Electric ENERGY T&D MAGAZINE

The Official Show Guide of the 2005 International Conference of Doble Clients and Industry Expo

Volume 9, No. 3 www.electricenergyonline.com Doble 2005 Issue

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Conference & Expo
May 9-11, 2005

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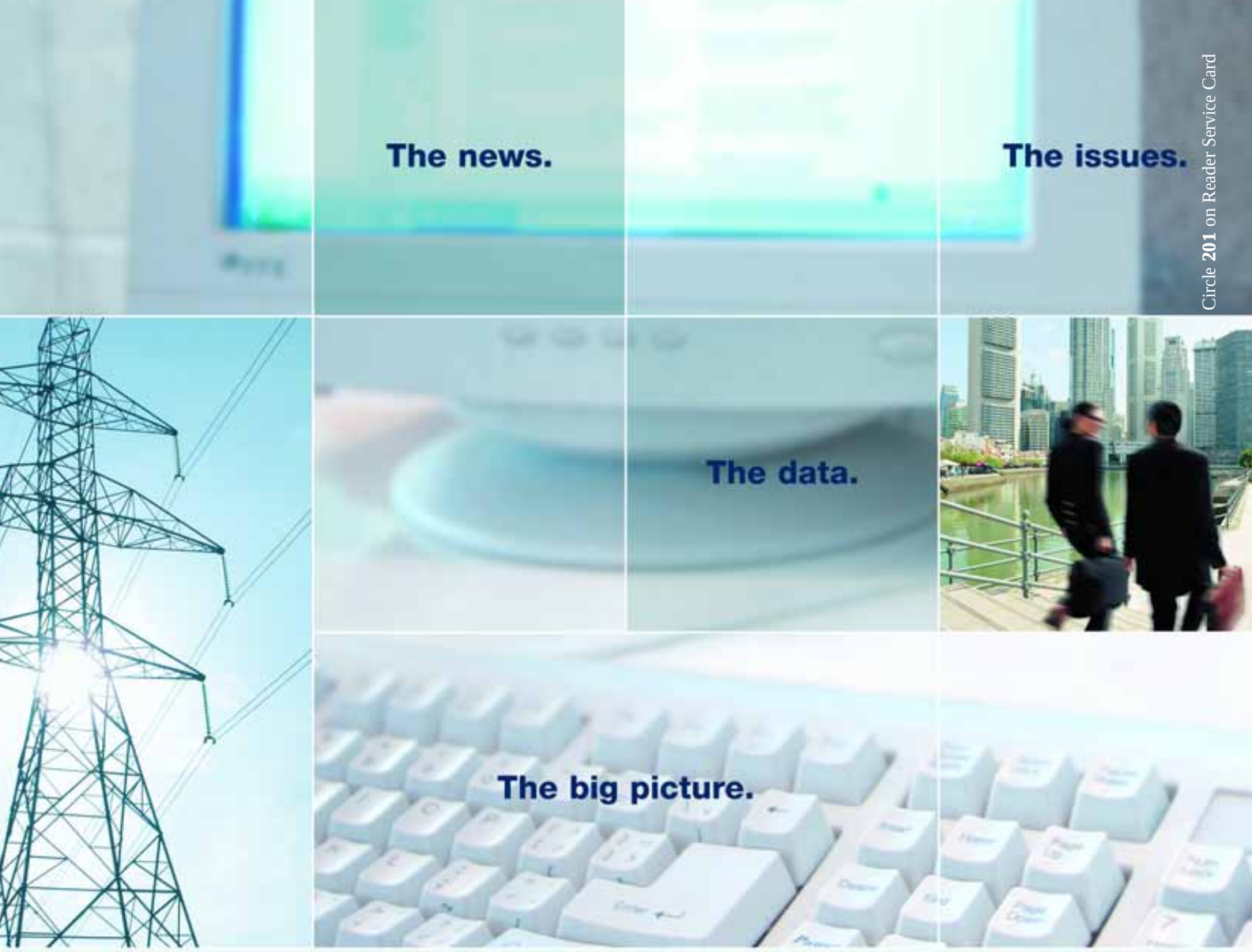

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Keynote Address "The Engineering Marvels of Boston's "Big Dig"

Electric Energy T&D MAGAZINE

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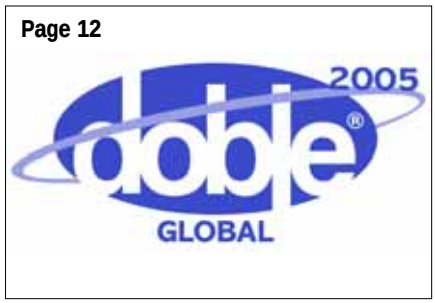

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New DualVision Substation Monitoring System is First to Combine Infrared-Enhanced Visual Surveillance with Thermographic Maintenance Monitoring

Intranet/Internet-enabled system offers 32 user-defined IR regions of interest per camera to trigger screen alarms or outputs to SCADA systems

Intruders can't hide and remote equipment inspections are made easier with Mikron Infrared's new DualVision 724 Remote Monitoring System. Ideal for pump stations, pipelines, telecom/broadcast facilities, electrical substations, coal piles, and similar facilities, the system is the first to combine visual and infrared cameras to produce optimized, blended images for simple quick analysis – all in a single

intranet/internet-enabled package. Utilized with Mikron's MikroSpec™ R/T software, the system produces a composite IR and visual image, as well as separate images of each. The resulting composite can be viewed in an infinitely blended percentage of visual/IR, simply by moving a slider bar in the software screen. Up to 32 regions of interest (ROI's) can be defined on the thermal image in any complex shape, enabling the system to trigger alarms at the approach of intruders or from temperature excursions on equipment. Visual surveillance enhanced with IR imaging makes it easy to spot intruders 24/7, without supplementary lighting.

The DualVision 724 system consists of separate thermal imaging and video cameras in an environmentally sealed, temperature-controlled enclosure. MikroSpec Real-Time Thermal Data Acquisition and Analysis software blends the thermal and IR camera feeds into a single DualVision image with correct aspect ratio and spatial area. Hot spots are easily identified while viewing the scene as a visual image by applying an isotherm color pallet to the IR image. The composite image can be adjusted to show any percentage of the IR and visual. ROI's in the image can be defined using 10 different shapes, including freehand.

All DualVision systems are fully integrated by Mikron Infrared and provided on a turnkey basis to ensure customer satisfaction. ■

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For additional information, contact Jon Chynoweth at 888-506-3900 or email: jon@mikroninfrared.com

CARE - NEW SOFTWARE MODULE FOR EQUIPMENT HEALTH MONITORING

Digital Inspections is pleased to announce a new software product that takes predicting equipment problems and monitoring equipment health to a whole new level. The module is called CARE, which stands for Cascade Algorithm and Rules Engine, and is available immediately. As the control center for a variety of information, CARE allows integration of data from realtime data sources like PI™ (OSIsoft) directly into Cascade calculations designed to identify equipment with potential impending problems. It enhances Cascade's ability to assess equipment health and help utilities better anticipate problems with equipment performance and reliability. CARE also allows users to take "snapshots" of data at specified times, creating what amounts to an "automated inspection" capability.

Although CARE integrates cleanly with CASCADE, CARE can be configured as an independent tool. Organizations that use another product for their maintenance or work management can still use CARE for monitoring realtime data flows, sending alerts to specified users as desired.

Digital Inspections, a KEMA Company, designs software systems that fit their function and outperform the alternatives. A pioneer in computer-based utility maintenance management, Digital Inspection has developed Cascade to provide a whole new level of functionality. Focused on Equipment Health and shaped by many utility customers, Cascade is a powerful tool for utility companies. For more information on Digital Inspections and Cascade, visit their web site at www.DigitalInspections.com or call (800)877-8783.

Be sure to attend the Digital Inspections Hospitality Suite in the Westin Nausett Room

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after the sessions on every night April 10 through 13. This Hospitality Suite is cosponsored by Delta-X Research, Cannon Technologies, CZAR/Kelman, and Enoserv and will provide a great place to get more information about Cascade and other utility software solutions.

Cannon Technologies provides system solutions for a number of Electric Utility T&D applications, and offers its Substation Advisor" System to monitor substation equipment condition and distribution system performance. The System, which includes Cannon and third party sensors, provides an open architecture to deliver substation information for use with existing RTUs and Scada/EMS systems, Cannon's Yukon Esubstation software or both. When coupled with Substation Advisor, Esubstation manages the substation information database, integrating with either Oracle or SQL. It provides interactive substation displays and delivers alert messages when configurable limits are exceeded for configurable times. Live video can also be included.

ENOSERV engineers software technologies that integrate O&M systems like CAPE, Cascade, Doble, Manta, Maximo, Megger, Omicron, Pulsar, SAP, SEL and SMC for standardization within System Protection & Control to help ensure total system reliability and efficient NERC and FERC compliance. RTS-FasTest™ is the most advanced, fully automated relay testing software available and includes a Library of over 400 relay test routines and can generate new tests on the fly without Users writing any code. RTS-Vector™ enables satellite synchronized end-to-end testing and multi-state dynamic testing for advanced logic, panel, and system testing. PowerBase™ is the only asset management database available that holds, manages, and tracks relay settings for enterprise-wide data exchange from the relay in the field to upper-level data management systems.

Delta–X Research provides TOA (Transformer Oil Anaylst) to monitor oil information including gas-in-oil, moisture-in-oil, partial discharge, and others. ■

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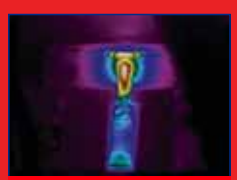
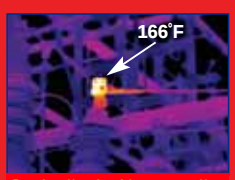


Bad bus-breaker connection

A major manufacturer suffered a $100,000 switchgear fire loss. After the switchgear was repaired by outside contractors, infrared inspection revealed improper installation in the exact area that caused the original fire. The contractor was notified, averting any potential new fires.

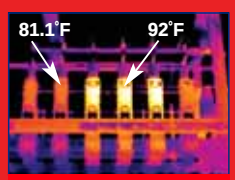
Locate poor electrical connections



Overheating bushing connection

A large paper manufacturer used infrared to scan their onsite substation. The inspection crew discovered a fault at the transformer feed not visible to the naked eye. A potential failure would have cost $200,000-$300,000.

Inspect outdoor electrical systems



Overheating capacitors

A routine infrared scan at a large public utility found one of the output filter capacitors of a station battery charger to be significantly hotter than others. Replacement of the failed capacitor avoided an outage which would have cost an estimated $500,000.

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Manitoba Hydro Dynamic Protection Testing

By: Ding Lin, Protection Engineering, Research Centre, Manitoba Hydro
Randy Wachal, Manitoba HVDC

A large set of fault cases was developed for the dynamic transient testing of line protection for a new 230 kV transmission line recently commissioned by Manitoba Hydro.

Transient simulation testing of protection offers many advantages over the more traditional (fundamental frequency) methods. Since the transient waveforms produced represent realistic voltage and current waveforms that the protection sees in service. The overall confidence in the testing results is greatly increased. And, the process to develop a transient system simulation model from a traditional phasor-based system is not difficult.

Accurate System Model:

It is possible to develop a study system that produces the same results as a fundamental frequency program. Once the positive and zero sequence networks are confirmed, the development of particular study cases of interest can be performed. The generated voltage and current test waveforms are then injected into the protection system using a transient playback system, allowing a thorough confirmation of the protection performance. The generated transient fault waveforms include all of the transient effects, such as DC offset, high frequency ringing, point on wave etc.

The Test Plan

Manitoba Hydro's "D72V" is a new transmission line with a portion of it constructed on the same towers of an existing line, and on the same right of way (ROW) with some additional existing lines. During some preliminary state simulation testing of the relay, the directional ground overcurrent elements of the relay were giving some questionable results for some current reversal conditions due to mutual coupling effects. It was not clear whether the operation of these fast reacting elements was affected by the unrealistic instantaneous simulation of the transition between states, or by different fault conditions such as fault inception angle or prefault line loading. It was determined that a time domain analysis of the protection system was in order. The sensitivity of the forward and reverse ground overcurrent elements 67F and 67R of the Nxtphase L-PRO relay on the new D72V line was the focus of the transient test plan.

