the standards for hardware and other components used in the power sector. HDG is a complex process involving various pre-treatment steps such as degreasing, pickling and fluxing. These steps are then followed by the actual galvanization phase. Thermally dipped galvanizing (TDG), by contrast, is an entirely different process and results in thermal diffusion and coating of zinc alloy onto a ferrous component to protect against corrosion. The zinc alloy coating is anodic in relation to ferrous metals. Pre-treatment steps for TDG include degreasing and then perhaps shot blasting the parts. The key steps are galvanizing and passivation. There are advantages to TDG when it comes to addressing some of the negative environmental impacts associated with the galvanization process. This paper and presentation review a study conducted to determine the comparative performance of TDG and HDG and to establish if the former might be a feasible alternative to the latter. If so, industry would have two alternative processes available.

11:25

Raouf Znaidi

T&D Consultant, Tunisia

Field & Laboratory Assessment of RTV Coated Insulators in Harsh Desert Environments

Mr. Znaidi has had a long career at STEG, the power grid operator in Tunisia, where he was responsible for setting up insulator test stations across the country. Through this work he has become an expert on the comparative performance of different insulator types and designs in severe service environments. He has visited power companies across the globe reporting on service problems as well as remedial solutions using RTV coatings to combat pollution flashover. He is active in relevant CIGRE Working Groups.

SYNOPSIS

In spite of lack of international standards and limited field studies dealing with high voltage insulators coatings (HVIC), the past decade has seen sharp growth in interest among utilities worldwide. The main goals have been to mitigate pollution-related flashovers of glass and porcelain insulators that suffer poor pollution performance due to improper selection as well as to optimize rising maintenance costs for overhead lines and substations. Such a preventive solution is increasingly being adopted in desert and coastal regions based on perceived advantages of the combination of high mechanical performance and long-term stability linked to ceramic insulators with the advantages of water repellency and encapsulation of pollution as provided by silicone insulators. Nevertheless, utility users still have concerns and questions relating to: how best to select coating formulations for service in harsh desert environments; how to optimize application in terms of thickness, uniformity and adhesion; how to test for end-of-life of a coating; etc. Nowadays, it has been clearly established that insulators coated with RTV silicone rubber will withstand higher levels of pollution than uncoated insulators having the same profile and material. But one of the issues still to be determined is residual dielectric strength and pollution withstand performance of a silicone rubber coating after several years service in severely polluted conditions. This paper and presentation reviews results of recent research on coating performance under both natural and simulated pollution conducted to better understand distribution of pollution and to establish correlation between natural and artificial pollution testing.

INSULATOR TECHNOLOGIES & APPLICATIONS PART 2: CANYON CONFERENCE ROOM Wednesday, Oct. 23 11:55 to 14:00

11:55

Chris Engelbrecht

Consultant, Electric Power Research Institute, United States

Advanced Coatings for Insulators & Conductors: Overview of EPRI Research

Mr. Engelbrecht has been internationally active in the field of insulation co-ordination since 1990. He convened CIGRE WG C4.303 that has completed the Guidelines for selecting HVDC insulators with respect to pollution. He has been Convener of CIGRÉ Working Group C4.23 as well as a member of IEC TC36 WG 11.

SYNOPSIS

Progress in materials science has resulted in development of advanced coatings that can be engineered to provide surfaces with specific desired properties, such as super-hydrophobicity as well as resistance to scratching, corrosion and chemical attack - properties that can prove highly beneficial for application on insulators operating in contaminated service environments. Advanced coatings have also been developed with the ability to repel water and ice from a surface. When hydrophobic, a treated surface repels water, which causes it to bead and roll off. Through this action, water droplets pick up and remove contaminants such as dust, dirt and salt from the insulator surface, resulting in a form of self-cleaning. In cold conditions, another aspect of hydrophobicity inhibits build-up of an ice layer since, when super-hydrophobic, water droplets bounce off a surface rather than sticking to it. This results in short contact time that does not allow water droplet to freeze onto the surface, thereby also inhibiting ice accretion - a property called 'icephobicity'. Coatings with ice repellant qualities can reduce risk of insulator flashover during winter storms and are also of interest for application on conductors and supporting structures where there is risk of mechanical overload due to ice accretion. In 2013, EPRI began research to investigate the applicability of advanced coatings to power systems and to provide a framework for utilities and network owners to qualify and specify them. This paper and presentation provides a background to the Advanced Coatings for Transmission and Substation Applications project and presents this research.

12:20

Dan Windmar

Vice President, STRI, Sweden

Progress on Revision of IEC 60383

Dr. Windmar received a Ph.D. degree in high voltage engineering from Uppsala University in Sweden. His professional experience includes extensive work in such areas as insulators (production, testing, materials), high power testing, high voltage testing and dielectric insulation. He has held several management positions at ABB and since 2009 has served as Vice President, Testing at STRI.

SYNOPSIS

IEC60383-1 "Insulators for overhead lines with a nominal voltage above 1000 V, part 1: Ceramic of glass insulators for a.c. systems – definitions, test methods and acceptance criteria" has not been revised since the 4th edition was released in 1993. The standard deals with four different types of insulators: pin insulators; line post insulators; string insulator units; insulators for overhead electric traction lines. While this standard has been stable and used frequently, the past ten years have seen a sharp increase in requests for non-standardized tests based on specific user requirements or adapted to meet more demanding conditions than in the standard. The main reason for this is that transmission system operators increasingly perceive that the tests specified are no longer stringent enough to fulfil their requirements. Indeed, different types of failures observed in service have only promoted development of more stringent testing, such as increased duration and increased number of samples, as well as certain entirely new test methods. In 2016, it was decided at the TC36 plenary meeting to begin revision of this important industry standard. This paper and presentation summarizes work done within IEC TC36 MT20 up until the summer of 2019, with a further update of on-going work also discussed. The final content and wording of the updated standard remains to be decided by MT20 as well as by the national committees of participating countries.

12:40

Ramiro Hernández-Corona

Research Engineer, INEEL, Instituto Nacional de Electricidad y Energías Limpias, Mexico

Effect of Cooling Towers on External Insulation of Substations

Mr. Hernández, an Electrical Engineer, graduated from Universidad Autónoma del Estado de Morelos, México and in1995 he obtained a Master of Science in the University of Salford in the United Kingdom. He has worked as a researcher for the Transmission and Distribution Division of the Instituto Nacional de Electricidad y Energías Limpia (National Institute of Electricity and Clean Energies) where his activities focus on modeling electromagnetic fields and evaluating behavior of external insulation on power networks under pollution. His achievements include development of test methodologies and selection criteria for polymeric insulators on transmission lines as well as Guides for visual inspection.

SYNOPSIS

Pollution is one of the main causes of failure of external insulation and therefore insulation design must always consider its potential impact. Moreover, in some cases pollution severity changes drastically due to external causes, reducing effectiveness of scheduled preventive maintenance and leading to service interruptions that can last hours. Among the pollution sources inherent in most power systems are the cooling towers of thermal power plants that extract heat from large volumes of water through evaporation and conduction. Steam generated during such extraction not only represents a means of wetting for nearby external insulation but, if steam conductivity is high, cooling towers also become another pollution source. Wetting of insulation can occur due to mechanisms such as condensation and the true impact takes place when vapor emissions cover and fully saturate the insulators. This presentation presents a case study where a power substation in Mexico has been exposed to the effects of nearby cooling towers. The affected insulators are glass and porcelain, some with more than 40 years' service. Over this time, insulators with different profiles and from different suppliers have been installed, both in primary equipment as well as for insulator strings. Insulation coordination has been maintained by applying hydrophobic coatings and by carrying out periodic maintenance. In addition, a leakage current measuring system was installed to predict risk of pollution flashover of insulators.

