

# **INMR World Congress (INMR 2023)**

Bangkok, Thailand  
12 - 15 November 2023

Volume 1 of 2

ISBN: 978-1-7138-9518-3

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

Copyright© (2023) by Insulator News & Market Report (INMR)  
All rights reserved.

Printed with permission by Curran Associates, Inc. (2024)

For permission requests, please contact Insulator News & Market Report (INMR)  
at the address below.

INMR  
P.O. Box 95  
Westmount (Montreal), Quebec  
Canada H3Z 2T1

Phone: (514) 939-9540  
Fax: (514) 939-6151

[info@inmr.com](mailto:info@inmr.com)

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2633  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

# TABLE OF CONTENTS

## VOLUME 1

Towards Ultimate Compaction of Overhead Transmission Lines: Integrating CICA & EGLA Technologies.....	1
<i>U. Ahmed</i>	
Silicone-Coated Porcelain & Glass Insulator Performance in GCCIA After 15 Years in Service .....	11
<i>A. Al-Thagafi, R. Znaidi, A. Bouchti, H. Al-Hamoud, M. Naud</i>	
Climate Change-Resilient Insulators: Design Optimization for Increased Transmission System Reliability (with Special Reference to Indian Environmental Conditions) .....	22
<i>N. Arora</i>	
Interchangeability of MV Porcelain Bushings with Composite Polymeric Bushings .....	33
<i>D. Fishman, R. Arrigoni</i>	
Composite Insulator Performance in Distinct Service Environments: Coastlines, Mountains & Forests .....	56
<i>S.A.A. Soto, D.A. Da Silva, R.A.S. Juliani</i>	
Online PD Measurement as Early Condition Health Assessment for Massive Underground Power Cable Networks .....	66
<i>M.A. Pangah</i>	
Comparative Evaluation of the Erosion Resistance of Silicone Elastomers Under DC Stress .....	73
<i>C. Baer, J. Lambrecht, K. Hindelang</i>	
Line Surge Arresters for Switching Overvoltages in UHV Transmission Systems .....	78
<i>P. Bhurat</i>	
Online Partial Discharge Detection with Ultra-Wide Band Antennas: Case Studies from South-East Asia.....	90
<i>E. Borsari, A. Madonia</i>	
Polymer Insulators for HVDC Applications.....	102
<i>J. Butler</i>	
Enhanced Corrosion Protection for High Voltage Transmission Lines.....	109
<i>J. Butler</i>	
New Approach to Diagnose ZnO Surge Arresters Combining Resistive Leakage Current & Infrared Inspection .....	115
<i>M.A.C. dos Santos, C.E.C. Rios, G. Zat, J.R.P. Vargas</i>	
An Improved Strategy in Distribution System Asset Surge Protection .....	130
<i>D. Cardenas, J. Woodworth</i>	
Insulators and Live Line Work .....	137
<i>A.J. Carreira</i>	

Partial Discharge On-Line Condition Monitoring System for Distribution & Transmission Power Cable Systems .....	145
<i>G. Cejka, B. Quak, A. Mavroeidis, R. Jongen, J. Parciak, E. Gulski</i>	
Balancing the Budget for Renovating Lines: Groundwires, OPGW, Insulation, Earthing & Arresters .....	152
<i>W.A. Chisholm</i>	
Selecting Insulators by Adapting & Calibrating Satellite & Ground-Based Measurements of Air Pollution .....	198
<i>W.A. Chisholm</i>	
Pollution Design of Outdoor HVDC-UHVDC Bushings .....	233
<i>L. De Fina, A. Pastore, A. Pigini, E. Squilace, S. Turetta</i>	
Wildfires as Increasing Threat to Overhead Lines: Experience in Italy .....	252
<i>M. de Nigris, E. Collino, L. Minto</i>	
Increasing the Resilience of Underground Distribution Lines Against Heat Waves: Case Study from Milan, Italy .....	281
<i>R. Bonanno, M. de Nigris</i>	
Monitoring & Mapping Threat of Surface Contamination to Enhance Resilience of Overhead Transmission Lines: Experience in Italy .....	304
<i>A. Balzarini, P. Berardi, M. de Nigris, M. Marzinotto, G. Pirovano, G. Pirovano, P. Portoghese, A. Toppetti</i>	
Application of Line Lightning Protection Device onto 33 kV Lines with High Soil Resistivity to Mitigate Transient Interruptions Due to Lightning .....	315
<i>M.F. Ariffin, M.F. Nozlan, N. Abdullah</i>	
Superimposed Impulse Voltage Tests on HVDC Cables Using Coupling Capacitor .....	320
<i>D. Filipovic-Grcic, S. Jancin, D. Brezak, B. Filipovic-Grcic</i>	
Examining the Evolution of Line Surge Arrester Technology .....	330
<i>R.C. Freeman</i>	
Seismic Qualification of Surge Arresters Through Shake-Table Test: Importance of Considering Support Structure .....	341
<i>D. Fuentes</i>	
Diagnostic Techniques for Assessing Silicone-Coated Insulators .....	351
<i>J. Garcia</i>	
Advances in Capacitance Graded Transformer Bushing Technology & Qualification Methods .....	369
<i>T. Gargano, P. Cardano, P. Mishawar, S. Iacono, B. Cheladan, J. Rocks</i>	
Coating...of Course .....	379
<i>J.M. George, S. Suc, F. Virlogeux</i>	
Pollution & Insulators .....	392
<i>J.M. George, D. Lepley, F. Virlogeux</i>	
Standards: What Now, What's Next? .....	401
<i>J.M. George</i>	
Advancing MOV Block Technology: Improving Performance, Stability & Protection .....	409
<i>G.E. Pingan</i>	