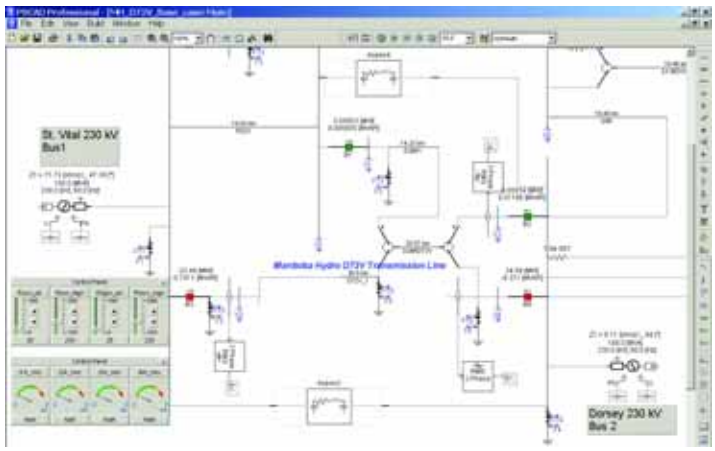
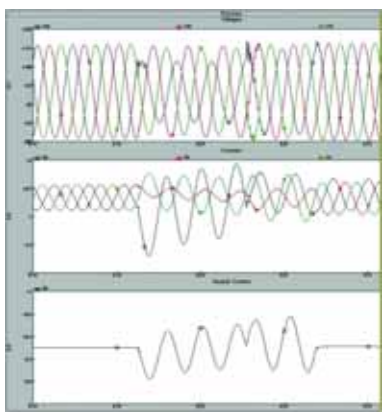


Figure 1: Manitoba Hydro System Model for generation of test waveforms

A number of time domain simulations were performed on the system model to generate the required testing waveforms. An "A" phase to ground fault was applied at one end of D36R, at Fault Location F3 on Figure 1, in order to produce a forward reverse current flow on he new line D72V. The application of fault angle was modified from 0 to 180 degrees in 30-degree steps; and the power flow from the Dorsey station to St. Vital on D72V was adjusted from 0, 100 and 200 MW. In addition, the telecommunications delay between line D36R breaker opening at the Ridgeway Station, B1 shown in Figure 1, and the breaker opening at the Dorsey end, B2 also shown in Figure 1, was selected at 30 or 100 msec. This set of tests was performed using a batch run feature of the PSCADTM power system simulation software, generating a total of 42 test cases. Each test case generated the three voltage and three current signals required for the transient time domain testing of the Dorsey and St Vital D72V protection system. An example of the waveforms applied is shown in Figure 2.



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Specifically, using the system model, 200 MW is initially flowing on the new D72V line. A SLG fault is applied at Ridgeway end of the D36R line. The voltage and currents presented are recorded at the Dorsey end of D72V. When the fault is applied, the D72V relay at Dorsey end sees reverse current. The Ridgeway breaker opens 50 msec (3 cycles) after the fault, changing the direction of the current as seen at the Dorsey end of D72V. The breaker on D36R remote from the fault opens 30 msec after the local end (approximately 2 cycles) and removes the fault current flow from D72V.

These generated fault waveforms were then used for real time field testing of the new line using IEEE Comtrade format waveforms and a test set such as the Doble F6000 series.

Results of the Protection Testing

The forward and reverse ground overcurrent elements 67F and 67R of the Nxtphase L-PRO relay used on the new line were verified over a large number of test cases during a one-day field testing period. It was confirmed that the relay operation was not dependent on the prefault loading, fault inception angle or the protection telecommunication delay on the line, but that the level of positive sequence component of the fault current does have an impact on the operation of the directional ground overcurrent elements.

The use of fully transient test waveforms represented the realistic voltage and current waveforms that the protection will see in service. This increases Manitoba Hydro's confidence that the test plan was realistic and fully exercised the line protection before the commissioning of the transmission line. ■

REFERENCE

[1] "PSCAD/Relay Installation and Operations Manual", Manitoba HVDC Research Centre, Aug 2001.

M.S. Sachdev, T.S. Sidhu, P.G. McLaren, Issues and Opportunities for Testing Numerical Relays, IEEE Power Engineering Society Summer Meeting, Seattle, Washington, USA, 16 – 20 July 2000.

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Welcome to the 72nd International Conference of Doble Clients!

During recent years, Doble has been expanding its global presence. This year's Conference is truly "International", with delegates from 22 different countries around the world, including:

- *Australia*
- *Canada*
- *China*
- *Czech Republic*
- *Germany*
- *Great Britain*
- *India*
- *Israel*
- *Japan*
- *Malaysia*
- *Northern Ireland*
- *Norway*
- *Panama*
- *South Africa*
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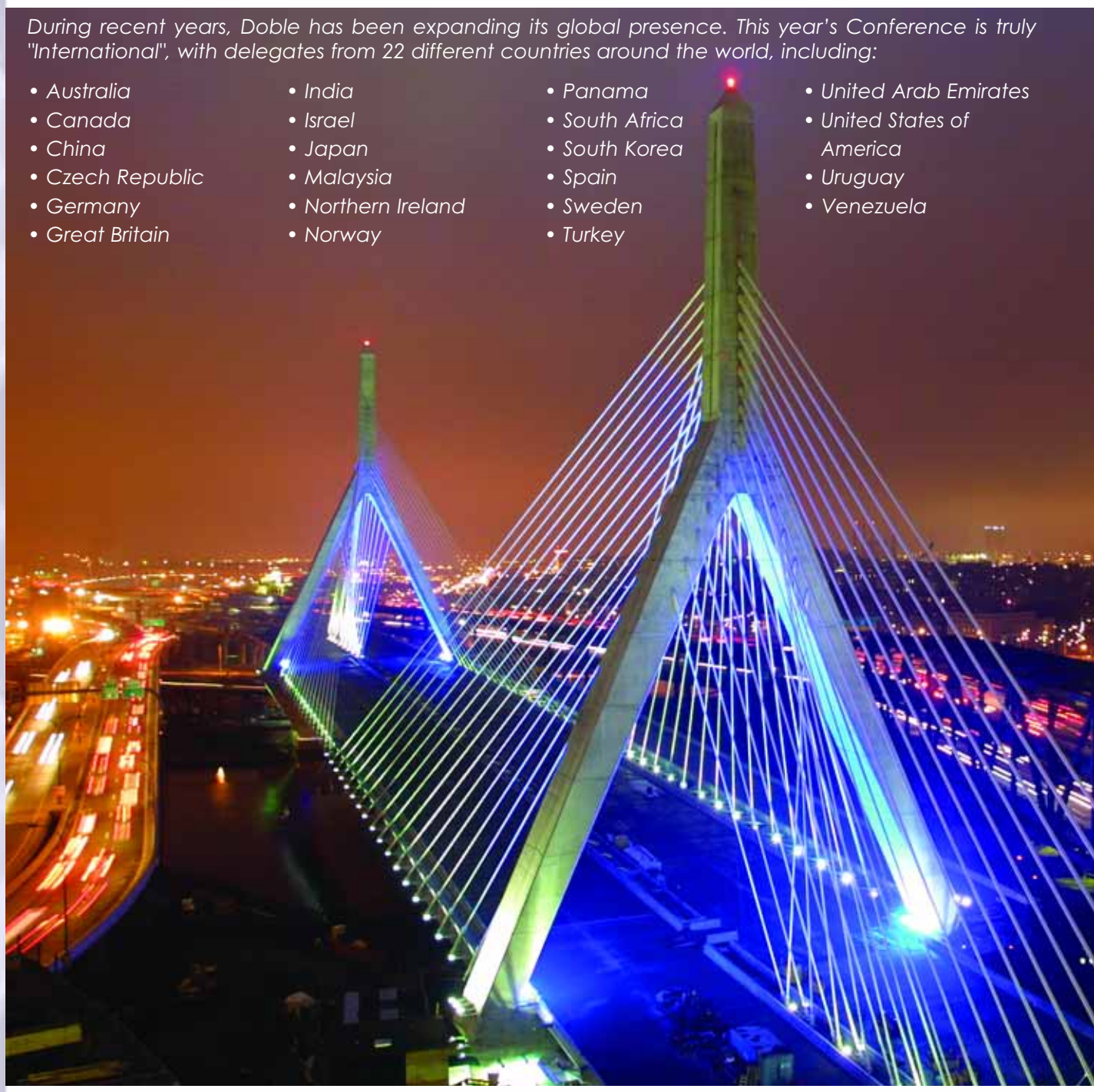
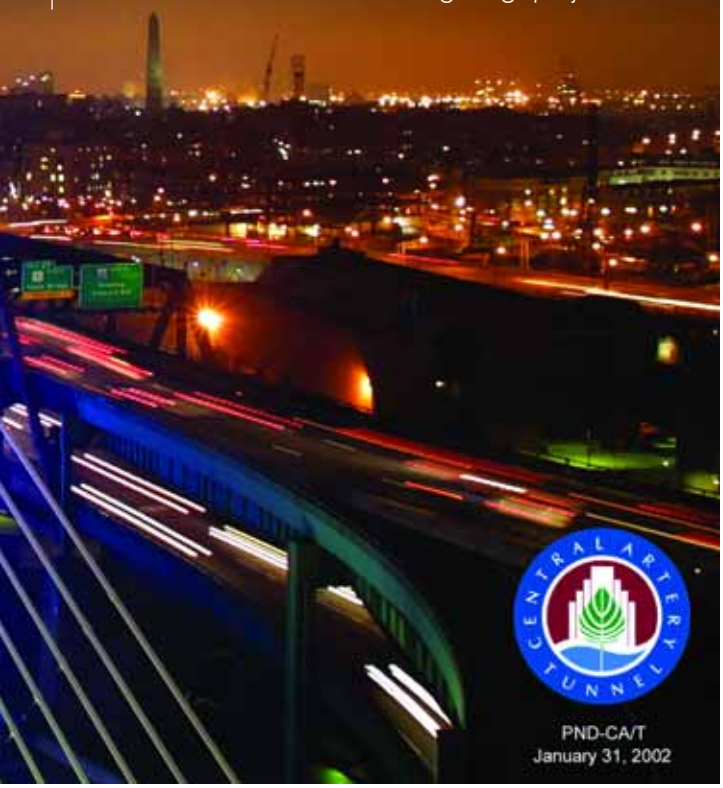


This year, Doble Engineering will be offering "Mini Tutorials" during Industry Expo Hours. These brief training sessions will allow delegates to learn more about a particular topic without investing a great deal of time.

Keynote Address "The Engineering Marvels of Boston's "Big Dig"

Monday, April 11th
Opening Session, 8:30 am
America Ballroom
4th Floor, Westin Hotel

The Central Artery/Tunnel Project has enough engineering marvels to fill a textbook. Its designers and builders had to tackle difficult soil conditions, tight working spaces, proximity to huge glass and steel office towers and fragile old brick buildings, the need to hold up an elevated highway while tunneling directly beneath it and - most important - keeping the city of Boston open for business throughout 14 years of construction. Our Keynote Speaker will provide Doble Conference attendees with an overview of this amazing megaproject.



Mini-Tutorials

Sunday, April 10
5:30 pm - 6:00 pm:
'See' what's inside your transformer using SFRA

6:15 pm - 6:45 pm:
Doble Test Assistant (DTA) Overview

Mini-Tutorials

Monday, April 11
11:30 am - 12:00 pm:
What's new in Laboratory Diagnostics

12:15 pm - 12:45 pm:
Detecting partial discharges in Gas Insulated Substations

6:15 pm - 6:45 pm:
Learn about the Doble KnowledgeBase

Mini-Tutorials

Tuesday, April 12
12:15 pm - 12:45 pm:
'See' what's inside your transformer using SFRA

6:15 pm - 6:45 pm:
Detecting partial discharges in Medium Voltage Cable Terminations

These Mini Tutorials will be held in the St. George Meeting room on the 3rd floor (Expo area) of the Westin. Please stop by the Doble Product Room, located in Staffordshire, for further information.

2005 International Conference of Doble Clients and Industry Expo

All of these delegates come together in Boston to share their own experiences and knowledge, and gain new information from their International colleagues. The average electric utility sends only one or two delegates to the Conference, so everyone is tasked with the mission of bringing home and sharing what they have learned with others at their company.

In response to client requests, Doble has recreated the traditional Boston Conference experience in other places around the world. In 2005, Doble Client Conferences in both India and Mexico have already been held. The topics discussed at these events were selected by the participating utilities as most critical to their electrical, economic and climatic environments. Later this year, the same Conference model will be utilized in Brazil, Norway and other parts of the world.

In addition to the traditional Client Conference model – where the Clients provide many of the technical presentations - Doble also conducts regional seminars and apparatus specific tutorials, where presentations by Doble and other industry experts are given. By the end of 2005, Doble will have hosted over 40 events in 25 different countries!

By offering in-country events, companies are able to send a larger number of delegates. In addition, Doble is able to meet local needs with native language presentations. As a result of Doble "bringing the conference" around the world, the audience is expanded. In 2005, a total of more than 5,000 utility engineers worldwide will attend a Doble sponsored event.

As new countries and companies join the Doble Client Community, their apparatus knowledge and test results are added to the Doble Knowledgebase – the resource library of information that benefits all Doble Clients. The technical presentations offered at Doble events also contribute to this growing collection. At present, Doble archives consist of more than 4,000 case studies and technical presentations. The KnowledgeBase also contains over 25 million test results on 150,000+ different apparatus. As Doble expands globally, the Doble Client Community will benefit from the growing interrelationship with power system experts everywhere and the addition of their knowledge to Doble's shared resources.

The mission of the first Doble Client Conference in 1934 was to bring together the best minds of the burgeoning electric power industry; to share knowledge and learn how to best evaluate apparatus health and to establish standardized reporting methods leading to comprehensive understanding of apparatus condition. By your participation at this year's International Conference of Doble Clients, the exchange of knowledge continues!