13:00
Lunch

INSULATOR TECHNOLOGIES & APPLICATIONS PART 3:
CANYON CONFERENCE ROOM Wednesday, Oct. 23 14:00 to 15:30

14:00
Steve Bell
Engineering Manager, K-Line Insulators, Canada

Case Study for Application of 400 kV Interphase Spacers

Mr. Bell holds a Bachelor of Applied Science ME degree from the University of Toronto. He has worked for K-Line Insulators for the past 5 years as part of the engineering and development team devoted to new composite insulator and interphase spacer designs and applications. His current involvement is focused on further improving insulator performance through research and product testing. He is an active member of IEEE/PES, including NEMA and ANSI C29 Insulator Working Groups and participates in current IEEE e-field sensitivity studies and Guide updates.

SYNOPSIS

A new overhead line in Scotland needed for increased renewable power transmission was designed with 400 kV capability but with circuits operated at 275 kV or 400 kV as needed. The new line follows the 220 km route of an existing 132 kV transmission line with single conductors from Beauly Substation to Denny North Substation. Due to concerns about galloping, interphase spacers were selected as mitigation to ensure reliability of this key link into the Scottish and Southern Energy grids. Since the route over hilly terrain experiences high winds combined with wet snow accumulations on conductors, composite interphase spacers had already been installed on the existing 132 kV line. Galloping is large amplitude, low frequency, wind-induced oscillation of overhead lines. In most cases, ice accretion on a conductor modifies the cross-sectional shape such that it becomes aerodynamically unstable. The types of ice and snow that can accrete on conductors are rime ice, glaze ice, frost, dry snow and wet snow. Amplitudes are principally vertical and can range from + 0.1 to 1.0 times the sag of a span, while frequencies usually range from 0.15 to 1.0 Hz. This paper and presentation reviews the background, engineering and installation of interphase spacers for a transmission line exposed to icing combined with driving winds between 8 to 72 km/h at an angle to the line of 10 to 90 degrees and that can be unsteady in velocity and direction.

14:20
Hector de Santos
R&D Engineer, La Granja Insulators, Spain

Smart Solutions for Insulator Condition Monitoring

Mr. de Santos received his Electrical Engineering Degree from the Technical University of Madrid, later completed his M.Sc. in Industrial Engineering and is currently working towards a Ph.D. at the ICAI School of Engineering at the Universidad Pontificia Comillas. After several years working for different power utilities as Project Engineer for overhead lines, he joined La Granja Insulators in 2014 as R&D Engineer. He is a member of the Spanish IEC TC 36 'Insulators', IEEE Power & Energy as well as Dielectric & Electrical Insulation Societies.

SYNOPSIS

Severe environmental and industrial pollution is a concern for electric utilities due possible resulting flashovers and unplanned line outages. In this regard, insulator condition monitoring is a valuable tool to allow maintenance actions, such as washing, to be scheduled when needed. Among the variables that can be monitored, leakage current stands out as the most meaningful since it provides a true measure of how close an insulator string is to flashover. The relationship between leakage current and environmental as well as climatic factors that can impact insulators has therefore attracted much attention. But since this relationship is complex and dynamic it cannot be successfully depicted using mathematical tools. This paper and presentation proposes a new solution for condition monitoring of insulators based on estimating leakage current from environmental and meteorological data with the help of machine learning. Such methods are a branch of Artificial Intelligence and allow computers to 'learn' from data. Set-up of different condition indicators is supported by leakage current data obtained from artificial pollution tests in a laboratory. Condition indicators can be also configured to measure Site Pollution Severity or to assess ageing of RTV silicone coatings. Results from a 3-year monitoring project in an outdoor test station show high accuracy when comparing estimated and actual condition indicators.

14:40
Jens Lambrecht
Manager, Application Engineering, Wacker Chemie, Germany

Silicone Gel: More Than Gap Filler

Dr. Lambrecht studied radio and power engineering, earning a doctorate degree from Dresden University of Technology. Since that time, he has made his career as a development engineer for silicone cable accessories as well as a specialist in application engineering for silicones for both medium and high voltage applications. He has been with Wacker Chemie since 2005.

SYNOPSIS

Silicone gels are a group of materials that usually appear as 2-component low viscosity fluids and cure to rather soft, viscoelastic materials when mixed and cured. They have become well known in the electrical insulation industry, particularly in casting applications where the very low elastic modulus of these soft materials is advantageous. Gel s were actually introduced as far back as the mid 19th century and at the time dealt mainly with colloids that consist of two non-mixable phases. These days, technically advanced silicone gels for insulation applications consist only of silicone polymers. In contrast to tightly cross-linked elastomers, the cross-linking density of silicone gels is low, allowing cured soft materials to fulfill important rheological conditions for gels, equality of storage modulus and loss modulus. From the point of view of material rheology, gel characteristics are attributed to a viscoelastic material when value of storage modulus (i.e. a measure of the ability to behave elastic) is about equal to that of loss of modulus (i.e. a measure of mechanical dampening ability). Soft silicone gels fulfill that condition and are therefore a perfect, low viscosity, castable, soft, elastic and dampening insulation material. Moreover, silicone gels show the same beneficial electrical behavior as silicone elastomers while the low viscosity of uncured components allows incorporating a variety of fillers. This paper and presentation discusses results of recent research into silicone gels.

15:00
Coffee Break & Visit to Exhibition

INSULATOR TECHNOLOGIES & APPLICATIONS PART 3:
CANYON CONFERENCE ROOM Wednesday, Oct. 23 15:30 to 16:40

15:30
Eduardo Hilsdorf
Sales Director, PPC Santana, Brazil

Hybrid Insulators for Distribution Lines: Advantages & Application Experience

Mr. Hilsdorf, an Electrical Engineer with both M.Sc. and MBA degrees, has had an extensive technical background in the field of high voltage power equipment, electrical system maintenance, service and distribution. He is responsible for product technical design and performance and has also managed R&D projects. He is also an active member of ABNT/COBEI, the Brazilian Standards Committee.

SYNOPSIS

Extreme service conditions and heavy pollution such as encountered in industrial, desert or coastal environments can lead to electrical activity on insulators in the form of high leakage currents. The polluted surface of an insulator operating in such regions can then lead to flashover and ultimately to outages. At the same time, power networks worldwide are striving to avoid such blackouts as well as any frequent shutdowns of lines due to maintenance activities such as washing. While the majority of insulators currently in use on transmission and distribution networks worldwide are porcelain, use of polymeric composite insulators has been increasing rapidly. A combination of these technologies has now emerged as a new class of insulator - the hybrid - combining known advantages of a porcelain core such as mechanical strength, stability and longevity with the excellent performance of silicone housings in highly contaminated service conditions. Until recently, there was no standard defining classification and testing methodology for hybrid insulators and this resulted in manufacturers creating their own classifications and test methods with both good and bad solutions. Fortunately, a new IEC standard provides definitions, test methods and acceptance criteria for hybrid insulators for AC and DC applications. This paper and presentation reviews R&D work as well as field application experience over the past 15 years with medium voltage hybrid insulators.

15:50
Giovanni Giobbe
Design & Technical Dept., EB Rebosio/Gruppo Bonomi, Italy

Application of Interphase Spacers to Transmission Systems

Dr. Giobbe graduated in electrical engineering from Genoa University and has been an expert in overhead line insulation since the 1980s. A speaker at several past INMR WORLD CONGRESSES, he is a qualified member of EB Rebosio's design and technical department, with primary focus on composite insulators. This sector is a branch company of Gruppo Bonomi - a manufacturer of electrical components for railways as well as medium voltage and high voltage applications.

SYNOPSIS

The key function of a phase spacer is to prevent the approach of phase conductors on a high voltage overhead circuit due to formation of ice sleeves and the presence of strong wind. Such natural events can lead to deflection of conductors that are subjected to the increased mechanical loads being generated. In the case of ice sleeve formation, different possible outcomes can arise. For example, an ice sleeve deposited on the lower phase can disperse while that deposited on the upper phase remains. Any whiplash oscillation triggered on the lower phase can then bring it dangerously close to the upper phase still fitted with the ice sleeve and generate discharge between the phases due to jumping. Similarly, during heavy ice storms where wind blows sideways to a line, rotational movements can occur that cause permanent deformation of the conductor as well as significantly increased load on both line insulators and the towers themselves. In the most serious cases, this can even lead to collapse of structures supporting the line. This paper and presentation explains how proper engineering and application of phase spacers in these types of situations can counteract excessive rotational forces on phase conductors and help avoid these types of issues.