Performance of Surge Arc Suppressors for Effective Lightning Mitigation.....	422
<i>F. Giraudet</i>	
Testing & Diagnosis of Long-Length Power Cables of On- & Offshore Wind Farms .....	437
<i>E. Gulski, R. Jongen, J. Parciak</i>	
Transformer Bushing Life Cycle Management in Indonesia: Specification, Operation & Diagnostic Methods.....	447
<i>H. Gumilang</i>	
Progress in IEC Standardization of Test Methods for Pollution Testing of Composite Insulators .....	462
<i>I. Gutman</i>	
Advanced Pollution Modeling on Insulators: Verification by Direct Measurements & Service Experience.....	471
<i>I. Gutman, C. Ahlholm, K. Halsan, B. Thorsteinsson</i>	
Evaluation of Recovery of Hydrophobicity of Composite Insulators: Test Methods Available .....	478
<i>I. Gutman, A. Dernfalk, A. Deckwerth, L. Diaz, M. Jalonen, M. Leonhardsberger, P. Trenz</i>	
Selecting Optimal Outdoor Insulation Under Heavily Polluted Conditions in Pakistan .....	493
<i>S. Hafeez, R. Znaidi, A. Ahmad, I. Yousaf, H. Ashfaq</i>	
Results of Testing Different Cable Screen Connections for 66 kV Offshore Applications with Direct Grounding Connection .....	519
<i>K.D. Haim, H.Z. Gorlitz, N. Maenza, D. Cisilino</i>	
Implementing EGLAs on 20 kV Overhead Distribution Lines: Design, Testing & Optimizing Placement.....	531
<i>L. Hartanto</i>	
Surge Arrester Considerations for Synchronous Generators .....	537
<i>J. Hoffman</i>	
Battling Pollution Problems on Overhead Lines in Japan: Recent Research at CRIEPI .....	546
<i>H. Homma</i>	
Micro- & Nano-Scale Characterization of Silicone Rubber Insulator Surfaces .....	557
<i>K.D.S. Bhuvan, H. Kaur, R. Padmawar, D.K. Hore</i>	
Design & Evaluation of Dual Function Integrated Insulators for Lightning & Ice Protection in Transmission Systems .....	571
<i>H. Hai</i>	
Partial Discharge & Commissioning Testing of Long (+20 Km) 400 kV XLPE Cables.....	580
<i>R. Hummel, M. Fenger</i>	
Experience with Salt Fog Testing of Composite Insulators.....	588
<i>H. Jahn, W. Manzke</i>	
Benchmarking Composite Insulators: Utility Perspective & European Initiative .....	595
<i>M. Jalonen, A. Deckwerth, L. Diaz, I. Gutman, K. Halsan, M. Leonhardsberger, M. Radosavljevic, P. Trenz, K. Varli</i>	
High Voltage Bushings: 100 Years of Technical Advancements .....	616
<i>L. Jonsson</i>	

Development of Dry, Fluid-Free Composite Insulators & Bushings for HV Cable Terminations .....	622
<i>I. Jovanovic, M. Muckenhumer, D. Lippe</i>	
Evaluation of Bushing Performance for Shunt Reactor & GIS Connected Transformer: Application in ASEAN Grid .....	629
<i>S.G. Kannan, K. Hafizzudin</i>	
Experience with Animal-Outage Protective Covers in Oman & Lessons for Utilities Worldwide.....	647
<i>I. Kanouni, A. Al Saifi</i>	
World's Lightest & Slimmest 380 kV Porcelain Long Rod Insulators for Ultra-High Pollution Levels .....	650
<i>C. Purucker, A. Karanth, M. Ruokanen</i>	
Life Cycle Analysis of Polymer Porcelain & Glass Insulators .....	661
<i>D. Kellett, A.J. Carreira</i>	
Remote Monitoring & Advanced Analysis of Surge Arresters & Power Grids .....	673
<i>M. Klemenc</i>	
Evaluation of Damage to HTM Insulators for Transmission Lines by Partial Discharge Under Polluted & Wetted Conditions .....	685
<i>K. Kondo</i>	