VI Conferencia Latinoamericana De Doble, held in Mexico City March 1- 3, 2005

2005 International Conference of Doble Clients — Schedule of Events

Program of Meetings and Activities

Sunday April 10

	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM
Registration/Info					Registration & Information Desk											
Committee Meetings							CCVT Tutorial 1 - 5 pm									
Industry Expo		Exhibitor Set Up									EXPO OPEN 5 - 7 pm					
Social											Welcome Reception 5 - 7 pm		Hospitality Suites open at 7 pm			

Monday April 11

	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM
Registration/Info	Registration & Info Desk															
Committee Meetings			AMM		BIIT			CB		IM						
Keynote Address & Opening		Keynote & Opening	PAT			DTA User Group			Basic Power Factor Training							
Newcomers Orientation	Newcomers															
User Group	IDD															
Committee Session				AMM Session				AMM Session								
Industry Expo					Expo Open 11 am - 2 pm						Expo Open 5 - 7 pm					
Oil Committee Mtg & Dinner					Light lunch served in Expo Hall							Oil Committee Meeting & Dinner				
Other - IEEE Working Group								IEEE Working Group								
Social													Hospitality Suites Open at 7 pm			

Tuesday April 12

	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM
Registration/Info	Registration & Info Desk															
Committee Meetings						Tutorial: Rotating Machinery Groundwall Insulation			RM Com							
User Group																
Committee Session		BIIT Session						IM Session								
Industry Expo					Expo Open 11 am - 2:00 pm				Exhibitor Mtng 3 - 4		Expo Open 5 - 7 pm					
					Light lunch served in Expo Hall											
Other - IEEE Working Group	IEEE Working Group							IEEE Working Group								
Social													Hospitality Suites Open at 7 pm			

Wednesday April 13

	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM
Registration/Info	Registration & Info Desk															
Committee Meetings		ACCA Comm		DGA of LTCs							TX Committee					
Industry Expo		Expo breakdown														
Committee Sessions	SFRA User Group Part 1		RM Session			SFRA User Group Part 2		RM Session								
									ACCA Session							
User Group																
Social													Hospitality Suites Open			

Thursday April 14

	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM
Registration/Info	Registration & Info Desk															
Committee Meetings						TRX User Group										
User Group																
Committee Sessions		CB Session						Transformers Session								
Social												Reception	Group Dinner at Hotel			

Friday April 15

	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM
Registration/Info	Registration & Info Desk															
Committee Meetings						Advisory Committee										
Tutorial																
Committee Sessions	Transformers Session															

*"Doble Gas Analysis of Load Tap Changers" Subcommittee

2005 Industry Expo Floor Plan

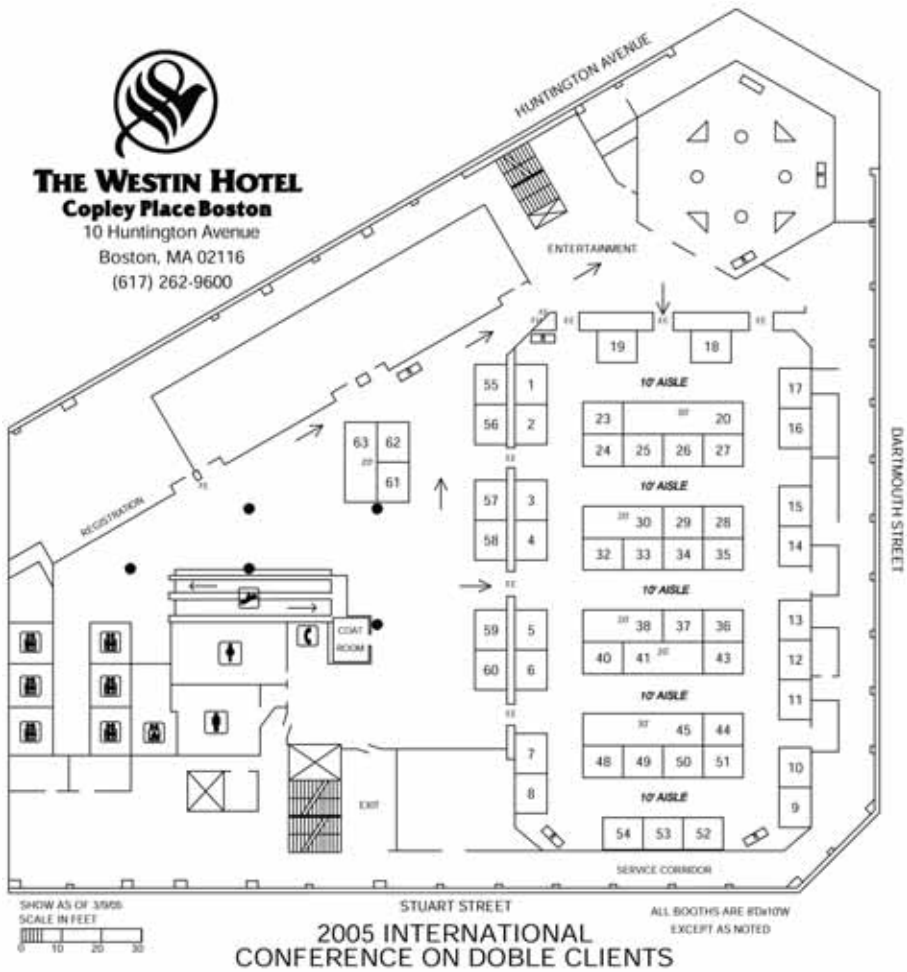
The Industry Expo at The 2005 International Conference of Doble Clients

April 10 - 12, 2005

The Westin Hotel
Copley Place
Boston, MA

Exhibitors List

Organization	Booth Assignment
American Electrical Testing Co.,Inc.	**33**
Arbiter Systems Inc	13
AREVA T&D	61
Beckwith Electric Co., Inc.	48
Cannon Technologies, Inc.	28
Colt Atlantic Services, Inc.	19
COSA Instrument Corp.	53
Delta X	9
Deutsch Metal Components	36
Digital Inspections, a KEMA Company	10
Doble Engineering Company	Staffordshire
Doble Lab / D.E.S.	5
Dynamic Ratings	6
Electric Energy Magazine	59
Electric Light & Power	15
Electricity Today Magazine	49
Electro Composite	32
Environmental Protection Services	7
Filmax Inc.	52
FISO Technologies Inc.	4
Flakt Coiltech	44
FLIR Systems	58
Foster-Miller, Inc.	40
General Electric	45, 46 & 47
I.C.M.I. Inductive Components Mfg,Inc.	17
Jordan Transformer, LLC	29
Kelman Ltd	20 & 21, 22
Megger	11
Midsun Group, Inc.	51
Mikron Infrared, Inc.	16
Morgan Schaffer	3
National Electric Coil	2
Neoptix Fiber Optic Sensors	43
Normandy Machine Co Inc	24
Nynas USA Inc.	55
Ofil Ltd	34
Opsens Fiber Optic Sensors	56
Phenix Technologies, Inc.	25
Power Asset Recovery Corporation	8
Qualitrol Corporation	23
R.B. Watkins, Inc	8
Reinhausen	57
Schweitzer Engineering Laboratories, Inc	62
SD Meyers	54
Serveron Corporation	26
Siemens Power T&D	1
Solidification Products International, Inc.	60
Southern States, LLC	41 & 42
Team Industrial Services	37
The VON Corporation	50
Thermoteknix Systems, Ltd	12
Tree Tech Digital Systems	35
Unifin International, Inc.	63 & 64
Velcon Filters, Inc.	18
VTCU Corp.	27
Waukesha Electric Systems, Inc.	38 & 39
Weidmann-ACTI	30 & 31
Woodgroup Generator Services	14



Preliminary Schedule of Events

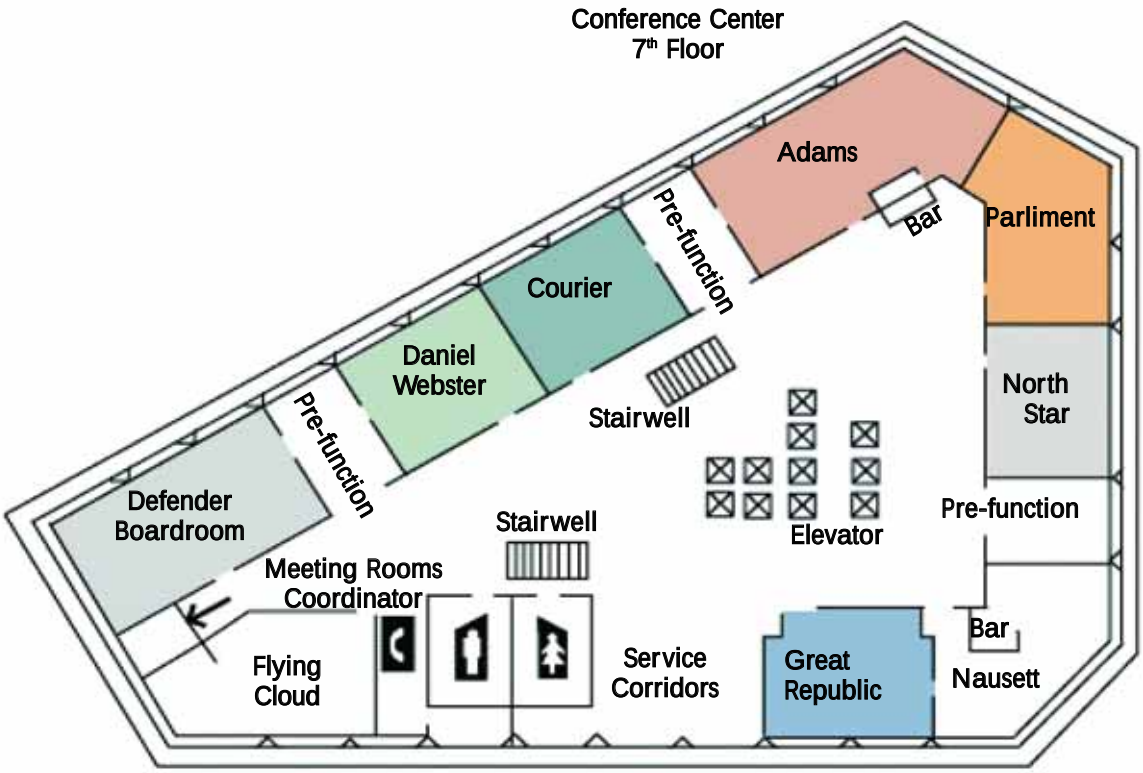
Hospitality Suites

The 2005 International Conference of Doble Clients

April 10 - 13, 2005

The Westin Hotel, Copley Place, Boston, MA

Suites Open after the close of the Industry Expo 7:00 PM



2005 Doble Suite Holders	Suites Open	Suite Location
ABB Inc.	April 11- 12	Daniel Webster/Courier
E Mfg. Co., Inc.	April 10 - 12	Great Republic
General Electric	April 10 - 12	Presidential 3612 (36th Floor)
Morgan Schaffer	April 11- 12	North Star
Nynas USA, Inc.	April 10 - 12	Imperial
PCORE ELECTRIC COMPANY, INC.	April 11- 13	Parliament
Petro-Canada Lubricants	April 13th	Great Republic
Reinhausen	April 13th	Presidential
SD Myers	April 12th	Turner Restaurant (1st Floor--accessed through 2nd floor retail gallery)
Southwest Electric Company	April 11-12	Adams
Uptime Engineered Solutions	April 10 - 13	Nausett
Velcon Filters, Inc.	April 11 - 12	Senator's Suite -- 2112/2113 (21st Floor)
VTCU Corp.	April 10 -11	Ambassador's Suite 3619 (36th Floor)
Waukesha Electric Systems, Inc. / High Voltage Supply	April 11 - 12	Governor's Suite 3112/3113 (31st Floor)
Weidmann-ACTI, Inc	April 11 - 12	Flying Cloud
Weschler Instruments	April 12 - 13	One Bedroom Suite (Floor TBD)

2005 Hospitality Suite Holder Company Descriptions

ABB Inc.
Daniel Webster/Courier
April 11- 12
Dan Marlowe
4350 Semple Ave
St. Louis, MO 63120
Tel: 314-679-4510
Dan.marlowe@us.abb.com
- ABB is a leader in power and automation technologies that enable utility and industry customers to improve performance while lowering environmental impact. The ABB Group of companies operates in around 100 countries and employs around 115,000 people.

EManufacturing Company
Great Republic
April 10 - 12
7275 Industrial Pk. Blvd.
Mentor, OH USA 44081
Phone: 440-951-0900
Fax: 440-951-0965
- E Mfg. is an innovative manufacturer of circuit breaker parts , tap changer parts, disconnect switches and other power transmission components, serving the utility industry for over twenty years.

General Electric
Presidential
April 10 – 12
4200 Wildwood Parkway
Atlanta, GA 30339
770-999-7141
http://www.ge.com
- GE (NYSE:GE) is a diversified technology, services and manufacturing company with a commitment to achieving customer success. GE operates in more than 100 countries and employs approximately 315,000 people worldwide. Our products and services range from power generation technology, energy services and management systems to the latest technological products used to distribute, protect and control electrical power and equipment. GE provides equipment, services and management solutions across the power generation, distributed power and utility industries.