16:15
Jens Seifert
Senior Expert, Reinhausen Power Composites, Germany

Innovative Applications & Developments of Hollow Core Composite Insulators

Dr. Seifert obtained his Ph.D. degree from TU Braunschweig in 1998. He has had 20 years of experience in development of composite materials for high voltage insulating applications. In 2018 he joined the MR Group as Senior Expert for basic development. He serves as Chairman of IEC TC 36 Insulators and is also Convener of CIGRE Working Groups D1.58 and D1.59.

SYNOPSIS

If traditional porcelain station post technology sustains catastrophic failure through being overstressed, this is normally easily apparent by fracture of the porcelain body. By contrast, structural damage to an insulator based on composite hollow core technology may not be so easy to detect visually. Examples include cracking of the composite tube or de-bonding of insulator bolting flanges, where rapid detection of such failures is generally obscured by the exterior sheath of silicone sheds. There may also be failure of the fittings, but this can normally be seen. A commonality to all failure modes is that they are all integral to gas pressurization of the hollow composite station post. As such, monitoring gas pressure within a hollow core station post allows extrapolation of the insulator's mechanical integrity. This paper and presentation introduces the concept of a 'Smart Insulator' and reviews field application of this new technology. The term 'smart' has become ubiquitous these days and generally connotes a device that has some intelligence. Introduction of such a self-diagnostic capability to station post insulator technology gives credence to this term since structural integrity of the insulator can be assessed immediately after any structurally traumatic event and appropriate action taken.

INSULATOR TECHNOLOGIES & APPLICATIONS PART 3:
CANYON CONFERENCE ROOM Wednesday, Oct. 23 16:40 to 17:40

16:40

Igor Gutman

Sr. Expert, Independent Insulation Group, Sweden

Software for Line Design & Operation: Case Studies

Dr. Gutman received his M.Sc. and Ph.D. from Leningrad Polytechnic Institute and developed experience over 40 years – starting at the Lenin-grad HVDC Transmission Research Institute. His later work involved outdoor insulation, particularly composite insulators. In 1994 he joined STRI where he specialized on optimal dimensioning of insulation; ageing and accelerated ageing tests. He has published 200 papers and is Sr. Member of IEEE. He is also member of Swedish IEC TC 36, Distinguished Member of CIGRE and active within CIGRE/IEC/IEEE. In 2011, he became Honorary Professor at St. Petersburg Power Engineering Institute and was the 2012 recipient of the Claude de Tourreil Memorial Award for Lifetime Achievement in the Field of Electrical Insulators. He is 2013 recipient of IEC 1906 Awards in recognition of service to international standards.

SYNOPSIS

Specialized software has become available to assist statistical dimensioning of insulators intended for service in polluted areas. The methodology took 10 years to develop including conversion into software that verifies calculations by comparison with service experience. For example, the Line Performance Estimator (LPE) Program goes back to the 1990s when the Norwegian TSO started a major upgrade of 300 kV AC lines to 400 kV with the requirement that system reliability would remain the same. This was resolved using statistical dimensioning which, after implementation, was converted into software that is presently available for both AC and DC applications. The capability of the LPE program is not limited to pollution performance but also includes insulator icing as well as lightning and switching overvoltage performance. The aim is to provide users with a complete view of the estimated insulation performance of any transmission line as a function of insulator length. The program not only estimates performance of the complete line but also shows how calculated insulation failure rates are distributed among different line sections. This presentation provides a description of these software programs, their features as well as relevant theoretical background and also discusses practical cases where they have been implemented.

17:00

Hokyoung Lim

Sr. Manager, Transmission & Substation Operations,
Korea Electric Power Corp., South Korea

Development of HV Live Line Testers for Porcelain Insulators Using LoRa Communication

Mr. Lim is a Senior Engineer with KEPCO, one of the world's largest power system operators. He has been working in the Transmission and Substation Department for 12 years now, focusing on transmission line management, especially in regard to insulators and line arresters. He has been a speaker at past INMR WORLD CONGRESS events.

SYNOPSIS

Among the recent trends in the global electricity supply industry is a continuous increase in the voltages used for long distance transmission. Accordingly, the number of insulators needed in suspension strings has also been increasing. In Korea, for example, a total of about 10 million suspension insulators - porcelain, glass and polymeric type - are used on 765 kV, 345 kV and 154 kV lines, with some 99% of this population being porcelain. Generally, defects in porcelain insulators occur due to possible structural limitations in material strength, insulation strength or mechanical strength. Since these types of deficiencies can directly contribute to transmission line failure, there has been a need for ongoing research to improve monitoring of in-service insulators with a view to detecting damaged suspension insulators before they fail. A variety of different methods have been used to diagnose the condition of porcelain suspension insulators, including measuring voltage and field distribution, ultrasound inspection and testing insulation resistance. However, there remains need for a test methodology that combines high reliability and improved efficiency. This paper and presentation introduces a new diagnostic system developed by Korea's TSO, KEPCO. The LoRa wireless communication, real-time performance tester is expected to play a major role in improving diagnostics for porcelain suspension insulators in Korea and elsewhere.

17:20

James Brady

Level-III Certified Infrared Thermographer, Level-I UVigrapher,
Brady Infrared Inspections, United States

Corona & Infrared Inspections of Power Lines

Mr. Brady has more than 17 years of experience in all aspects of thermal imaging of electrical systems and has expertise to design projects, provide technical oversight of field technicians and approve final reports to clients. Looking to apply innovative technologies, he has aimed to provide his clients with better options, as demonstrated by drone-based thermal surveys and solar blind UV corona camera inspections. A respected opinion leader in this industry, Mr. Brady frequently gives technical presentations on unique projects he has accomplished.

SYNOPSIS

Corona discharges in the high electric field region of an insulator are linked to an ionization process involving continual transfer of electrons being knocked from orbit and recaptured. Energy released in the form of photons is the glow commonly observed on some power infrastructure during low light conditions and can also be detected during daytime using a solar blind UV camera. In order for corona activity to exist, high electric field is needed, combined with how the shape of an energized component influences that field. Sharp edges, corners, points, tight radius and other irregularities within an area of high E-field all have the potential to initiate corona. This presentation reviews the background and findings from inspections carried out on behalf of Florida-based utilities that share operation of a critical 138 kV transmission line. The utilities had contracted these inspections to identify incidence of corona in response to recent insulator failures and as part of a program of annual visual and infrared inspections to search for possible threats to reliability. The inspection identified vulnerabilities and allowed corrective action to be taken in regard to both critical and non-critical threats.

INSULATOR TECHNOLOGIES & APPLICATIONS PART 3:
CANYON CONFERENCE ROOM Wednesday, Oct. 23 17:40 to 18:30

17:40

LEE Yanmin

Chairman, Square Silicone, China

Conducting Liquid Silicone Rubber with Carbon Nanotubes & Carbon Black

Dr. Lee graduated from South China University of Technology with a degree in polymer science and was awarded a DBA from the Université of Nice Sophia Antipolis in France. He founded Square Silicone in 2002, which became the first company in China to start local industrial production of additional type LSR. The company began supplying applications in the energy field in 2004. As Chief Material Expert, he has been taking part in research of LSR used in high voltage cable accessories for DC as well as for glass insulator coatings at the electrical technology laboratories of Tsinghua University's Shenzhen Campus.