## VOLUME 2

Investigation of Pollution Flashover Behaviour of Hydrophobic, Hydrophilic & Partly Hydrophobic Coated Glass Insulators .....	696
<i>S. Kuhnel, S. Kornhuber, C. Bar, J. Lambrecht</i>	
Interface Testing of Polymeric Insulators .....	705
<i>J. Lachman, M. Novotny</i>	
Artificial Pollution Testing: Aspects to Be Considered .....	718
<i>J. Lachman</i>	
Application & Field Experience with Metal Oxide Surge Arresters (MOSA) CIGR WG A3.39 .....	727
<i>R. Leroux, F. Richter</i>	
Cable Testing & Diagnosis: State-Of-The-Art, Standards & Technological Developments .....	739
<i>P.P. Leufkens</i>	
The Revisions of IEC/TS 60815 Series & IEC 62217.....	751
<i>X. Liang, C. Wu, Y. Gao, Y. Wang</i>	
Impact of VFT on Bushings & Necessary Protection When Using On-Line Monitoring .....	763
<i>H. Lofas, R. Hedlund</i>	
Hydrophobic Recovery of HTV Silicone Rubber Insulators .....	772
<i>K. Maghsoudi, A.J. Carreira</i>	
Power Transformer Testing & Selection of Bushings for Specific Conditions at PV Plant.....	780
<i>R. Ma</i>	

Applying EGLAs on Transmission Lines in Japan: Overview of Experience & Lighting Outage Data .....	790
<i>T. Miki, M. Miki, S. Watanabe, R. Yamada</i>	
State of the Art Monitoring & Analysis for Overhead Transmission Lines in Japan .....	799
<i>A. Mukai</i>	
Increasing Confidence in Medium-Voltage Cable Diagnostics: Evaluation & Strategic Approach .....	808
<i>A. Ng</i>	
Electrical Stress Analysis & Mitigation of Polymeric Insulators with Different Types of Material .....	814
<i>M.A.F. Zulkafli, N.H.N. Ali, M.S.A. Rahman, A.A. Salem, M. Kamaruding, M.Z.A. Ab Kadir</i>	
Best Practices for Bushing Installation .....	822
<i>B. Nissle</i>	
Simplifying Interchangeability of Transformer Bushings Through Dimensional Standardization: IEC Work in Progress .....	829
<i>B. Nissle, P. Cardano, T. Gargano, G.F. Giorgi, L. De Fina</i>	
Pollution Test Results on Live Tank Circuit Breakers with Polymeric Housings .....	837
<i>A. Pignini, M. Nosilati, E. Stella, R. Saraceni</i>	
Development of Filament Cage Design Arresters: Long-Term Achievements .....	848
<i>T. Paalhorn</i>	
Next Generation Silicone Rubber Insulators: Market Analysis, Product Design & High Voltage Testing .....	862
<i>R. Padmawar, K.D.S. Bhuvan, D. Hore</i>	
Comparing AC Composite & Porcelain Dry High Voltage Bushings for Severe Service Conditions .....	875
<i>L. De Fina, E. Foppiani, A. Pastore, A. Pignini</i>	
Dielectric Frequency Response: A Novel Diagnostic Tool for Bushings .....	892
<i>P. Patel</i>	
Dielectric Measurement for Condition Monitoring & Testing of MV Cable: Experience in Thailand .....	909
<i>N. Pattanadech, S. Lacharochana, S. Jeenuang, T. Worthong, P. Udomluksananon, K. Chumpiboon, S. Kerdmanee, W. Rojanasunan, K. Dorkmai, S. Mongkolsatitpong</i>	
Estimating DC Pollution Requirements: Comparison of Simplified IEC Approach & Statistical Approach .....	925
<i>A. Pignini, R. Cortina, M. Marzinotto</i>	
Challenges in Sensitive PD Measurements on Extra-Long 525 kV HAVD Land Cables During AC After-Installation Testing (According to DIN IEC 62895:2019) .....	958
<i>R. Plath</i>	
EGLA Application on 70 kV Overhead Transmission Line in Indonesia: Statistics, Design & Lightning Performance Review .....	967
<i>R. Priatmadja, R. Septiyani, L. Hartano, A. Susilo, A.D. Setyawan, T. Wihardiyono</i>	
Arresters with Brains: New Era IoT-Enabled Condition Monitoring Enhanced by Artificial Intelligence .....	983
<i>P. Raschke, S. Fotsing</i>	