Morgan Schaffer
North Star
April 11- 12
5110 Avenue de Courtrai
Montreal, Quebec H3W 1A7 Canada
William Morse
514-739-1967
wmorse@morganschaffer.com
www.morganschaffer.com
- Morgan Schaffer, a pioneer in the development of DGA, now has a tool to help laboratories verify their results, our True North DGA Oil Standard. True North will ensure accurate and precise Dissolved Gas Analyses. Our on-line transformer monitor, Calisto, continuously measures Hydrogen and Water found in power transformers.

Nynas USA, Inc.
Imperial
April 10 – 12
1800 West Looop South, Suite 1150
Houston, TX 77027
Jeremy Kriska
713-586-3832 X106
jeremy.kriska@nynas.com
www.nynas.com
- Nynas is a Global Manufacturer and Marketer of Standard and High Grade Type I and II Transformer Oils. We are the global leader when it comes to Transformer Oil quality and knowledge. Product is currently available domestically. US production of our quality NYTRO grade transformer oils begins June 2004.

PCORE ELECTRIC COMPANY, INC.
Parliament
April 11- 13
135 Gilbert Street
LeRoy, New York 14482
Phone: (585) 768-1200
Fax: (585) 768-1212
- PCORE Electric Company, Inc. is an ISO 9001:2000 certified company and leading provider of apparatus bushings, related components, diagnostic services, and bushing repairs to the North American electric utility industry and its equipment suppliers.
PCORE Electric was established in July 2004, when the assets of the Bushing Division were acquired from Lapp Insulator Company, LLC.

Petro-Canada Lubricants
Great Republic
April 13th
2310 Lakeshore Road West
Mississauga, Ontario Canada L5J 1K2
Phone: 416-532-1473
Fax: 416-532-2593
- Petro-Canada's LUMINOL electrical insulating fluids represent a breakthrough in electrical insulating fluids technology. Unlike napthenic mineral oils, LUMINOL uses synthesized isoparaffins to minimize power loss and maximize productivity.*

Reinhausen
Presidential
April 13th
2549 North Ninth Avenue
Humboldt, TN 38343 USA
John S. Gamane, Jr.
731-784-7681
www.reinhausen.com
- On Load Tap Changers Sales and Service. In Boston we will feature our Maintenance-Free designs (Model "B" monitoring for RMV LTCs and Tap Guard monitoring for MR In-Tank LTCs) which allow for up to 500,000 operations without a time limit. All new designs are retrofittable.

SD Myers
Turner Restaurant
April 12th
180 South Avenue
Tallmadge, OH 44278
Becky Compton
330-630-7000
Becky.Compton@sdmyers.com
- S. D. Myers, Inc. provides analytical, training and international field services with the ultimate goal of extending the reliable life of your substation equipment and international environmental services to reduce your PCB liability.

2005 Hospitality Suite Holder Company Descriptions

Southwest Electric Company
Adams
April 11-12
6503 SE 74th Street
Oklahoma City, OK 73135
Phone: 405-733-5691
Website: www.swelectric.com
- Since its founding in 1945, Southwest Electric has grown into one of the Foremost Re-Manufacturing, Manufacturing and Service Companies for Electrical Equipment in the Central United States. Featuring knowledgeable Engineers and Dedicated Employees with State-of-Art Production Facilities, Southwest Electric Company can provide Quality Redesign and Re-manufacturing of your Medium Class Power Transformers, Electric Motors, Rotating Equipment and Metal Clad Switchgear. Southwest Electric Company manufactures Custom Metal-Clad Switchgear for the Utility and Industrial Market along with Specialty Transformers for the Oil Field Pump Industry. delete this line: Southwest Electric Company Services Companies can supply on-site service for the above products, plus replacements if needed. and add: Our company's field service capabilities can also provide on-site services and replacement for all of the above products.

Uptime Engineered Solutions
Nausett
April 10 – 13
5317 Highgate Dr.
Durham, NC 27713
toll free: 800-835-3839
fax: 919-544-2257
- The following companies will be sharing this suite: Digital Inspections, Delta X, Seidel, Vanquish Fencing, Cannon Technologies, and Psd Tech.
- Substation Integration of all IEDs (existing or new) including local and remote communications and data concentration
- Web based delivery of substation monitoring information including providing server, database and application software
IEDs to detect and monitor(partial list):
** Gas-in-oil*
** Moisture-in-oil*
** Partial Discharge*
** Vibration*
** others.....*
- Portable field test for complete DGA
- Lab services for complete oil testing
- Software to analyze DGA, Fluid Quality & Electrical Tests
- Computerized Maintenance Mngmt System (CMMS) includes integration of field collected data, SCADA data, on-line monitoring data, DGA, Relay Settings, Electrical Tests and other data sources like PI Historian and MMW. Provides Automatic Maintenance Triggers and Alerts. Existing data can be imported in advance of installation to insure successful implementation.
- Animal related outage prevention using modular fencing internal to substation; placed around critical equipment
- Automated Load bank for checking calibration of relay test sets.

Velcon Filters, Inc.
Senator's Suite
April 11 - 12
4525 Centennial Blvd.
Colorado Springs, CO 80919
Linda Oppelt
719-53-5855
719-531-5690
vfsales@velcon.com
www.velcon.com
- Turn oil handling into art with Velcon! Our fixed, portable, and mobile filtration and storage systems combine such features as versatility, simplicity, and quality to purify insulating oil using advanced SuperDri® cartridge technology. See our website at http://www.velcon.com for additional information.

VTCU Corp.
Ambassador's Suite
April 10 -11
3770 Pole Line Rd.
Pocatello, ID 83201
Janet Moore
208-238-0720
sales@vtcucorp.com
- Transformer Repair and Reconditioning.

Waukesha Electric Systems, Inc. / High Voltage Supply
Governor's Suite
April 11 - 12
400 S. Prairie Ave.
Waukesha, WI 53186
800-835-2732
wesinfo@waukeshaelectric.spx.com
www.waukeshaelectric.com
- Waukesha Electric Systems, Inc. (the largest manufacturer of medium-power transformers), along with its subsidiary, High Voltage Supply (Dallas, TX), will present an extensive range of products and capabilities, including Transformers and Accessories, Load Tap Changers, Modular Substations, Substation Transformer Condition Assessment Services, Reverse-Engineered LTC and Circuit Breaker Components, and complete Substation Repair and Maintenance Services nationwide. The company also provides systems-engineered EPC solutions through its subsidiary, PSD, Inc. (Canton, OH), including engineered switchyards, substations, overhead and underground transmission lines, and Wind Energy projects.

Weidmann-ACTI, Inc
Flying Cloud
April 11 - 12
One Gordon Mills Way
St. Johnsbury, VT 05819
Contact: Lisa Bean Newell
Tel: 802-751-3530
Fax: 802-748-8630
e-mail: lbean@weidmann-systems.com
web: www.weidmann-acti.com
- Weidmann-ACTI brings value to the electric generation and T&D industries by providing diagnostic testing, expert services and quality products that improve the life, loading and reliability of substation transformers. Industry Asset Managers are increasingly turning to Weidmann-ACTI engineers and chemists to bolster their in-house resources and testing capability

Weschler Instruments
One Bedroom Suite
April 12 – 13
Terry Martin
16900 Foltz Industrial Parkway
Cleveland, OH 44149
Phone: (440) 238-2550
- Weschler Instruments has been supplying innovative, service oriented solutions to the power and process industries for almost 65 years. Products include transformer temperature monitoring equipment for the utility market and digital and analog panel board and switchboard meters for the utility and process control market. We are also a distributor of electrical and electronic measurement equipment. Customers worldwide use our products in power plants, steel mills, chemical plants, paper mills and other industrial applications that require rugged, reliable and accurate instrumentation.

2005 Doble Industry Expo Exhibitors

American Electrical Testing Co., Inc. **Booth 33**
480 Neponset Street, Building 3
Canton, MA 02021
Paul M. Kelly, 781-821-0121
http://www.99aetco.com
American Electrical Testing Co., Inc. maintains a staff of highly trained NETA certified field service engineers and technicians providing power system studies and complete engineering and testing services for acceptance, maintenance, retrofit and repair of electrical power distribution systems and equipment from low voltage through 345KV.

Arbiter Systems Inc. **Booth 13**
1324 Vendels Circle, Suite 121
Paso Robles, CA 93446
Christine Greco, 805-237-3831
cgreco@arbiter.com *www.arbiter.com*
Arbiter Systems, the leader in GPS timing products and the manufacturer of the most accurate portable three-phase power meter (Model 931A Power System Analyzer) is introducing the new Model 1133A Power Sentinel The Model 1133A provides GPS synchronized real time measurements for revenue metering, power quality monitoring, and synchro-phasors as per the IEEE 1344 Standard (20/s.)

AREVA T&D Inc. **Booth 61**
1 International Plaza, Suite 300
Philadelphia, PA 19113
office +1.484.766.8100
Customer Care 888-AREVA-TD
customer.care.usa@areva-td.com
www.areva-td.com
AREVA's T&D division is an active player around the globe. It designs, manufactures and supplies a complete range of equipment, systems and services for all stages in the transfer of electricity, from the generator to the large end-user. AREVA T&D offers a complete range of reliable T&D solutions to address the different needs of every stage in the equipment life cycle, including high voltage switchgear, large power transformers, power quality solutions (e.g. SVC, STATCOM, HVDC), and T&D services (e.g. equipment refurbishment, retrofits and maintenance).

Beckwith Electric **Booth 48**
Beckwith Electric Co., Inc.
6190-118th Avenue North
Largo, Florida 33773-3724
Engineered Solutions for Power System Protection and Control, System Voltage, Regulation and Reactive Support, Energy Efficiency, and Power Quality.

Cannon Technologies, Inc. **Booth 28**
Mike Cannon, Phone: 712-279-8750
Email: mikec@cannontech.com
Dave Snyder, Phone: 804-360-3282
Email: DSnyder@cannontech.com
Providing integrated distribution automation tools for the electric utility industry since 1987, with over 300 electric utility customers, we are an end-to-end technology company offering innovative software, custom and 3rd party hardware, support and service.
Optimizing Energy Delivery
From our early days, the focus was monitoring the load of the substation and responding to provide relief to reduce demand and extend the life of substations. Today, we have numerous applications, but still focus on delivering the bread and butter asset management tools that both monitor and control. By performing predictive maintenance and real-time monitoring of substation transformers, switchgear and breakers, utilities manage expensive and critical assets. Add capacitor control, demand response systems (such as direct load control), thermostats, and distributed generation for system relief when needed. Optimizing energy delivery through better asset management, improved system reliability, automatic and targeted demand management, and customer-focused value-added services are the tools we deliver.
Strong Solutions with Strong Value Propositions
We don't make a big deal about the many partners we have in this business, but they are a key to our success - both customers and vendors. We have access to virtually any product; be it meter, substation device, or radio, and have the ability to turnkey. Our diverse optimization solutions do not need subsidies and mandated funds to make them hunt. These solutions deliver. We hope you will visit us at the conference, or contact us for an on-line Web-based demonstration today!

Colt Atlantic Services, Inc. **Booth 19**
PO Box 74396
Richmond, VA 23236
James Hackett, 770-831-8135
jhackett@coltonline.com *www.coltonline.com*
Transformer oil and SF6 gas leak repairs are what we do, Bushings, Flanges, Packings, and Fittings to name a few. So give us a leaker, the one that is tough, and we will show you our customer satisfaction is enough. So please arrive at booth number five.

COSA Instrument Corporation **Booth 53**
84G Horseblock Road
Yaphank, NY 11980
Tel.: (631) 345-3434 - Fax.: (631) 345-5349
e-mail: cosa@cosaic.com
Cosa Instrument Corporation is the leading distributor of moisture measurement instrumentation servicing the Electric Utility Substation Maintenance industry.
The portable Xentaur Dewpoint Meter Model XPDM with HTF™ technology is designed for quick and accurate dewpoint measurements in insulating gases (SF6 , Nitrogen, Air) in transformers and circuit breakers. Model XPDM provides results with unsurpassed speed, resulting in small samples and short measurement times.
The portable Mitsubishi Karl Fischer Titrator Model CA-21 is a primary standard for transformer oil moisture measurement, allowing measurements in the field for predictive maintenance purposes.
The Xentaur Model HDT-LQ Transmitter provides reliable online moisture measurements in transformer oils.
Cosa Instruments 20+ year experience in laboratory and field of the electrical distribution industry provides valuable solutions for substation maintenance and analysis.
Cosa Instrument has sales offices in Norwood, New Jersey and Houston, Texas. For more information, call (201) 767-6600 or (713) 947-9591. Visit the website at www.cosa-instrument.com. Email: cosa@cosaic.com

Delta X **Booth 9**
P.O. Box 42083
2200 Oak Bay Avenue
For more information consult the web site
www.deltaxresearch.com
call our sales office (919)-544-8191.
Delta-X Research, developer of TOA, dissolved gas analysis software for insulated fluid-filled power equipment is about to release its new DGA software TOA4 On-Line.
Delta-X Research has been developing software for 10 years, is renowned worldwide for the quality of its products and is in use by more than 400 companies both industrial and electric utility. It has established itself as a standard in DGA diagnosis and is proud to say that TOA4 is at the forefront of current development software platforms and DGA diagnostic knowledge.
TOA4 On-Line will offer better diagnosis by the introduction of the latest scientific knowledge. The number of false positives has been reduced significantly by embedding the most advanced statistical algorithms. New techniques have been incorporated to provide diagnostics on LTC including the Duval Triangle and more.
The upcoming release will be accessible as an online web service through subscription, or pay-as-you-go. Shortly after, TOA4 will be available as a server or stand alone software. TOA4 is platform independent and can run on Windows, Linux or Mac.