SYNOPSIS

Carbon nanotubes (CNTs) have unique structures as well as excellent electrical conductivity, which make them suitable for widespread use in preparing composite materials. In recent years, increasing attention has been paid to studying the mechanical and electrical properties as well as heat resistance of CNTs and polymer composites. However, research into composite materials of liquid silicone rubber (LSR) and CNTs has only recently started. LSR has excellent fluidity and is particularly suitable for injection molding, allowing for high automation, process stability and high efficiency. Vulcanized LSR also has excellent thermal stability, insulation, resilience and weather resistance, making it highly suitable for electrical insulation and stress control applications. But the large aspect ratio of CNTs can lead to anisotropy of electrical conductivity due to orientation of calendaring in the dispersion process. Moreover, CNTs bypass each other and, due to Van Der Waals Forces, fluidity of silicone rubber can decrease and form a viscoelasticity that is disadvantageous during injection molding. This paper and presentation reviews research into overcoming these challenges.

18:00

Summary of Session/Questions

CABLE & ACCESSORY TECHNOLOGIES & APPLICATIONS
MURPHEY CONFERENCE ROOM

Wednesday, Oct. 23
08:00 to 09:15
Session Chairman:
Klaus-Dieter Haim, Professor, Zittau-Gorlitz University of Technology, Germany

08:00

Hansjoerg Gramespacher

Director & Consultant, ec4ac Engineering, Switzerland

Requirements & Challenges in Technology & Application of HV Cable Joints

Dr. Gramespacher studied physics and received his PhD from ETH Zurich. He has worked for more than 15 years at international companies in Germany and Switzerland in development of medium and high voltage cable accessories. One of his main research activities has been developing non-linear field grading material. In 2014, he founded ec4ac, a consulting company that offers technical support in high voltage cables and cable accessories for both AC and DC.

SYNOPSIS

Pre-moulded joints for polymeric high voltage AC cables have been in operation for decades and their production, testing and application is a well-known technology. Nevertheless, there still exist a relatively large number of joint failures during type tests or pre-qualification tests, with about 30% failing in the first attempt. One reason for this is too high temperature in the joint during heat cycling tests required by international standards. This is often caused by a variety of possible errors during installation, making this an important topic to resolve. Another issue that has become important is temperature monitoring of HV cable systems using optical fibres. Distributed temperature sensing, together with software tools that allow conductor temperature of a power cable to be calculated, make real time thermal rating of a cable system possible. However, at joints, the thermal environment around the cable connector differs from that of the cable itself, making calculation of conductor temperature inside the joint more difficult. In combination with possible issues during installation, temperature inside the joint can be much higher than at the cable. This can lead to increased ageing of cable insulation inside joints and, in the worst case, to joint failure. This paper and presentation reviews requirements in application of HV cable joints that are still under discussion, including thermal resistivity of joints and electrical losses at cable connectors. These parameters influence temperature inside a joint and therefore reliability of the entire cable system.

08:25

Lukasz Chmura

Product Development Engineer, Royal Lovink Enertech, the Netherlands

Future Challenges for Cable Accessories in MV Networks

Dr. Chmura received his MSc from Warsaw University of Technology in Poland. In 2009, he joined Delft University of Technology in the Netherlands where he completed his doctoral research in the field of asset management. His post-doctoral study was on impregnation optimization of transformer insulation. He has worked on various aspects of HV and MV insulation such as ageing, diagnostics and failure statistics. He is a member of IEEE and CIGRE WG D1.39. Currently, he is focused on developments in the field of MV joints and also lecturer at Delft University of Technology in the field of high voltage and diagnostics.

SYNOPSIS

In recent years, the architecture of power systems has been undergoing a major change. The commonly known structure with centralized generation and uni-directional power flow has gradually been giving way to the concept of a power network where both the energy generators and the energy consumers are distributed. In particular, continuously increasing environmental concerns as well as legal regulations have resulted in more widespread installation of renewables. Moreover, storage devices are now being incorporated into power networks to cope with sudden increases in generated energy. To facilitate energy flow from renewables towards the power network, proper voltage level is maintained by means of transmission controllers that consist of high frequency switching elements. The operation of such devices introduces high frequency harmonics that are propagated in the vicinity of the installed controller. On one hand, high content of harmonics is an emerging issue for power networks. On the other, research has shown that high frequency signals can have a possible deleterious impact on reliability of electrical insulation. Finally, for many years harmonic content has not been considered either during component design or testing. This paper and presentation reviews published research regarding influence of harmonics on reliability of cables, terminations and transformers. In addition, an approach is proposed to model influence of high frequency on electric field and temperature distribution in two types of medium voltage cable termination.

08:50

Detlef Klingberg

Technical Manager, Application Engineering Energy, Wacker Chemical Corp., United States

Interesting Aspects of Special Cables with Silicones

Dr. Klingberg studied Chemistry earning an M. S. degree from the University of Saarland in Saarbrücken, Germany, and a doctorate degree from the University of Utah in Salt Lake City. Since 1996, he has been employed by Wacker Chemical Corp. specializing in application engineering in the wire & cable industry and in the T&D industry.

SYNOPSIS

Over the past decades, silicones have emerged to become a key material serving the needs of the transmission and distribution industry. In fact, there has been a clear trend towards replacing older technologies, such as glass and porcelain, with high-consistency and liquid silicone rubbers. For example, long rod and hollow-core composite insulators and arresters are increasingly made using silicone elastomers. In addition, silicone high voltage insulator coatings are used to give ceramic and glass insulators the pollution performance advantages that silicone has to offer. Similarly, manufacture of high-tech cable accessories also demands a fine-tuned portfolio of insulating, semi-conductive and conductive silicone elastomer products. For the wire and cable industry, silicone elastomers feature benefits such as outstanding heat resistance, excellent electrical properties, high-speed extrusion capability and flexibility of the final product. One application that has emerged in recent years is use of silicone rubber compounds for fabrication of fire safety cable products that survive a fire for a certain time while maintaining electrical circuits in a building to help ensure safe evacuation. This paper and presentation reviews current international standards for fire safe cables and discusses the mode of action and advantages of silicone for this and other cable-related applications.

CABLE & ACCESSORY TECHNOLOGIES & APPLICATIONS
MURPHEY CONFERENCE ROOM Wednesday, Oct. 23 09:15 to 10:40

09:15

Falk Hardt

Head, Product Portfolio & Cable Accessory Development, Pfisterer Holding, Germany

Shearbolt Connectors for LV/ MV Underground Power Cables: Reliability & Failure Modes

Mr. Hardt is an Electrical Engineering professional. He has had more than 24 years of experience in manufacturing as R&D-Manager for connectors and fittings as well as in development of underground power cables and accessories. He has in-depth knowledge of related production processes, quality and environmental management and holds patents for bolted technology and ring connector technology.

SYNOPSIS

The technology of shear bolt connectors for current transmission has developed quickly. The principle was first introduced in the early 1980s when manufacturers sold the first types of low voltage bolted connectors. The next step was adopting shear bolt technology for use in low voltage cable applications, where required torque moment was a pre-set parameter machined into the bolt. Based on positive field experience, shear bolt connector technology was adapted for use in medium voltage applications as well. But cable accessories up to 42 kV require concentric connector bodies and smooth outer surface, without sheared off bolts standing proud and no sharp edges at the connector and bolts. In the 1990s, connector manufacturers introduced different types of multiple shear bolts, allowing a requested torque moment to a particular cable cross-section while ensuring that bolts shear off flat with the outer circumference of the connector body. At the same time, IEC 601238-1 was established to replace former local standards and set higher requirements in terms of contact ageing. The most important advantage of bolted contacts is that one connector type applies for different cross-sections and conductor materials. This created a user-friendly and reliable connector, simplifying allocation of conductor cross-section to connector. These days, those same principles and connector body design have been adapted and optimized to cover cross-sections of up to 3000 mm² and even for HV/EHV applications. This paper and presentation describes the advantages of shear bolt technology and shows results of an assessment in regard to network reliability and failure modes identified.