Strategic Role of Diagnostics in Asset Management Under Ageing, Climate Change & Earthquake.....	998
<i>R. Ross</i>	
Recycling Ceramic Insulators.....	1019
<i>M. Ruokanen</i>	
Aging Behaviour & Resistance of Ceramic Insulators.....	1024
<i>M. Ruokanen, E. Lehmann</i>	
Experience-Driven Improvements in Surge Arrester Performance Through Short Circuit Testing.....	1033
<i>A. Saboo</i>	
Wet Snow Accretion Packed with Sea-Salt on Insulator Strings.....	1051
<i>M.G. Sakata</i>	
IEC TC37: Major Developments in Standards for Substation & Line Surge Arresters.....	1057
<i>F. Dube, M. Schubert, J. Taylor</i>	
Foam-Filled Post Insulators for HVDC/HVAC Substation & Compact OHL Applications.....	1073
<i>M. Domm, A. Baumer, J. Seifert</i>	
High Performance Silicones for Transmission & Distribution Applications.....	1080
<i>R.S. Pal</i>	
Insulation Capability & Degradation of Highly Aged XLPE Cables Decommissioned from Service on Power Grids.....	1085
<i>T. Takahashi</i>	
Unusual Bushing Failure Modes Detected with Continuous Online Monitoring.....	1093
<i>N/A</i>	
Insights from Pollution Mapping & Insulator Dimensioning.....	1106
<i>N. Vasudev, S. Shunmugam</i>	
Experience Type Testing HVAC/HVDC Cables & On-Site Commissioning Tests of AC Cables.....	1118
<i>F. Schulze, B. Verhoeven, U. Vercelloti</i>	
Power Utility Perspective on Site Pollution Severity Assessment.....	1128
<i>W. Vosloo, R. Davey, F. Jooste</i>	
Voltage Uprating of the Distribution Network for Net Zero.....	1137
<i>A. Walsh</i>	
Design & Experience from Operating Transmission Lines in Sweden.....	1149
<i>D. Windmar</i>	
Efficient & Reliable Asset Utilization: Optimizing Line Ampacities Through Dynamic Line Rating (DLR).....	1158
<i>N.H. Abas, M.Z.A. Ab Kadir, N. Azis, J. Jasni, N.F. Ab Aziz</i>	
Issues & Challenges on Voltage Uprating: Case Study of 132 kV Transmission Line in Malaysia.....	1170
<i>M.Z.A. Ab Kadir, S.F.M. Nor, A.M. Ariffin, M. Osman</i>	
HV Insulator Coatings in Severe Service Conditions: Pollution Accumulation & Hydrophobicity.....	1187
<i>R. Znaidi, A. Al-Thagafi, A. Bouchti</i>	



Ground Lead Disconnectors Without Dangerous Goods Classification .....	1200
<i>R. Beuting</i>	
Case Study: Mitigation of Environmental Impact on Line Insulators Installed in K-Electric Transmission Network.....	1210
<i>R.A. Bhutto</i>	
Best Practices for Bushing Diagnostics.....	1216
<i>F. Dollinger</i>	
Offline Commissioning & Maintenance Testing of HV & EHV Cable Systems.....	1233
<i>M. Fenger, R. Hummel</i>	
Revision of IEC 62217 .....	1255
<i>X. Liang</i>	
Revision of IEC/TS 60815 .....	1263
<i>X. Liang</i>	
MEA: Driving Toward Greater Reliability & Resilience .....	1273
<i>S. Homklinkaew</i>	
Cable Fault Location on HV Versus MV Cables: Problems & Solutions .....	1290
<i>P. Lee</i>	
Insights from Pollution Mapping & Insulator Dimensioning: An Indian Peerspective .....	1303
<i>N. Vasudev</i>	
Online PD Measurement as Early Assessment for Massive Underground Power Cable Networks .....	1321
<i>M.A. Pangah, H.S.A. Halim</i>	
Case Studies of Disturbances on Java-Madura-Bali Transmission Lines by Lightning & Performance Improvement .....	1331
<i>J. Purnama</i>	
Pakistan: A Study in a Dry, Dusty, Coastal Environment with Strong Wind Corridor & High Industrial Pollution .....	1344
<i>S. Rehman</i>	
Experience with Animal-Outage Protective Covers in Oman & Lessons for Utilities Worldwide.....	1367
<i>A.R.S. Al Saifi, I. Kanouni</i>	
Transmission Asset Planning, Management & Future Refurbishments.....	1387
<i>D. Schlender</i>	
IEC TC37: Major Developments in Standards for Substation & Line Surge Arresters .....	1399
<i>J. Taylor, M. Schubert, F. Dube</i>	

**Author Index**