2005 Doble Industry Expo Exhibitors

Deutsch Metal Components **Booth 36**
14800 South Figueroa Street
Gardena, California 90248
April Schemper, 310-323-6200 phone
customerservice@deutschco.com
www.deutschco.com
Deutsch Power Products connect your substation with PowerLok® bus connectors, CableLok® cable connectors and GroundLok© grounding connectors. Our 360 swaging technique gives you a superior connection. Deutsch connectors and tooling save you time and money.

Digital Inspections **Booth 10**
804A NW Buchanan Ave
Corvallis OR 97330
John Lane, Sales Manager, 541-752-7233 x117
jlane@diginsp.com www.digitalinspections.com
For over ten years, Digital Inspections has provided utilities with powerful and configurable equipment health software for maintenance management and inspections. CASCADE™ is the system equipment health system of choice for maintenance management and inspections and continues to focus exclusively on the needs of utility maintenance, operations, and management. From in the truck, to the field, or in the office, CASCADE is helping utilities increase system reliability and optimize the use of their assets, through interfaces with industry standard diagnostic testing software, inspections, and user-configurable equipment condition assessment.

Doble Engineering **Staffordshire**
85 Walnut Street
Watertown, MA 02472
Tel: 617-926-4900 - Fax: 617-926-0528
www.doble.com
Doble Engineering has been supplying diagnostic instruments and engineering services to the electric power industry for decades. Doble also maintains the industry's most extensive resource library of apparatus test results and knowledge. The company maintains close working relationships with the world's electric power companies, working in partnership to improve the performance of their systems and operations.
Contact: DobleInfo@doble.com

Doble Lab **Booth 5**
Bill Beese
Business Development Office
3801 Whipple Avenue, NW
Canton, OH 44718
Phone: 330-493-0301 - Cell: 330-284-0347
Fax: 330-493-0302 - Bbeese@doble.com
The Doble Materials Laboratory, established in 1933, is staffed by dedicated, experienced chemists, and supported by engineering personnel knowledgeable in apparatus diagnostics. We provide answers and solutions to your problems based upon quality data from a wide range of testing capabilities and a rich experience in apparatus diagnostics. We can help you develop the most cost-effective testing program for condition assessment or to help identify or solve apparatus problems. All test reports include an analysis of the data and recommendations for remedial action when warranted.

Doble Engineered Strategies (D.E.S.)
Rick Ladroga
65 Boston Post Rd W
Marlboro, MA. 01752
Phone: 617-393-3133 - Fax: +1.617.926.0528
rladroga@doble.com
Doble Engineered Strategies has developed a proprietary method for estimating the remaining service life of a transformer. This method builds upon a comprehensive condition assessment program, and is designed to systematically identify changes in transformer condition. Doble's Condition Assessment solution can reduce the risk of transformer failure and extend the life of your valuable capital assets.

Dynamic Ratings, Inc. **Booth 6**
N59W14339 Bobolink Ave.
Menomonee Falls, WI 53051
Tony Pink, 262-703-0792
Tony.pink@dynamicratings.com
www.dynamicratings.com
Dynamic Ratings provides an economical transformer monitoring and control system to suit individual customer needs. A single connection to the Dynamic Ratings control provides both control and monitoring of the complete transformer system including cooling, LTC, and on-line monitoring and diagnostics.

Electric Energy Publications **Booth 59**
Steven Desrochers
1160 Levis, Suite 100
Lachenaie, QC J6W 5S6 Canada
Tel: 888.332.3749 ext. 222 - Fax: 888.243.4562
steven@jaguar-media.com
www.electricenergyonline.com
From the board room to the field, whether it is from our eNewsletter, eZine or our print magazine, Electric Energy Publications delivers insightful and informative content. Watch The Trends, Get The Facts, Have The Edge!

Electricity Today Magazine **Booth 49**
Carol Gardner
The Canadian Electricity Forum
204 - 15 Harwood Ave South Ajax,
Ontario, Canada, L1S 2B9
Tel: (905) 686-1040 - Carol@electricityforum.com
Electricity Today's mission has always been to Àfulfill the needs of our readers and advertisers with an editorial product that is unmatched in quality and integrity. Our thorough and well-balanced editorial coverage for more than 13 years has generated unsurpassed reader loyalty and cemented the magazine as the choice for information about Canada's utility/industrial power engineering and maintenance industries.

Electric Light & Power **Booth 15**
PennWell Publishing
Shirley Wilson
1421 South Sheridan Rd
Tulsa, OK 74112
918-831-9447 shirleyw@pennwell.com
Known as the voice of the electric utility industry since 1922, Electric Light & Power is the authoritative source of electric industry business news for electric utility executives and management. Each month, Electric Light & Power provides insight into industry news, financial, legal and regulatory issues, and reviews T&D, technology, information systems, customer systems, and electric and gas trading trends. This single source provides a broad view of the electric utility industry, with in-depth analysis of key business issues and regular interviews with industry leaders.

Electro Composite **Booth 32**
1919 Lionel Bertrand # 107
Boisbriand, Quebec J7H 1N8 Canada
Sébastien Riopel, 450-430-1181
s.riopel@eci-co.com www.eci-co.com
ECI is a world leader in the design and manufacture of high voltage insulating systems for the energy business. We manufacture superior performance and durable polymer bushings up to 69kV for all types of applications and insulators for transmission applications up to 765kV and substation applications up to 161kV.

Environmental Protection Service **Booth 7**
4 Industrial Park Drive
Wheeling, WV 26003
Brad Joseph
304-232-1590 ext. 42 (phone) - 304-232-1599 (fax)
brjoseph@epsonline.com www.epsonline.com
EPS specializes in the installation, maintenance and disposal of electrical equipment. This includes PCB, PCB-Contaminated and Non-PCB disposal, energized transformer dechlorination, energized hot oil reclamation, installation/ vacuum-filling and retrofills. EPS also sells Trans-X oil, a reclaimed mineral oil dielectric fluid that meets the standards of virgin but at considerable savings.

Filmax Filtration, Inc. **Booth 52**
6775 Corporate Park Dr.
Loudon, TN 37774
David M. Butler, 800-321-3895
sales@filmaxinc.com
Filmax holds numerous patents on technology specifically designed for filtration equipment in the power industry. Through a process of constant customer feedback and on site servicing we have established ourselves as providing the best filtration products on the market for switchgear power distribution and transmission equipment. Filmax has proven to consistently extend the life, reliability, performance, and maintenance intervals of crucial substation equipment. Filmax specializes in a wide range of filtration applications, from high flow to low flow, permanent mount to portable equipment. Our complete line of filters, ranging from pleated and stack disk to ultra fine, will interchange with all vessels currently in the field. Filmax has pioneered a new technology in three-phase filtration. At this years Doble Conference we will be displaying our FBR-310 filtration unit specifically designed for oil circuit breakers, three tank LTCs, single-phase regulators and capacitor banks. Filmax is the only company to manufacture and offer the FBR-310 which features a 'three machines in one' design. We look forward to seeing you at this year's Doble Conference.

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FISO Technologies Inc. **Booth 04**
500, ave. St-Jean-Baptiste, Suite 195
Quebec, PQ G2E 5R9 CANADA
Sharon Walsh, 418-688-8065
sales@fiso.com *http://www.fiso.com*
FISO Technologies is a leading supplier of fiber optic solutions for direct monitoring of substation assets. Products are EMI immune and designed for long-term reliability.

Flakt Coiltech, Inc. **Booth 44**
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Mike Martin, 731-987-2228
mike.w.martin@flaktwoods.com
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FLIR Systems **Booth 58**
16 Esquire Road, N. Billerica, MA 01862
Tom O'Toole, 978.901.8000
info@flir.com *www.flirthermography.com*
FLIR Systems, the global leader in infrared cameras, will exhibit two new handheld ThermaCAM IR cameras that are ideal for predictive maintenance: the ultra-lightweight E4 and the high-performance P60. Both are revolutionizing the management of electrical and mechanical equipment by finding faults before failures, outages or even fires occur.

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Phone: +1.781.684.4000
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http://www.ge.com
GE (NYSE:GE) is a diversified technology, services and manufacturing company with a commitment to achieving customer success. GE operates in more than 100 countries and employs approximately 315,000 people worldwide. Our products and services range from power generation technology, energy services and management systems to the latest technological products used to distribute, protect and control electrical power and equipment. GE provides equipment, services and management solutions across the power generation, distributed power and utility industries.

I.C.M.I. Inductive Components Mfg. Inc. **Booth 17**
Contact: Dirk Mooibroek, Tel: 513-752-4731
dwm@ICMIinc.com *www.ICMIinc.com*
ICMI has a 30 year history of manufacturing control products starting with the McGraw Edison CL-2 through the Cooper/McGraw CL-5A. In the late 90's ICMI released the UVR-1 Control, retrofitable for all Cooper/McGraw, Siemens/Allis, and GE controls. Recently the UVR-1 Control was selected by Howard Industries as the standard control offered on their new regulators.
With a simple hinge rail and cable harness, the UVR-1 control fits directly on Cooper/McGraw, Siemens/Allis, GE and Howard 32 step single phase regulators. With RS-232, RS-485, DNP3.0 Level 2 communications. A user friendly scrolling menu accesses selectable data logging, graphic displays and the newest tap logging features. Fiber Optics and modem connections are optional. In 2003 the UVR-1 was re-certified by AEP-Dolan Labs as fully ANSI/IEEE compliant, accurate within .3% (-40C to +85C). ICMI's DNP3.0, Level 2 report by exception, was certified as fully compliant by ACS – Atlanta. The UVR-1 is available for LTC applications and features Master/Slave paralleling. The NEW USC-1, Simple Control, also certified as ANSI/IEEE compliant, is a low cost alternative control for applications not requiring communications. With all the retrofit capabilities of the UVR-1, it provides a cost effective alternative for customers who need to upgrade controls but don't want to continue to dump money into old analog controls. ICMI also offers the URC-24 Recloser Control for direct retrofit to existing Kyle/Cooper Form 2, 3 and 3A Reclosers.

Jordon Transformer, LLC **Booth 29**
1000 Syndicate St.
Jordan, MN 55352
800-328-5894 phone - 952-492-2720 phone
952-492-2796 fax
www.jordantransformer.com
sales@jordantransformer.com
Jordan Transformer is in the business of repairing and rewinding substation transformers up to 50 MVA with voltages of 138 kV and below as well as offering a full range of testing and field services. Jordan Transformer is located in Jordan, Minnesota where it has been providing quality transformer repair services to the utility and industrial marketplace for the past 32 years as US Transformer East, Inc. During the fall of 2004, the former U.S. Transformer East, Inc. was purchased by Dick Ames, the founder and owner of Ames Construction, Inc., one of the largest road, civil, and mining construction firms in the US. Ames Construction, Inc. has extensive experience in the power plant and utility marketplace and has annual revenues in excess of $500 million. The new ownership and capitalization structure has allowed Jordan Transformer to move forward with plant improvements and personnel additions. Look for continued growth and improvement from Jordan Transformer in the upcoming months and years. Please visit us at the Doble Conference at booth #29.

Kelman Ltd. **Booth 20, 21 & 22**
4147 N. Ravenswood Ave.
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Tel: (773) 944-0693 - Fax: (773) 944-0690
Kelman provide innovative solutions for the power industry, with products designed to meet real utility requirements that have been adopted successfully throughout the world. Based in Northern Ireland, Kelman has centers in the US, England, Germany, Denmark, Russia, South Africa, China and India.
Transport X – Portable DGA
The **Transport X** *provides accurate and reliable DGA results in a truly portable, rugged package that is simple to use, measuring 7 fault gases and moisture in minutes. Using PAS technology the* **Transport X** *gives direct ppm results and requires no carrier gases or regular calibration.* **Transport X** *can also measure high gassed samples, such as LTC's, with no cross-contamination of samples. An embedded PC allows storage of approx. 20,000 TOA compatible records and user friendly diagnostics.*
Used successfully in the US, Europe, Asia, Africa and Mexico.
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info@midsungroup.com www.midsungroup.com
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Midsun Group Inc. offers service work by trained Midsun employees, allowing us to offer warranties on labor and materials. In addition, Midsun technical supervisors can train your employees allowing us to offer the same warranties on labor and materials as if performed by our technicians.