09:40

Stefan Kornhuber

Professor, Zittau-Görlitz University of Technology, Germany

Long-Term Experience with Cable Joints under Water Stresses

Dr. Kornhuber received his Electrical Engineering Degree and later his doctorate from Graz University of Technology with main research on temperature measurement and uprating of OHTLs. Until 2006, he worked at the Test Institute for High Voltage Engineering in Graz doing testing, simulation and investigation of stresses of transients. He later joined Lemke Diagnostics/ Doble Lemke with responsibility for production, development and sales and then ABB Power Transformers as Head of Condition Management as well as on-site and local HV test field and systems. In 2014, he was awarded Professorship in High Voltage and Theoretical Electrical Engineering. His research topics are electrical interfaces of polymeric materials as well as diagnostic test and measuring methods. He is a member of several Working Groups and Convenor of CIGRE D1.58 and IEC TC 112 WG3.

SYNOPSIS

To ensure reliable medium voltage distribution networks, it is important that cable components can withstand a range of electrical, mechanical, thermal and ambient stresses. Water is one of the main factors behind degraded insulation. If the tightness of cable joints or cable shielding is not assured, moisture ingress can adversely affect the inner interface and lead to internal puncture. Several construction methods are used to protect this critical inner joint system and a special water stress test procedure has been developed to ensure correct tightness and functionality. As part of this process, a special test stand was designed to expose joints without outer protection systems to combined stress with water and medium voltage and several joints were investigated over a period of up to 10 years. Some joints were stressed with continuous voltage while others were stressed electrically at prescribed intervals. During the continuous stress by water and voltage, breakdown voltage tests, PD tests and visual examination after dismantling were performed. This paper and presentation outlines the test set-up and different test objects studied, reviews results after the long-term evaluation and offers key conclusions.

10:15
Coffee Break & Visit to Exhibition

10:40

Doug Craigen

Team Leader, Benchmark & Testing, Integrated Engineering Software, Canada

Efficient Simulation of Electric Line Parameters for Cables

Dr. Craigen has a B.Sc. with Physics Major from the University of British Columbia and M.Sc. and PhD in Semiconductor Physics from the University of Waterloo (1991). Since then, he has served as Assistant Professor at Acadia University and taught as well as researched at the University of Winnipeg. He was also self-employed, working for companies in magnetic shielding, interfacing equipment to computers, modeling microwave communication networks and analyzing test data. In 2001, he joined Integrated Engineering Software and has since worked with scientists and engineers across the globe, assisting their decisions about how best to use software for simulations across a diverse range of electromagnetic and thermal applications.

SYNOPSIS

Electromagnetic transient analysis of cables is an important aspect in design of electric power systems. While direct modeling of specific transient cases using methods such as finite element analysis is possible, it is not practical. Rather, it is preferable to conduct a frequency dependent analysis of self- and mutual-impedances as well as of constituent parameters such as capacitance, inductance, resistance and conductance between the individual conductors. These types of results can then be used efficiently, as needed, for a multitude of specific transient cases utilizing dedicated software. However, before using such results it is generally necessary to assess the accuracy of a large number of individual results relative to the needs and each set of these results can take significant time to calculate. This paper and presentation provides a case study for a process to efficiently assess accuracy of results for a four-sector cable and sheath and adjust solver conditions as necessary.

11:05

Paul Leufkens

President, Power Projects Leufkens, United States

Damped AC for Commissioning & Diagnostic Testing of HV Cables

Mr. Leufkens holds an MS EE Degree from Delft Technical University in the Netherlands and has had more than 20 years' experience as an executive in the power sector. He worked internationally for consulting and testing companies, including 13 years with KEMA in Netherlands and in the United States. Previously he directed product development in the cable and switchgear industry. In recent years, he has built technical and business cases for new High Voltage, High Power and Energy Storage laboratories as well as a technical and commercial market introduction of new generation switchgear. His U.S.-based consulting firm now provides strategic support to manufacturers and testing organizations in growing their business.

SYNOPSIS

Reliable transport is fundamental for on- and offshore energy infrastructure and that implies maintaining strict quality control on all newly installed as well as service-aged cable connections. In this regard, important issues for any transmission grid operator to ensure reliable network operation and responsible asset management include: how best to detect risk of workmanship related defects on newly installed cable circuits in a sensitive yet non-destructive way; and how to perform non-destructive diagnostics on in-service cable circuits in order to determine their actual condition. Based on present IEC standards for power cables up to and above 150 kV operating voltage, test protocols after installation of power cables are limited to minimum manufacturer recommendations and do not meet the need to keep failure risk during operation as low as possible. By contrast, IEEE 400 and IEEE 400.4 standards recommend partial discharge monitored testing, for example using continuous or damped AC voltage (DAC). This paper and presentation focuses on use of DAC for after-laying testing and diagnostics on all types of transmission cables, based on experience collected over more than 15 years and across many different power grids worldwide.

11:30

Guoyan Sun

Scientific Engineer, Brugg Cables, Switzerland

Optimizing a HV Joint to Withstand High Short-Circuit Current Faults

Dr. Sun received her doctorate in nuclear physics and has worked for many years at nuclear research institutes in China, Germany and Switzerland. In 2007, she joined Brugg Kabel AG where her main activity is feasibility study of new high-voltage cable accessory products, using finite element method simulation that couples multi-physic phenomena, i.e. electromagnetic, thermal & mechanical.

SYNOPSIS

Developments in today's power distribution and transmission networks are leading to higher and higher levels of short-circuit current. That means that high voltage cables and accessories in a system are under growing dynamic and thermal stresses during any short-circuit faults. Short circuits occur when an accidental or intentional conductive path between two or more conductive parts forces the electric potential difference between the parts to be equal or close to zero. This results in a huge amount of current flowing in the circuit, consisting of a DC component as well as an AC component at the same frequency as the system. High voltage equipment in the system must be able to withstand the dynamic and thermal stresses during such short circuits and, at present, cable accessories are being systematically updated to withstand short-circuit current of 63 kA for 1 s. This paper and presentation discusses optimization of a cable joint that then successfully passed thermal short-circuit testing.

11:55

Hansjoerg Gramespacher

Director & Consultant, ec4ac Engineering, Switzerland

Reliability of HVDC Cable Joints: Today & Future Challenges

Dr. Gramespacher studied physics and received his PhD from ETH Zurich. He has worked for more than 15 years at international companies in Germany and Switzerland in development of medium and high voltage cable accessories. One of his main research activities has been developing non-linear field grading material. In 2014, he founded ec4ac, a consulting company that offers technical support in high voltage cables and cable accessories for both AC and DC.

SYNOPSIS

Due to the large number of joints in land-based HVDC cables, which can easily reach over 1000 in a single system, failure rate of joints plays a decisive role in overall system performance. Unfortunately, routine tests in the case of HVDC cable joints may not be sufficient to guarantee high reliability during operation. This is because electric field in some regions within an HVDC joint during operation can be much higher than seen during routine testing due to the fact that field distribution in such a joint is highly sensitive to temperature. Therefore, to properly cover field distribution in the joint at higher conductor temperatures, additional electrical testing may be needed. This paper and presentation explains how simulation has shown that fields in some parts of an HVDC joint can be higher during operation than seen during the DC routine test according to IEC 62895. That means that not all critical defects in a joint can be detected during routine tests, which will increase failure rate during operation in the field. Performing an additional DC routine test with higher temperature is recommended.

12:15

Paolo Miolo

Marketing & Sales Director, CESI, Italy

Experience from Long Duration Tests on Extruded Cable Systems up to 525 kV DC

Dr. Miolo received a Doctor's Degree in Electrotechnical Engineering from Padova University in 1994 and has worked more than 20 years in the energy sector. After technical training and experience in HV equipment, he started a career with Coelme and later with Alstom Grid where he rose to the position of country sales director. He joined CESI in 2014 where he supervises sales activities for the testing division, with laboratories in Milan, Berlin and Mannheim.