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John Chynowet, 906-487-6060
kinn@mikroninfrared.com
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Morgan Schaffer **Booth 03**
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sjeney@national-electric-coil.com
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National Electric Coil, world's largest independent high voltage coil manufacturer, produces a full range of generator stator and field windings for units of all makes and ratings. Also complete services for testing, evaluations, repairs and winding installation at our facility or at customer site. Customers include utilities, IPPs, industry, OEMs.

Neoptix Fiber Optic Sensors **Booth 43**
1415 Charest Ouest Blvd, Suite 220
Quebec (Quebec), Canada G1N 4N7
Michel Plourde, V. P. Sales & Marketing
Tel: (418) 687-2500 - Fax: (418) 687-2524
mplourde@neoptix.com www.neoptix.com
Neoptix Fiber Optic Temperature Monitoring System
Neoptix developed a fiber optic monitoring system for true and direct winding temperature measurement. The Neoptix t/Guard and t/Guard+ are multi-channel fiber optic temperature monitoring systems for power transformer hot spot measurements. These systems have been developed with long-term performance and stability in mind. This fiber optic temperature monitoring system for power transformers offers accuracy, toughness and long-term resistance to failure. Coupled with the t/Guard and t/Guard+ systems, the Neoptix T2 fiber-optic temperature probe provides accurate and direct temperature monitoring of transformer windings. The probes are based on the solid-state proven GaAs technology, which will never drift or fade through time. This solution provides a realistic, real-time view of winding conditions that is quicker and more accurate than top oil measurements, and greatly complements indirect measurements based on thermal models. Neoptix fiber optic probes give the exact temperature in less than a second. Peak load or emergency overloads are thus detected almost instantaneously. You now have a powerful tool to optimize power transformer performance and life expectancy. The t/Guard+ system, in addition to the a/m features, offers 16 form-C relays that are controlled by an industrial grade PLC subsystem, that can easily be interfaced to user computers, via SCADA protocol or OPC servers. This system is fully user configurable through a local keypad or an OPC server link (RS232). With a possibility of 1 to 8 channels, the Neoptix fiber-optic systems are specifically designed to meet power transformer industry requirements: extended intervals between servicing, low maintenance, rugged components and the ability to withstand the harshest conditions. Neoptix latest addition to its line of temperature monitoring systems is the HandyFlex. It is a portable 1-channel battery-operated thermometer used to test probes during transformer manufacturing or to read probes in the field.

Normandy Machine Co. **Booth 24**
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jerry@normandymachine.com
www.normandymachine.com
Normandy Machine Co., Inc. is a manufacture of electrical contacts for LTC, OCB and related switchgear along with porcelain transformer bushings and connectors. NMC DESIGN 1 contacts exceed OEM design. Varies remanufactured LTCs in stock for exchange. Customized consulting and training for your substation requirements available.

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Nynas is a Global Manufacturer and Marketer of Standard and High Grade Type I and II Transformer Oils. We are the global leaders when it comes to Transformer Oil quality and knowledge. Product is currently available domestically. US production of our quality NYTRO grade transformer oils begins June 2004.

Ofil Ltd. **Booth 34**
Dr. Pinhas Lindner
POB 4016 Kiryat Weizmann Science Park,
Nes Ziona, 74140 Israel
Phone: +97289407953 - Fax: +97289407873
ofil@inter.net.il www.daycor.com
Ofil Ltd., founded in 1993, is an Israeli company that specializes in detection in the Ultra Violet (UV). The company manufactures and markets detection systems based on its proprietary Ultra Violet (UV) Solar Blind optical filter technology. Ofil's solar blind filters, enable detection of corona in full daylight with only negligible background noise and at high signal-to-background ratio.
The company's flagship product, the DayCor® corona camera, detects and locates in full daylight corona discharge and arcing on overhead lines and substations. The DayCor camera is used for inspection for corona and arcing by maintenance teams of electrical utilities and as instrument for testing and research in high voltage testing laboratories. The camera is also used to test insulation quality of windings of big motors and generators.
Among Ofil's customers are leading electricity companies worldwide like: NYPA (US), ConEd (US), Illinois Power (US), EGAT (Thailand), Kansai Electric (Japan), China L&P (Hong Kong), AltaLink (Canada), SPInet (Australia). The camera is also used in high voltage laboratories and research organizations like EPRI (USA), STRI (Sweden), VEIKI-VNL (Hungary), CESI (Italy), IIE (Mexico)

Opsens Fiber Optic Sensors **Booth 56**
2014, Jean Talon Nord, Bureau 125
Sainte Foy, Quebec, Canada G1N 4N6
Tel: 1-418-682-9996 - Fax: 1-418-682-9939
info@opsens.com www.opsens.com
Opsens Inc, a leading developer and manufacturer of premium quality fiber optic sensors, is dedicated in providing the most technically advanced products for the monitoring and control of transformer's winding temperature.
Opsens uses The SemiConductor Band Gap technology also known as the GaAs technology that is known in the power transformer industry in its PowerSens signal conditioner and PowerTemp fiber optic temperature transducer. Opsens is proud to offer an updated version, which is fully compatible with the existing sensors installed in the field but with unique features and performances.
Opsens' fiber optic temperature sensor is designed for your installation team. Our sensor's rugged construction and packaging offer high tolerance for extreme mechanical stress. Combined with the improved sensor connectivity solution, we eliminated the cumbrousness of cable spooling and handling during installation thereby maximizing efficiency in your installation process.
Opsens offers a small portable handheld unit as well as multi-channel system with an extended user interface for field monitoring use. Our data acquisition unit, built on an open architecture platform uses common industrial communication protocols that enhance flexibility in your system communication.
In addition, Opsens offers a complete line of fiber optic sensors for pressure, strain and displacement measurement in circuit breakers, load tap changers, cables, bus bar and other components in the presence of high voltage and EMI/RFI environments.
Contact Opsens today for your customized fiber optic sensors.

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Accident, MD 21520
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info@phenixtech.com www.phenixtech.com
PHENIX Technologies manufactures electrical test equipment ranging from portable test instruments to large, fully-automated test systems. Equipment is available for testing circuit breakers, reclosers, transformers, rotating electric machinery, cables, switchgear, rubber goods/protective gear, field/maintenance testing, and much more. PHENIX Technologies has supplied test systems to over 75 countries, offers 30 years experience, and is an ISO 9001 Quality Certified company.

Power Asset Recovery Corporation **Booth 08**
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Canton, OH USA 44718
Phone: 330-493-1890 - Fax: 330-493-1893
http://www.power-asset.com
Our mission is simple ... to buy and sell transformers and related equipment to utilities and industrial companies ... and you, the customer, profit both ways.

Qualitrol Corporation **Booth 23**
1385 Fairport Road
Fairport, NY 14450
Dave Billings, 585-586-1515
dave.billings@qualitrolcorp.com
www.qualitrolcorp.com
As a leading supplier of substation instrumentation and automation equipment, Qualitrol can provide intelligent electronic devices, remote terminal units, substation information servers and software packages for making intelligent loading decisions and extending transformer life.

R.B. Watkins **Booth 08**
P.O. Box 2649
Stow, OH 44224
office: 330.688.4061
RB Watkins, founded in 2004 by three transformer industry professionals, provides transformer repair and complete field services to its clients in the utility and industrial markets. We pride ourselves on our exceptional experience and our superior equipment. With 54 years of transformer industry experience between the founders, we bring the knowledge that gives our clients peace of mind. On average, our employees have 17 years of experience in the transformer industry. We believe in investing not only in the right people, but in top of the line equipment, which has helped leverage RB Watkins into a position of strength in the industry - one surprising for a company less than a year old. The services offered by RB Watkins are comprehensive. We offer assembly/disassembly, transformer repair, electrical testing - even complete turn-key. We have two oil processing rigs, a complete set of electrical testing equipment and a Fuller's Earth systems. RB Watkins capabilities include transformers up to 500 kV. Our work speaks for itself with our growing customer list. Visit www.rbwatkins.com for a complete service listing and to view some job pictures to get an idea of the level of work we do. Contact us at 1.866.602.2600 to see how RB Watkins can serve you.

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SEL provides complete protection, control, automation, and metering systems for electric power generation, transmission and delivery.
We sell products in more than 100 countries worldwide. More than 45 SEL Technical Service Centers around the world provide the best customer service and sales support in the industry. Our first meter, the SEL-734 Revenue Metering System, leads the industry by providing a complete phasor measurement unit to give system operators a real-time view of the power system state. SEL relays, communications processors, meters, fiber optics, and software products are the roots of complete integrated solutions.
Our Systems and Services Division delivers innovative solutions worldwide, including integration architectures, relay coordination and settings, model power system studies and simulations, and complete substation control, protection, and automation solutions. Drop-in control houses provide a cost- and space-efficient integrated system solution.
We take our commitment to quality very seriously, as demanded by your very critical applications. Our worldwide, ten-year warranty reflects our commitment and demonstrates the quality and value we deliver. Our products meet or exceed both national and international testing standards. We look forward to working carefully with you to make electric power safer, more reliable, and more economical.

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Becky Compton, 330-630-7000
Becky.Compton@sdmyers.com
S. D. Myers, Inc. provides analytical, training and international field services with the ultimate goal of extending the reliable life of your substation equipment and international environmental services to reduce your PCB liability.

Serveron Corporation **Booth 26**
3305 NW Aloclek Drive
Hillsboro, OR 97124-7101 503-924-3200
info@serveron.com www.serveron.com
Reliability of the worldwide electrical grid is paramount. Serveron asset condition assessment and management tools are critical to utilities in improving grid reliability while optimizing their asset base. Serveron develops, delivers and supports on-line transformer and battery monitor products as well as diagnostic services that transform the way utility assets are managed. Headquartered in Hillsboro, OR Serveron serves major electric utilities in the United States and around the world.

Siemens
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Jeff Phelan, 919-365-2329
jeff.phelan@siemens.com
www.usa.siemens.com/energy
Siemens serves Doble clients with advanced power products and innovative equipment repair and life extension service solutions. Its products and systems are sued to increase power system capacity and improve the reliability, stability and flexibility of power delivery and network control systems. Its service operations are located in Wendell, NC, Jackson, MS, and Stoney Creek, Canada.

Solidification Products International, Inc. **Booth 60**
Phone: 800-758-3634 or 813-478-4224
pvanfossen@oilbarriers.com www.oilbarriers.com
Solidification Products International, Inc. (SPI), a thirteen-year-old environmental products company that supplies oil and water absorbents for the control and disposal of various waste materials. SPI's products provide complete solidification of hydrocarbon and aqueous wastes in emergency response operations, as well as for routine maintenance applications, both on land and water. SPI products have been used by major utility companies for years, as well as by major hazardous waste remediation contractors. During the 1990s, SPI environmental control products have set a new standard for the industry by providing 100% effective means of spill control in a cost-effective manner.
In response to EPA regulations, SPI developed new oil spill containment and storm water handling systems for utility industry and others. SPI developed technology that allows for direct discharge of storm water while providing 100% foolproof protection against oil spills. Although there are a handful of other products that can claim to compete with SPI, there are no other companies providing 100% effective state-of-the-art spill containment and storm water handling systems. Three patents were issued to protect this newly developed technology -- #6,485,639 on November 26, 2002, #6,503,390 on January 7, 2003, and #6,841,077 on January 11, 2005. The Company's attorneys have filed two additional patents, and also have filed for Canadian and other foreign patents.
We will work with you on site-specific projects and have the ability to customize systems for your application.

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Southern States, LLC is a world leader in the design and manufacture of high voltage switching devices. The company offers a full line of circuit switchers, load and line switches, capacitor switches, and disconnect switches.

Team Industrial Services **Booth 37**
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Alvin, Texas 77511
W. R. McAfee, 800-662-8326
rmcafee@teamindustrialservices.com
www.teamindustrialservices.com
Team Industrial Services performs onsite, inplace, nondestructive repairs to transformers leaking oil and circuit breakers leaking SF6 gas and/or oil. Other services include onstream leak sealing, hot taps, line stops, freeze stops, field machining, bolt tensioning and torquing, onsite and inline valve repairs, fugitive emissions control (LDAR), plus non-destructive testing.

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Special thanks to Unifin for providing the bottled water for the 2005 Doble Clients Conference

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Email: enquiries@thermoteknix.com
Thermoteknix is well established as a leading supplier of OEM electronics and software to many of the world's major manufacturers of infrared cameras and its own branded technology is recognized worldwide for its innovation, reliability and ease of use.

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301-387-7012 - fax 301-387-7013
em: info@treetechusa.com
Tree Tech Digital Systems engineers and manufactures a comprehensive line of power transformer monitoring and control products that include: digital winding temperature indicators, on-line gas and moisture in oil monitors, on-line bushing power factor and capacitance monitors, OLTC controllers/monitors, position indicators, paralleling systems and more. The devices are classified as IED's and are constructed using microcontroller based electronics making them a rugged and reliable device in the substation/power transformer environment. Equipped with multiple communication possibilities, the devices are ideal for legacy as well as new installations. In addition to the transformer sensors; Tree Tech offers a scalable expert system for monitoring, data treatment and asset management. More than just a database, the system offers comprehensive tools that can be used by the end user to make operational, maintenance and asset life extension decisions. The software is web based so that all the users can access data using a standard web browser over internet/intranet channels. The system is modular in architecture which gives the user maximum flexibility to build a system that meets their specific needs. Founded in 1992, Tree Tech Digital Systems employees Engineers that have hands on power transformer experience therefore the product designs encompass the end users perspective. Tree Tech has provided over 10,000 devices on transformer around the world and is dedicated to providing effective solutions to the utility market.