SYNOPSIS

Growth in installation of cable systems worldwide is being driven by the boom in renewable power generation, increased use of interconnectors and submarine cables construction of urban substations in cities with huge populations and general public resistance to new overhead lines. In this regard, both transmission system operators and distribution system operators are looking for innovative solutions to further develop their grids while also demanding components that deliver the highest quality. Moreover, especially for long distance transmission with minimal losses, DC is finding more and more preference, in some cases helping supplant old HVAC networks. For example, many billions will be made in new investments in HVDC over the next two years to keep pace with development of renewables globally while, over the next decade, the market for HV submarine cables will reach $ 25 billion, with about 3/4 of the projects located in Europe. Independent testing and certification provided by a third party is seen as the best way to deliver the qualification process for a cable system so that utilities and network operators can be confident of delivering a reliable electricity supply. This paper and presentation highlights experience gained during the first long duration tests for 525 kV DC cable systems, performed both in the laboratory and outdoors.

12:35

Klaus-Dieter Haim

Professor, Electrical Engineering, Zittau-Görlitz University of Applied Sciences, Germany

Cable Accessory Technologies: Current Situation & Developments to Watch

Professor Haim studied Electrical Engineering at the University of Zittau earning his Doctor's degree in 1985 in the field of MV network design and optimization. His career has covered a diverse range of assignments, from a research project for EDF to serving as a Professor in Algeria. Between 1994 and 2005, he worked as Head of Production for medium voltage cable accessories before assuming his current position. He is a Sr. Fellow for electrical power systems and networks and Dean of the Electrical Engineering Department at University of Applied Sciences Zittau/Görlitz.

SYNOPSIS

Along with the expected future energy transition toward increased importance of electricity will be a significant change in the contribution of low and medium voltage networks to smart grids. With this, the ratio of cables compared to overhead lines at these voltage levels will increase and, in fact, in some countries has already reached 100 percent. In the case of high and extra high voltages, although overhead lines will remain the dominant means of power transmission, the relative important of cables will increase as well. In terms of technology, polymeric cables have now become a cost effective and extremely reliable solution for all AC applications and voltages as well as for most DC cable applications. With this, the main cause of cable system failures these days is either mechanical damage by third parties or poor workmanship during installation of accessories. In this regard, responsibility for errors during installation is not due only to workers installing joints. Rather, manufacturers of accessories can also influence failure rates through use of quality materials as well as application of fault tolerant installation methods. This paper and presentation reviews alternative installation technologies and different insulation materials, from the low to the extra high voltages. The focus is on accessory insulation and also on connection of conductor and cable screen as well as on outer protection against both moisture and mechanical damage.

12:55
Summary of Session/Questions

13:00
Lunch

ARRESTER TECHNOLOGIES & APPLICATIONS PART 2: SONORAN 1 & 2 CONFERENCE ROOM

Wednesday, Oct. 23
10:40 to 12:10
Session Chairman:
Jonathan Woodworth, Principal, ArresterWorks, United States

10:40

Michael Champagne

Senior Engineer, Waldemar S. Nelson & Company, United States

Protecting Neutral Terminals of Power Transformers in Distribution Substations

Mr. Champagne received a BSc in Electrical Engineering from Louisiana State University. Beginning 1987, he worked 28 years in the electric utility industry in areas including distribution line design, construction and maintenance, transmission line maintenance, transmission planning and substation design. Since 1999, he has been active in high-voltage working groups of the IEEE Power and Energy Surge Protective Device Committee and contributed to test standards and Guides in arrester testing and application, utility neutral grounding and insulation coordination. He also served as technical advisor to a NEETRAC project and is currently Chair of the high voltage subcommittee for SPDC. In 2015, he joined a private consulting firm, where he works on industrial design projects that include arc flash hazard calculations.

SYNOPSIS

When delta-wye power transformers are installed in distribution substations, common practice is to ground the neutral of the wye-connected windings directly to the substation ground using an adequate conductor in which no impedance has been intentionally inserted. Such an arrangement is said to be solidly grounded. However, in many installations, the transformer is grounded through an impedance - whether resistive or inductive - or even altogether ungrounded. While a transformer's neutral remains solidly grounded, there is no change in voltage between its neutral and ground. However when a transformer is resistively or inductively grounded, or ungrounded, there is likelihood of large voltage developing during ground faults or whenever surges occur. It is therefore important to protect the neutral terminal in such applications from surges that can develop as the result of a transfer from the primary, secondary, or tertiary terminals of the transformer. The current version of IEEE C62.22 *(Guide to the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems)* offers limited advice on how to apply arresters on impedance-grounded or un-grounded transformer neutrals but is currently under revision. This paper and presentation discusses selecting and applying arresters to protect neutral terminals of transformers, given the soon-to-be updated Guide's explanation of how surge voltage is transferred through a transformer.

11:10

Prof. HE Jinliang

Chair of High Voltage & Insulation Technology Research Institute, Tsinghua University, China

Development & Application of Polymeric Surge Arresters for Transmission Lines in China

Professor He received a PhD in high voltage engineering from Tsinghua University in Beijing in 1994. Currently, he is a Cheung-Kong Scholar Distinguished Professor of the Ministry of Education of China in the Department of Electrical Engineering, Tsinghua University and leads the university's High Voltage and Insulation Technology Research Institute. His research interests include lightning and overvoltage protection technology, advanced power transmission technology, sensor network and big data mining, nano-dielectric materials for recycling HVDC cable and environment-friendly gas-insulated power transmission lines. He was Chairman of several international conferences, is Convener of CIGRE C4.26 and a Fellow of IEEE and IET.

SYNOPSIS

According to data on power system failures, lightning is the most significant cause of power grid trip-outs in China. Moreover, total average lightning trip-out rate over 5 years reached about 62% of all transmission line trip-out faults. For example, recent lightning trip-out failure rates on 110 kV, 220 kV and 500 kV lines in the southeastern Province of Guangdong were 68.7%, 47.8% and 60.3% respectively. In spite of this data, lightning protection performance of transmission lines has been improving greatly due to application of polymeric-housed ZnO line arresters that are being put into operation in parallel with insulators to limit overvoltages. This presentation addresses some of the key issues necessary for line arresters to achieve the most effective lightning protection of a transmission line, including the design principle of series gaps as well as insulation coordination between the line arresters and the insulator strings. The so-called 'transverse discharge' phenomenon caused by the proximity effect of the discharging ring of the line arrester is also introduced as is selecting the correct distance between line arrester and insulator string. Another topic discussed is development of high voltage gradient ZnO varistors to allow reduced length of line arresters.

11:40

Haley Engel

Marketing Manager, Hubbell Power Systems, United States

Advantages of Enhanced Silicone Polymer for Distribution Arresters

Ms. Engel received her Bachelor of Science in Mechanical Engineering from Texas Tech University. She joined Hubbell Power Systems in 2017 as an Application Engineer and is currently in charge of marketing for the arrester business unit.

SYNOPSIS

Power distribution equipment these days is expected to last decades, even in harsh environments. In the case of distribution arresters, because the polymeric housing protects the internal metal oxide varistor discs, the service life of critical equipment can be directly related to lifetime of the polymer. Polymeric insulation materials used in distribution arrester housings are typically defined by a base polymer suitable for electrical insulation but also contain a variety of fillers and additives that enhance performance characteristics. It has become common belief that the single most important characteristic for insulating materials is their ability to shed water or cause water films to bead, thereby breaking up potential paths for leakage current. But other important characteristics, apart from hydrophobicity, must also be taken into consideration. It is the combination of all required characteristics that contribute to long-term performance and these include: resistance to tracking and erosion; resistance to UV; high mechanical strength; low moisture permeability; and short-term as well as long-term hydrophobicity. This paper and presentation highlights the extensive development history behind an enhanced silicone polymer and demonstrates its benefits as a reliable housing material for both distribution arresters and other system critical equipment.