Unifin International, Inc. **Booth 63 & 64**
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Waukesha, WI 53186
800-835-2732
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Waukesha Electric Systems, Inc. (the largest manufacturer of medium-power transformers), along with its subsidiary, High Voltage Supply (Dallas, TX), will present an extensive range of products and capabilities, including Transformers and Accessories, Load Tap Changers, Modular Substations, Substation Transformer Condition Assessment Services, Reverse-Engineered LTC and Circuit Breaker Components, and complete Substation Repair and Maintenance Services nationwide. The company also provides systems-engineered EPC solutions through its subsidiary, PSD, Inc. (Canton, OH), including engineered switchyards, substations, overhead and underground transmission lines, and Wind Energy projects.

Weidmann-ACTI, Inc **Booth 30 & 31**
One Gordon Mills Way
St. Johnsbury, VT 05819
Contact: Lisa Bean Newell
Tel: 802-751-3530 - Fax: 802-748-8630
e-mail: lbean@weidmann-systems.com
web: www.weidmann-acti.com
Weidmann-ACTI brings value to the electric generation and T&D industries by providing diagnostic testing, expert services and quality products that improve the life, loading and reliability of substation transformers. Industry Asset Managers are increasingly turning to Weidmann-ACTI engineers and chemists to bolster their in-house resources and testing capability

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David Y. Robinson, 505-327-6363
davidr@irscoil.com
Wood Group Generator Services, Inc. is a manufacturer of high and medium voltage coils and Roebel bars. Our service facility specializes in inspection, in-plant and field service, coil installation, repair and rewinding of generators and high voltage motors.

Assessing Health and Criticality of Substation Transformers

By: *David J. Woodcock, Weidmann Systems International*

Utilities in North America installed a large number of transformers from the early 1960's to the end of the 70's. As a result of diminished capital spending since that time, many transformers are approaching the end of their technical life and most have reached the end of their financial life. Driven to reach an increasingly higher level of reliable electrical service, the trade-off for diminished capital investment is to spend more on equipment maintenance. However, many utilities operate under budget restraints and need to get the biggest-bang-for-their-buck by allocating maintenance spending based on need within the transformer fleet. In addition, T&D system operators are developing other condition-based asset management tools, techniques and criteria to manage these critical assets as a way of maintaining reliable operation at a reasonable level of risk and expense.

At this time, a significant increase in failure rates is not yet apparent for this older population. However, it is also apparent that substation transformers, like all electromechanical equipment, do not have an infinite technical life. T&D utilities that, for the most part, replace transformers only for capacity increases or failures are now starting to rethink their approach. As the risk of failure increases with deteriorating condition, and as the risk of consequential costs rise, proactive transformer replacement has started to become a strategic option.

Although this situation has become clearer to North American utility managers, available capital to reinvest in this aged infrastructure is not readily available and projections of future peaks of needed capital, required to maintain reliable service across the system, are very large indeed. Therefore, "Condition-Based" Strategies are not only being applied to prioritize maintenance expense, but the same condition ranking systems are being applied to forecast and allocate future capital spending.

The challenge facing the industry today is in leveraging the most out of existing assets without reducing customer service, while increasing the stakeholder's value. This requires operations and maintenance managers to fully understand the probable condition of old and often highly loaded units. In many cases, this requires "re-rating" the transformer's planned loading capacity for normal and contingent operation. In many cases, use of these planned loading limits may be dependent on the condition of the unit. Refurbishment or

options for enhancing transformer performance to reduce temperature, increase life and/or increase load capability are often considered as O&M options to defer capital spending on new equipment.

The following chart indicates that optimization of risk, based on limited capital and O&M spending and increased loading limits, is the ultimate management challenge that affects customer satisfaction and bottom-line performance in today's electric utility environment. This challenge can only be met with a thorough understanding of transformer health and criticality on the system.

Utility managers are today using condition-based tools that rank the health and criticality of the equipment, as the starting-point for prioritizing maintenance expenses, for proactive capital reinvestment for groups of transformers or for making decisions about replacement of individual problem units on the system.

Determining Health and Criticality for Operating Power Transformers

Statistical methods, based on historical failure modes, are often used to establish the probable condition of all units or groups of transformers on the system. However, this method cannot identify the condition state or vulnerability of individual operating units. Unfortunately, there is no single scientific method available and condition evaluation is often subjective. Evaluation methods are often modified or limited by the availability of information from the manufacturer or from the system's operations and maintenance records. Added to this, the skill level and experience of the people involved in the process are a key variable in making decisions related to the quality of the available information and, subsequently, the probable condition of the unit. A complete appraisal method for an individual unit will often involve field inspections and testing. This decision often depends on the feasibility of taking units out of service, balanced against the importance of the unit on the system and the related cost.

The process for benchmarking the probable condition of an individual unit, compared to other units on the system, is often controlled by moving through three gates or levels:

Level 1 - Data and Design Analysis

Level 2 - Energized and De-Energized Testing

Level 3 - External and Internal Inspection

Condition evaluation methods are subjective and are generally based on the quality of information, requiring the results to be weighted depending on each of the factors or condition indicators that have been selected. Typical factors used for evaluation are related to the equipment design, environment, usage and historical maintenance or testing data and are listed in the following Table.

Typical Factors for Calculating Weighted Condition Factor (WCF)

Design		Operating Environment	Usage	Historical Tests & Diagnostic
Main Unit • Manufacture • Vintage • Winding Configuration • Materials • Short Circuit • BIL	Ancillary Equipment • Oil Preservation • LTC • DETC • Cooling Equipment • Bushings	• Source Impedance • Protection Scheme • Lighting Level • Ambient Temperatures • Load Power Factor • LTC Regulation Range	• Historical Loading Pattern • Prior Overload Conditions • Prior Through Faults • Fault Levels • Maintenance Practices	• DGA • Oil Quality • Power Factor • Insulation Resistance • Maintenance Records

It is normal to select up to 10 factors (Condition Indicators) for Level 1 evaluation, which can be used as a preliminary process (and as the only method) for evaluating large groups of units. When used with transformer priority (discussed in the following section), Level 1 ranking can provide the basis for deciding if subsequent Level 2 and 3 inspection and testing, using as many as 25 or 30 factors (Condition Indicators) will be required for evaluating smaller groups of critical units.

As we have seen from the criteria given in the above Table, many factors must be considered and weighted against each other to result in a realistic condition evaluation. However, the probable condition of the internal insulation is usually a key consideration due to the fact that the condition is, for the most part, "irreversible". Spontaneous and non-spontaneous events will have combined to lead to this irreversible condition. Years of use or high loading, frequent and/or close-in faults, high moisture or oxygen in oil over time, high measured furan levels and/or low measured degree of polymerization (DP) are all key indicators of this condition.

However, defective ancillary equipment, bushings, cooling systems, tap changer mechanisms etc, can be placed in the "as new" condition with a scheduled maintenance outage. The decision to invest capital dollars in refurbishing the unit is often based on a thorough economic evaluation. It is also a fact that failures from internal insulation damage or deficiency often result in major damage or even catastrophic failure with long-term loss of service and severe financial implications. Determination of the associated risk of operation for condition-based loading limits, and selection of appropriate margins to mitigate risk, should consider all of the above factors. Additional factors for more detailed Level 2 condition evaluation are discussed later in this article.

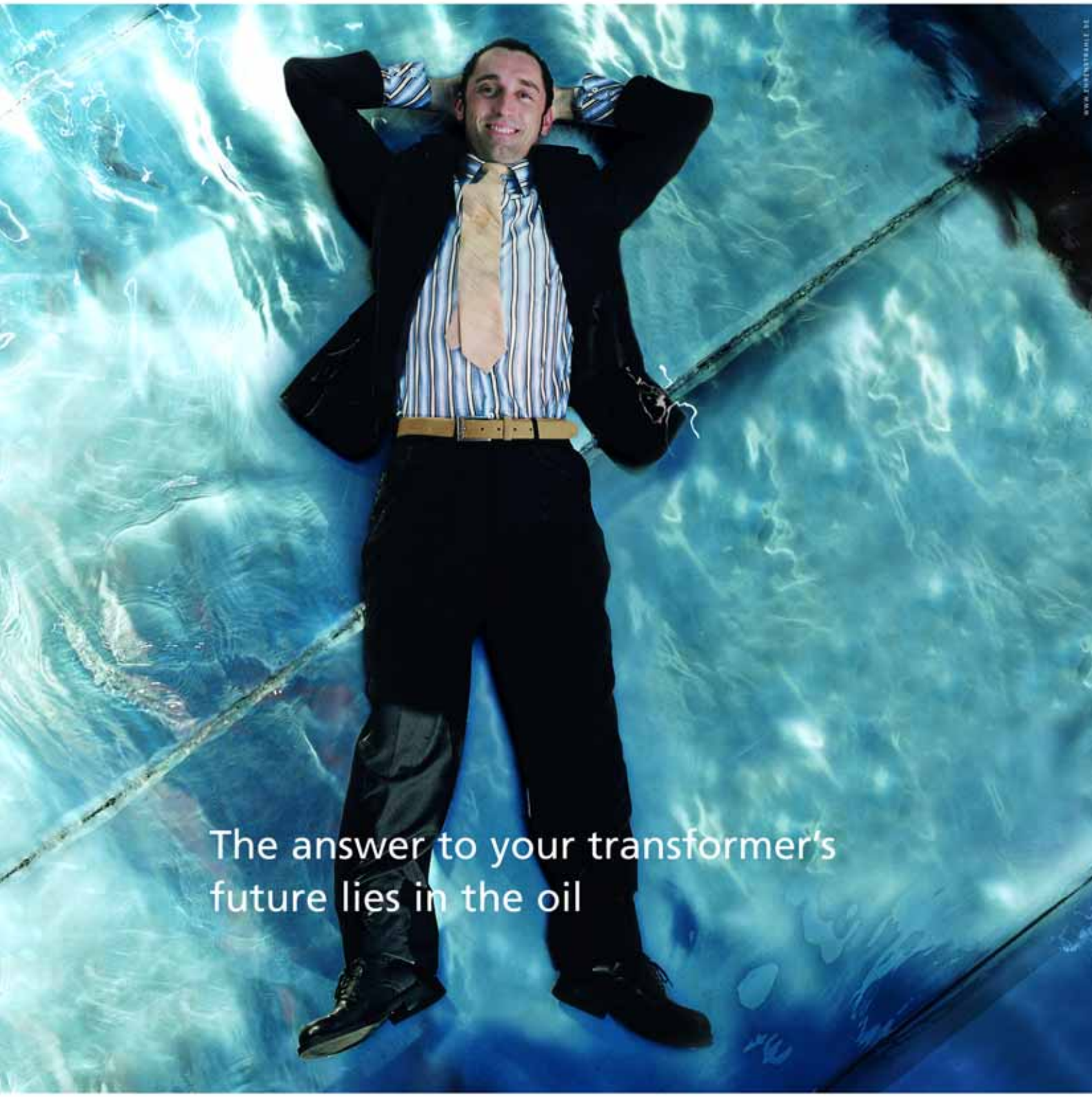
Establishing Group Ranking and Priority

For most substation transformers, knowledge about the probable condition of an individual unit does not in itself provide the basis for making good maintenance, loading or capital spending decisions. As an example, two units of equally poor condition may result in one being placed on a high level of care and attention while the other is placed on a "run-to-failure" status. It is important to compare the unit's probable condition or Weighted Condition Factor (WCF) versus the level of its importance or criticality for future use on the system (TPI). For the utility to determine this importance, the criteria must be selected by a cross-section of appropriate asset managers, maintenance staff, operations managers and engineers. These criteria can be determined by canvassing a list of the above selected people and by voting based on the most/least important factors for future use.

Typical factors are shown in the Table below. The individual unit's Transformer Priority Index (TPI) can be calculated by scoring the available data for the unit being evaluated against a quantitative or qualitative subset for each of the selected factors.

Transformer Priority Index (TPI) – Factors Crucial for Future Use

Maintenance	Planning	Operations
Application (use)	Growth Areas	Load Served
Size of Units/voltage class	System Location	Contingency
Type / Brand/ Age	Capital budget	Customer Contracts
Vintage/Family connections	Available Spares / Risk	System Impact/Auto Switching
Historical Problems/fault levels	Load Limits	Risk Level/Consequential costs
Ancillary Equipment State	- High	
- Bushings/Tap Changer/Cooling	Population Density	



When it comes to transformer oils you have to take the longer perspective. The cost of the oil is normally just two percent of the initial investment. But knowing that the right insulating oil can add years to your transformer's lifetime, the initial cost may not be the most important factor. If you want to know more about how to increase your transformer's performance at a lower lifetime cost in the future, contact Nynas today.

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The combination of the individual unit's Weighted Condition Factor and Transformer Priority Index can be used to make decisions about the extent to which the unit can be operated and maintained. For instance, a unit rated in poor condition, and in a position vital to the system's operation would warrant a high level of attention; whereas a unit rated in similarly poor condition but not crucial to future system operation, may be operated with a minimum of attention.

Testing and Technologies as Indicators for Detailed Condition Assessment

Selection of the applicable and preferred types of testing, for use as an indicator for Level 2 condition evaluation, will depend on the transformer design area or ancillary component of interest. In addition, the selection of testing type will depend on the number of units in the assessment process, criticality of the unit on the system, available skill sets and cost associated with the available technology and test methods. A list of available on-line and off-line testing techniques and technologies is shown on the following chart.

Applicable Transformer Design Area or Ancillary Components.

1. Solid Insulation (Moisture, Dirt, Destruction)
2. Magnetic System (core compression, component to tank insulation damage)
3. Windings (buckling and other deformation)
4. Transformer Oil Condition
5. Systems for oil cooling, treatment and protection
6. Bushings
7. Voltage Regulation and contact systems

The following chart makes the connection between the test type and it's applicability to the above listed area of interest.

An example of the Condition Ranking method is shown in the following Table. The units are ranked into four groups: Red, Yellow, Blue and Green, indicating the level of risk associated with operating older units, and can be used as a "Decision Matrix" for all areas of Asset Managementv

Weighted Condition Factor (WCF)	TRANSFORMER PRORITY INDEX (TPI)									
	VITAL			CRITICAL			IMPORTANT			
	1	2	3	4	5	6	7	8	9	10
15										
14										
13										
12										
11										
10										
9										
8										
7										
6										
5										
4										
3										
2										
1										

For the purpose of determining risk associated with health and criticality it is necessary to couple condition assessment with failure probability. Transformer failure rate is a subject for debate throughout the industry and very little real failure data is available. However, despite the fact that some units last for 80 years, most fail in their middle years and this depends on many factors such as design, application on the system, loading, type of ancillary equipment, systems protection etc.

As a rule of thumb the following simple table applies to estimating failure probability versus assessed condition.

Condition Rating	Failure Rate
Good	**0.6%**
Satisfactory	**1.0%**
Fair	**1.5%**
Poor	**2.0%**
Bad	**3.0%**

Current use of condition-based tools increasingly provides T&D asset managers with the ability to make intelligent decisions about allocation of maintenance expenses and potentially to determine future transformer loading limits as part of a condition-based dynamic loading program. In the future, risk and financial models, based on a better understanding of the health and criticality of substation transformers, will be required to support a "Risk-Based Reinvestment Strategy" aimed at predicting the future peaks of capital needed to operate the system at a predetermined level of reliability. ■

REFERENCE

David J. Woodcock is V P of Business Development with Weidmann Systems International Inc.

Method	1	2	3	4	5	6	7	On-Line
Infrared Scan		+			+	+	+	+
Dielectric Dissipation Factor (DDF) & Capacitance				+				
Winding Turns Ratio	+							
DC Winding Resistance			+				+	
Percent Impedance/Leakage Reactance Test			+					
Partial Discharge (acoustic & electrical)	+	+	+			+	+	+
Sweep Frequency Response Analysis (Transfer Function)		+	+					
Recovery Voltage Measurement (RVM)	+							
Vibration Analysis		+	+		+			+
Gel Permeation chromatography	+	+			+	+	+	
Dissolved Gas Analysis (DGA) & gas ratio analysis	+			+			+	+
Furan Analysis	+			+		+		
Moisture/Water content	+			+				
Resistivity, Acid Number (or Acidity), Interfacial Tension (IFT) and DDF				+				
Degree of Polymerization (DP)	+							
Dielectric loss angle (DLA)			+	+		+		

Transformer cooling – The impact of oil viscosity on the performance

By: *Dipl.Ing. Gerfrid Newesely, technical consultant for Nynas*

The cooling behaviour of oil filled transformer is influenced by several factors including the type and volume of insulating oil, the surface and design of the radiators, the availability of oil pumps or air fans, the loading mode, etc.

When comparing various mineral oils for heat dissipation efficiency, it is important to evaluate oils of similar quality to have a fair comparison. Referring to the CSA-C50-97 standard for example, comparing a class A oil with a class B one will normally demonstrate that the class A provides better performance. When comparing oils meeting the same standards, many of the factors are constant figures (Heat transfer coefficient, Heat Capacity, Thermal conductivity). With these parameters fixed, one need to look at the other properties of the insulating oil that can differentiate their performance for heat transfer.

If the transformer design is fixed, and if it is a transformer with natural oil flow (thermosyphon circulation without pump) and natural air circulation without fans (by IEC terms this is called ONAN Oil Natural Air Natural [1]), then it is mainly the physical properties of the insulating oil that plays the most important role. This can be understood as a low viscosity oil will allow for a higher circulation speed of the oil that results in a better efficiency of the cooling system.

a) Flow speed: It is true that the flow speed in various part of a given transformer will not be easy to calculate but nevertheless, in a given design, it is safe to assume that the oil flow pattern will be similar and governed by the oil viscosity at a given temperature. This has been verified in many equipment and is accepted as basic design data. The flow speed can be evaluated by the formula for the "frictional resistance" [2] that is based on the laws of Bernoulli and Newton:

$$\Delta p = \frac{32 * \nu * l * \gamma * w}{d^2 * g}$$

Where
p = pressure
ν = kinematic viscosity
l,d = dimensions of the tube
γ = specific weight
w = oil speed in the tube
g = gravity constant

When further developed this formula gives for v:

$$w = \frac{\Delta p * d^2 * g}{32 * l * \gamma} * \frac{1}{\nu}$$

A part of the term is constant (at a certain temperature), therefore:

$$w = f * \frac{1}{\nu}$$

Or in words: The lower the viscosity, the higher the circulation speed of the oil which equates in a higher quantity of heat being dissipated.

b) Heat exchange factor: This has an important influence on cooling. The heat exchange to the oil happens on the surface between the winding and the oil. This factor as well is improved with lower oil viscosity. The Reynolds Number is a basic engineering parameter that is used in the evaluation of the flow profile of a liquid. The Reynolds (Re) indicates whether the fluid, in this case the insulating oil, has a laminar or a turbulent flow characteristic:

Reynolds number [2]: $\mathrm{Re} = \frac{w * d}{\nu}$

Or in words:
High flow speed and low viscosity give a high Reynolds Number.
If this value is:
Re < 2300: flow is laminar
Re > 2300: flow is turbulent

Laminar flow means that the boundary layer between the winding and the oil is not disturbed and is thick. This boundary layer of oil insulates and impedes the heat transfer from the surface of the winding to the oil. In a turbulent flow situation, this layer is disturbed and this allows for other parts of the oil to contact the surface. Therefore turbulent flow gives better heat exchange factors.

High quality transformer oils are formulated to have low viscosity (with observation of all given security limits as for example Flash Point, see Specification, [3]).

In the Standards for insulating oils (IEC 60296 [4], ASTM 3487 and others) there is an upper limit for viscosity which is 12 mm2/sec at 40°C. High quality transformer oils are normally in the range of 7- 8 mm2/sec at 40°C and even with such low viscosity, they still meet the requirement for flash point (<135°C) from the same standard.

Benefits and value:

There is the question whether and in which way these better cooling properties of a low viscosity transformer oil could be utilised for the optimisation of design of the cooling system of a transformer.

a) This could be used for the refill of older units where the surface of the insulated windings is clogged by some sludge that is hindering the heat exchange on the heat exchange surface thus decreasing the cooling properties of the system. This lower heat exchange capacity can be compensated by oil with low viscosity that gives higher oil flow speed and therefore should result in better dissipation of the heat generated.

b) Another option would be to reduce the cooling surface of radiators (or reduction of the number of radiators) when such low viscosity oil is used. This allows for a reduced manufacturing cost of the transformer and can also allow for a more compact design.

Experience:

A Canadian transformer manufacturer was interested to reduce the number of radiator banks on a 1500 kVA ONAN transformer from 3 to 2 (reduction of cooling surface). The use of a high quality naphthenic oil was considered along with a more expensive CDP parafinic insulating oil (also known as synthetic isoparafin insulating fluid). Both oils meet the CSA-C50-97 standard for Class A oil.

To prove the oils had the required cooling properties, that transformer has been tested using the "Heat run test" following IEEE C 57.12.90-1999 [5], chapter 11 (Temperature rise) equivalent to IEC 60076 part 2 [1]. This test determines the average winding temperature rise of the transformer. If it rises more that 65 C above ambient temperature, overheating of the insulation takes place and that leads to an accelerated ageing of the insulation and, in excessive cases, could damage the transformer.

The comparative test within this Canadian transformer manufacturer was initiated as the supplier of the more expensive parafinic based insulating oil claimed superior heat exchange properties of his oil without proving that statement. But, considering all the above explanations, it becomes clear that this statement was not correct, as the physical properties of both oils were quite similar.

Test set and procedure:

A specific unit was selected for the testing. The transformer was tested first with the parafinic oil, drained and tested again with the naphthenic oil.

The transformer was first filled and put under vacuum. After vacuum treatment the oils were tested for water content and breakdown voltage (ASTM D 877, IEC 60157). After being prepared for the heat run, the transformer was loaded by simulating loading using the short circuit method for more than 24 hours with total losses (no load and load losses) to rise the temperature of windings and oil from start (ambient) temperature to maximum operation temperature at a defined load. During that procedure, all relevant temperatures have been measured and plotted:

- top oil temperature (by a sensor in the transformer tank near to the oil surface)
- oil temperature radiator top and bottom
- ambient cooling air temperature (as an average of 3 sensors each in a distance of approx. 1,2 m from the transformer at about half the height of the transformer, therefore approx. 1 m height)

The transformer was protected against air current to avoid disorder of the measurements.

Before starting to load the transformer, the cold resistance of the windings was determined. After that, following the Standard, the transformer was loaded (heated) with total losses until the unit's temperature did not rise (vary) by more that 1 C during a consecutive period of 3 hours.

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This was reached after 27 hours. Then, the load was reduced to rated current for 60 minutes and after that period, the load was switched off to determine the average winding temperature by the resistance method (hot resistance).

The average winding temperature is determined by the equation:

$$T = R/R_0 (T_k + T_0) – T_k$$

(Equation 26, chapter 11.3 IEEE C57.12.90-1999, [5])

Where:

T	is the temperature (°C) corresponding to hot resistance R,
T_0	is the temperature (°C) at which cold resistance R_0 was measured
R_0	is the cold resistance, measured according to Clause 5, (Ohm)
R	is the hot resistance (Ohm)
T_k	is 234,5 °C for copper (resp. 225,0 for aluminium)

Final conclusion:

- The result of the calculation was a similar value (below 65 C) with both oils and therefore the test was passed successfully.

- The result with the CDP parafinic insulating oil (synthetic isoparafin) was similar to the one obtained with the naphthenic oil.

- Considering the difference in the procurement of the oils as well as the value associated with the long experience (>40 years) of naphthenic oils in real life applications as opposed to the limited (<10 years) experience in actual application of the newer CDP parafinic oil tested, it was agreed that the high quality naphthenic oil was offering the most competitive alternative.

- On a transformer of the same type but with the full set of 3 radiator banks, a similar heat run test has been performed in the past. The test was passed successfully but with a smaller temperature raise.

- Using low viscosity naphthenic oil allows for more efficient cooling which permits transformers to :

  1) Be less intensive on radiator usage
  2) Be smaller in size
  3) Be less demanding in the amount of oil required
  4) Be less expensive to build
  5) Operate at lower temperature

Lowering the operating temperature of transformers is of great benefit as it reduces the thermal ageing of the cellulose insulation, therefore extending the life of the transformer.

Literature:

[1] IEC 60076 Part 1 (2000), Part 2 (1993) Power transformers
[2] Dubbel, Taschenbuch für Maschinenbau, Ed.17, Berlin 1990
[3] Nynas, Specification for Insulating oil Nytro 10CX
[4] IEC 60296 Ed.3 (2003), Specification for mineral insulating oil for transformers and switchgear
[5] IEEE C 57.12.90-1999, Power transformers

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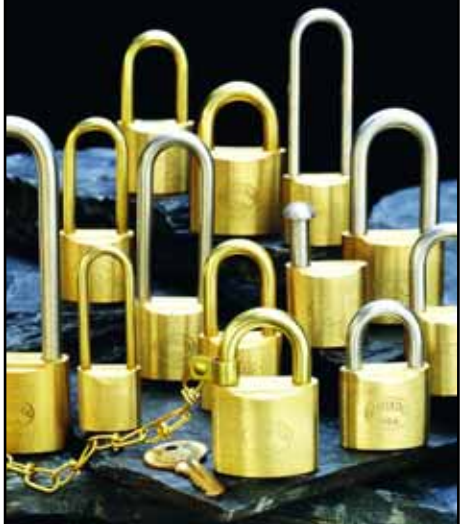

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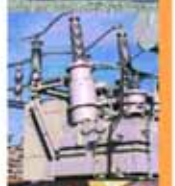





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