ARRESTER TECHNOLOGIES & APPLICATIONS PART 2: SONORAN 1 & 2 CONFERENCE ROOM Wednesday, Oct. 23 12:10 to 14:00

12:10

Rogerio Verdolin

Principal, Verdolin Solutions, Canada

Application of Surge Arresters in Mitigating Breaker Transient Recovery Voltage

Dr. Verdolin received B.Sc. and M.Sc. degrees in Electrical Engineering from the Federal University of Rio de Janeiro and a Ph.D. from the University of Manitoba. He spent more than 20 years with CEPEL Electrical Energy Research Centre in Brazil, where he managed the high voltage laboratory as well as research programs from utilities and equipment manufacturers. He has worked with GE Energy Services, SNC Lavalin, Enmax, ATCO and Teshmont Consultants supporting substation design, HV equipment specifications, power system transient overvoltage studies and services including transient recovery voltage, insulation coordination and geomagnetically-induced current simulations. He has long involvement with IEEE, including the PES Transformers Committee and is currently Chair of two working groups and Secretary of the Performance Characteristics Subcommittee. He has authored many technical papers and is a member of APEGA, IEEE and CIGRE.

SYNOPSIS

Transient Recovery voltage (TRV) of a circuit breaker is the difference of voltage measured between each side of the breaker to ground. The most severe TRV, from an amplitude point of view, follows interruption of the first phase to clear an ungrounded three-phase fault. In such cases, shift in system neutral results in high amplitude TRV. While probability of this fault ever occurring is low, it is nevertheless the basis for rating a breaker's TRV capability. TRV should be measured across the terminals of all circuit breakers in the substation under study and three-phase ungrounded faults, three-phase grounded, and short line faults near the circuit breakers should all be applied. Moreover, several fault locations should be applied to find out the worst system TRV on breakers in order to test breaker capabilities. For example, a breaker clearing a capacitor bank is also prone to restrike due to TRV. Similarly, transmission lines and equipment connected to the station busbar impact the TRV for the three-phase ungrounded fault test. When studying TRV, it is necessary to ensure that all suitable lines, transformers and bus equipment are represented in the simulation. This paper and presentation investigates dielectric performance of circuit breakers during a zero current interruption process and application of surge arresters in mitigating breaker TRV.

12:35

Paul Leufkens

President, Power Projects Leufkens, United States

Developments to Watch in HV Surge Arresters

Mr. Leufkens holds an MS EE Degree from Delft Technical University in the Netherlands and has had more than 20 years' experience as an executive in the power sector. He worked internationally for consulting and testing companies, including 13 years with KEMA in Netherlands and in the United States. Previously he directed product development in the cable and switchgear industry. In recent years, he has built technical and business cases for new High Voltage, High Power and Energy Storage laboratories as well as a technical and commercial market introduction of new generation switchgear. His U.S.-based consulting firm now provides strategic support to manufacturers and testing organizations in growing their business..

SYNOPSIS

Reliability of substation equipment is a major concern to power system operators since failures can result in significant outages along with associated restoration efforts as well as possible safety issues. There are financial implications as well. Moreover, poor reliability contributes to higher system operating and maintenance costs. Metal oxide surge arresters are installed in substations and on transmission lines to limit lightning and switching induced overvoltages to some specified protection level. Experts in Working Groups have recently been addressing several topics relevant for reliable design and operation of surge arresters with focus on energy handling capability of MO resistors when stressed with repeated and multiple current impulses of different wave shape and changing polarity. The same study mentioned that, while for AC system voltages of Us > 800 kV surge arresters are now basically 'standard', some applications still need special considerations. Moreover, a completely new classification system for MO surge arresters has been introduced, replacing the former Line Discharge Classes with the concept of charge transfer and energy handling schemes. This presentation describes some of the latest important developments in HV surge arresters driven by the need for greater safety and reliability.

13:00
Lunch

ARRESTER TECHNOLOGIES & APPLICATIONS PART 2:
SONORAN 1 & 2 CONFERENCE ROOM Wednesday, Oct. 23 14:00 to 16:00

14:00

Bas Verhoeven

Director High Voltage Laboratory, Global Quality & Innovation, KEMA Laboratories, The Netherlands

Laboratory Experience Type Testing Cables & Arresters

Bas Verhoeven received an M.Sc. in Power Engineering from Eindhoven University of Technology before joining KEMA in 1991 as R&D Specialist on digital protection systems for high voltage networks. Starting 1995, he worked as consultant on international projects for network design and protection before being appointed in 2000 as Manager of KEMA's High Voltage Laboratory, which became the world's largest commercially operated laboratory under his guidance. He was assigned Director of KEMA Laboratories, including the High Power Laboratory and the High Voltage Laboratory, in 2011. He is a Member of the Board of the NEC, the Dutch IEC and Member of the Board of the International Short Circuit Test Liaison (STL). He has authored numerous papers on testing and certification of power components.

SYNOPSIS

International standards for testing medium, high and ultra-high voltage cables typically include three distinct groups of tests. The first is Type Testing, where a cable or cable system, including the cable, joints, open-air termination and SF6 or oil plug-in termination, is tested to verify design and manufacturing. The second group, only applicable for high and ultra-high voltage cables, is Pre-qualification Testing. The third group is Commissioning Testing of a newly installed cable system in the field. KEMA Laboratories test and certify components used across all types of power networks and many decades of testing experience have allowed valuable insight into the performance/quality of these components. In particular, data on failures during testing have demonstrated the value and need for independent certification when it comes to power network components and equipment. This paper and presentation reviews years of data on testing cables and cable accessories and also offers an outlook on tests conducted on surge arresters.

14:30

Jonathan Woodworth

Principal, ArresterWorks, United States

Best Practice in Lightning Protection of Distribution Lines

Mr. Woodworth is founding partner of ArresterWorks, a 12-year old independent consulting firm. His areas of specialization include insulation coordination studies, surge arrester design and application issues and arrester forensic analysis. He has written more than 40 columns and articles for INMR on surge arresters since 2008 and is Convener of IEEE Working Group and co-Convener of IEC Working Group responsible for High Voltage Arrester Test Standards. He has been active in this industry since 1980 when he first joined Cooper Power Systems.

SYNOPSIS

As demand for more reliable power continues to grow worldwide, improving the lightning reliability of distribution systems is becoming a more important exercise. In North America, for example, distribution systems are often a 4-wire configuration, with three phase conductors and one neutral. The neutrals are typically grounded at equipment locations. For systems located in areas of high lightning activity, the neutral is also grounded where the line arresters are installed. The two most common distribution system configurations are 4-wire solidly grounded and three-wire grounded at source only. This paper and presentation discusses the options available to distribution engineers and reliability engineers to improve a system's reliability by means of optimized application of surge arresters. Most of the ways this can be accomplished are based on distribution systems found in the United States and Canada but in fact are also applicable to any system.

15:00

Bryan Beske

Consulting Engineer, American Transmission Company, United States

Line Arrester Installations on ATC System: What Was Done Right & Further Improvements

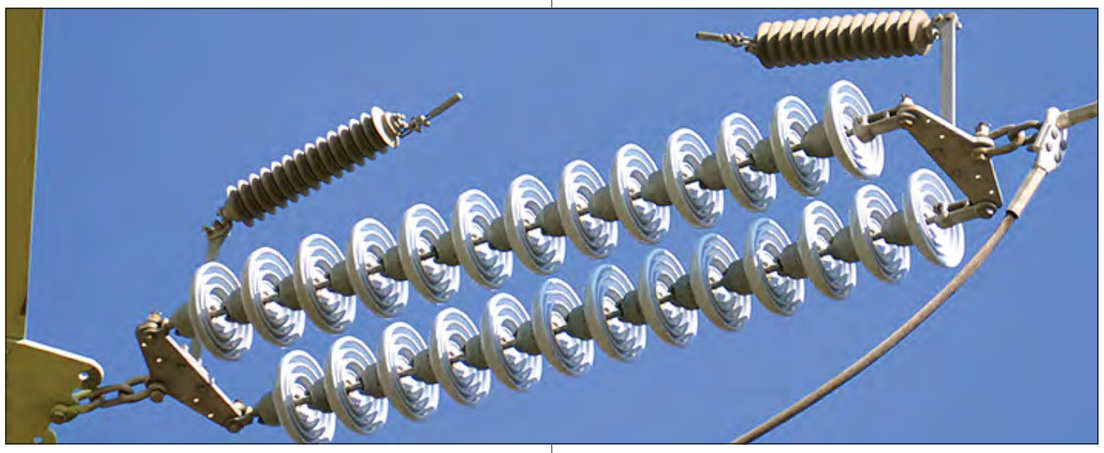
Mr. Beske received his B.S. in Electrical Engineering from the University of Wisconsin Platteville. He has been with the American Transmission Company since 2002 and is currently a Consultant Standards Engineer, with primary responsibilities that include lightning and grounding aspects of transmission lines. He is a member of IEEE, ASTM and CIGRE and is an ATC delegate for various industry research and standards working groups pertaining to lightning and grounding.

SYNOPSIS

ATC, the first for profit, multi-state, transmission only utility in the United States, owns and operates the transmission system in portions of Wisconsin, Michigan, Minnesota and Illinois, with primary voltages of 69 kV, 138 kV and 345 kV. The network was originally the transmission systems of many local utilities that had different standards. This resulted in a variety of different configurations on the system, some of which involved installation of transmission line surge arresters (TLSAs). In August 2017, a site review was performed with the goal of documenting and providing feedback on the many different types of arrester installations on ATC's 69 kV and 138 kV systems. In preparation, a records search was carried out to establish where on the system arresters were installed along with their configurations. A representative sample of 25 installations on 12 lines were then selected and reviewed. These installations ranged from 'one-offs' and special designs to legacy structures to installations that conform to present standards. While some gapped arrester installations were documented, gapless arresters are the primary type installed. This paper and presentation details findings of a field review of TLSA installations on the ATC system performed by the Electric Power Research Institute and reviews the important lessons learned. The field review included visual inspection of the different installations along with recommendations for improvements where deemed necessary.

15:30
Coffee Break & Visit to Exhibition

ARRESTER TECHNOLOGIES & APPLICATIONS PART 2:
SONORAN 1 & 2 CONFERENCE ROOM Wednesday, Oct. 23 16:00 to 17:00



16:00

John Lauletta

CEO, Exacter, United States

Using Grid Analytics to Evaluate Lightning Protection

Mr. Lauletta has been involved in electric utility measurement technology since 1975. His career includes 10 years with American Electric Power as Measurements Manager as well as 14 years as VP at Scientific Columbus before becoming CEO/CTO at Exacter – a developer of predictive technologies for electric utility reliability, grid conditions-based assessment, grid preventive maintenance, and Smart Grid network performance. He holds electrical engineering degrees from both Ohio State University and Purdue University and is the Past Chair of the Central Ohio Power and Energy Society Chapter of IEEE. John holds several patents in predictive failure technologies and manages several research programs for IIoT sensor development for electric utility applications as Visiting Scientist at the University of Akron.

SYNOPSIS

Predictive maintenance is a proven technique to lower operating costs and improve system performance. Capturing and assessing the condition of a transmission and distribution grid enables such predictive maintenance but can be challenging and expensive. Fortunately, new technologies applied to grid surveys using advanced RF emission and ultrasonic acoustical emission detection and discrimination allow rapid assessment of large areas of the grid. Such evaluation of large grid geographies gives rise to statistically significant grid analytics that can then be used to evaluate unique grid conditions and define systemic problems. This paper and presentation reviews technologies used for grid assessment and related deployment strategies and discusses typical maintenance efforts to utilize predictive maintenance analytics. A case study identifying failure of lightning arrester protection is also presented as is use of novel RF survey technology to identify grid conditions that indicate deteriorated electrical equipment.

16:30

Jonathan Woodworth

Principal, ArresterWorks, United States

Overview of Progress on Harmonization of IEC and IEEE Arrester Standards

Mr. Woodworth is founding partner of ArresterWorks, a 12-year old independent consulting firm. His areas of specialization include insulation coordination studies, surge arrester design and application issues and arrester forensic analysis. He has written more than 40 columns and articles for INMR on surge arresters since 2008 and is Convener of IEEE Working Group and co-Convener of IEC Working Group responsible for High Voltage Arrester Test Standards. He has been active in this industry since 1980 when he first joined Cooper Power Systems.

SYNOPSIS

At the first IEEE Working Group meeting to create the latest revision of C62.11 in May 2013, the goal was to continue evolution of this standard toward rationale-based tests as well as to make it more in line with IEC 60099-4 by December 2018. But it soon became clear that 100 percent formal harmonization was not going to be possible. Since the formal methods available for using IEEE/IEC Dual Logo standards development process with two existing standards did not appear a reasonable path to harmonization, it was decided instead to move ahead with informal harmonization. Similar test methods were developed that could be adopted by both standards bodies in their normal cycles and organizations. To that end, there will soon be an IEEE standard whereby most of the major tests conducted in the laboratory are also useable to produce a certified IEC-based or IEEE-based test report. A secondary initial goal was to create a set of tests that apply to transmission line arresters, especially since mechanical tests applicable to this type of arrester are not covered in C62.11 and only partially in IEC 60099-4 and 8. A task force was created to address this issue and it was soon realized that the IEEE/IEC Dual Logo process could also apply here. A joint IEC/IEEE group has been working on a new line surge arrester standard that covers both non-gapped and externally gapped line arresters. This paper and presentation reviews the status of these various joint efforts whereby the majority of IEC and IEEE arrester design tests are now becoming harmonized.

ARRESTER TECHNOLOGIES & APPLICATIONS PART 2: SONORAN 1 & 2 CONFERENCE ROOM Wednesday, Oct. 23 17:00 to 18:00

17:00

Nadew A. Belda
DNV Energy, the Netherlands

Peter Hock
Technical University of Darmstadt, Germany

Metal Oxide Surge Arresters for HVDC Circuit Breaker Applications

Mr. Belda received a joint M.Sc. in electric power engineering from the Eindhoven University of Technology (TU/e) and the Royal Institute of Technology (KTH), Sweden. Currently, his section is involved in development of test methods and design of test circuits for HVDC switchgear. This research is part his Ph.D. at Technische University of Darmstadt (TU Darmstadt), Germany, where he is an external Ph.D. candidate. He is a member of IEEE and CIGRE and actively participates in related Working Groups.

Mr. Hock received his M.Sc. in electrical engineering in 2015 from Technische Universität Darmstadt, Germany. Since 2016, he is a research associate at TU Darmstadt in the working group of Prof. Volker Hinrichsen. His main focus is investigation of HVDC circuit breakers with special interest on the metal-oxide surge arrester as an energy absorption element in the breaker. Other research topics have been accelerated ageing of composite insulators made from epoxy resin filled with microvaristor particles as well as arc interrupting behavior of direct current load switches in electrified railways. He is active in CIGRE Working Group A3.40.

SYNOPSIS

Considerable effort is being devoted these days to realizing multi-terminal, meshed HVDC transmission networks. One of the crucial components of such a grid is the HVDC circuit breaker, which must be capable of clearing DC faults without de-energizing the DC side of the grid. Recently, several HVDC circuit breaker solutions have been proposed and some are already available as prototypes. Unlike AC circuit breakers, a DC breaker has to deal with special requirements for interrupting direct current, e.g. creating artificial current zero(s), generating a counter voltage higher than system voltage and large energy absorption with extremely fast operation. So far, the energy absorption requirement of an HVDC breaker has not yet been brought to consideration, even though all technologies proposed include an energy absorption component. Metal oxide surge arresters (MOSAs) are used for this purpose, however the kind of stress an MOSA has to deal with in a HVDC circuit breaker is not taken into account during their engineering for application on an AC grid and is also not yet covered by any standard. This paper and presentation discusses requirements of MOSAs for HVDC circuit breakers. For example, several parallel-connected columns are needed to cope with large energy absorption and, due to application conditions, DC stable metal oxide varistors must be used. Features such as current sharing among columns, temperature rise, energy handling and accelerated ageing are all investigated and results of tests performed under real application conditions are presented.

17:30
Summary of Session/Questions