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Real-Time Performance Management

Plus

Power Quality Exhibition and Conference

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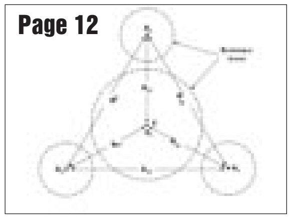
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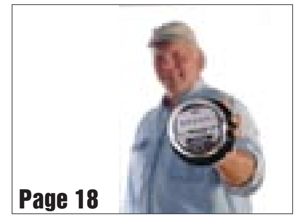
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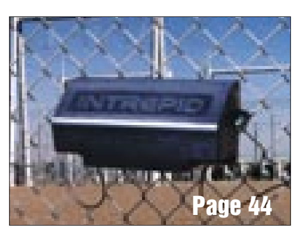
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LTC Condition Assessment by Diagnostic Testing

By: Fredi Jakob, Karl Jakob, Simon Jones
Weidmann-ACTI

During the past forty years, dissolved gas analysis DGA, has become universally accepted as the premier diagnostic tool for location of incipient faults in transformers. Extension of DGA to other oil filled equipment were proposed and debated during the past decade. The consensus opinion was that gases developed during the switching operation would "cover up" any gases due to equipment problems. Table 1 shows the gas producing processes that occur in oil filled electrical apparatus. The gases that are produced by these various processes are listed in Table II. Recognition of these differences between normal and abnormal gassing conditions paved the way to diagnostic evaluation of load tap changers LTC's, and oil filled circuit breakers, OCB's.

Table I.
Gas Producing Processes

Equipment	Normal	Abnormal
Transformers	Heating	Excessive Heating, Partial Discharge and Arcing
LTC's and OCB's	Arcing	Excessive Heating and Partial Discharge

TABLE II.
Gasses Produced.

Gasses	Indication
Hydrogen	Partial Discharge, Heating Arcing
Ethylene, Ethane, Methane	"Hot Metal" Gasses (Heating)
Acetylene	Arcing
Carbon Oxides	Cellulose insulation

If you asked the average utility management about the amount of maintenance they want to perform their answer would be minimal or none. As demanding as the requirement seems, it is approachable with currently available diagnostic testing equipment and procedures. Both on-line and off-line tests can be employed.

Transformers require very little component maintenance but the oil must be carefully maintained. Thus transformer maintenance costs are already minimal. In contrast LTC's and OCB's currently require time or operation count based maintenance. Alternative maintenance strategies based on non-invasive diagnostic tests can significantly lower LTC and OCB maintenance costs. An achievable goal is to use condition based maintenance test results as the primary driver for maintenance scheduling. Savings in maintenance dollars must not adversely impact the number of outages, in fact unplanned outages must also decrease when a condition based maintenance program is implemented.

DGA and other non-invasive tests can be combined to give a very clear picture of LTC condition. Diagnostic programs have been successfully developed to achieve the desired goals.

Diagnostics

In order to bring to bear the most useful analytical diagnostic tools, one has to identify problem scenarios. In the case of LTC's the most common problems and the applicable diagnostic methods are listed in Table III. It is obvious that DGA plays a primary diagnostic role. The interpretation protocols for applying DGA to the evaluation of LTC gas data will, as in the case of power transformers, be empirical in nature. Transformer DGA interpretation, as presented in the IEEE guideline C57.104.91 is generic in nature. In the case of LTC's it is generally accepted that fault gas interpretation will be most useful if it is model specific.

Table III.
Diagnostic Tools.

Diagnostic Tool	Problem Detected	Result
DGA	Coking, Contact Misalignment	Overheating
Oil Quality	Coking, Contact Wear, Change in Arcing Characteristics	Conducting particles in oil
Metals Analysis	Contact Misalignment	Contact Wear

Individual gas concentration based diagnostics for LTC's are not as useful as they are for power transformers. This is due to the fact that individual gas concentrations are operation count and breathing configuration dependent. These LTC gas "signatures" also vary widely from model to model. We have found that ratios of fault gases are fairly independent of operation count. Our evaluation of various gas ratios indicate that ratios or heating / arcing gases, such as the ratio of ethylene/acetylene and temperature dependent ratios of "heating gases" such as ethane/methane are excellent diagnostic tools. Table IV lists the gas ratios that we employ for the evaluation of LTC data. Table V summarizes the advantages of using gas concentration ratios, rather than individual gases.

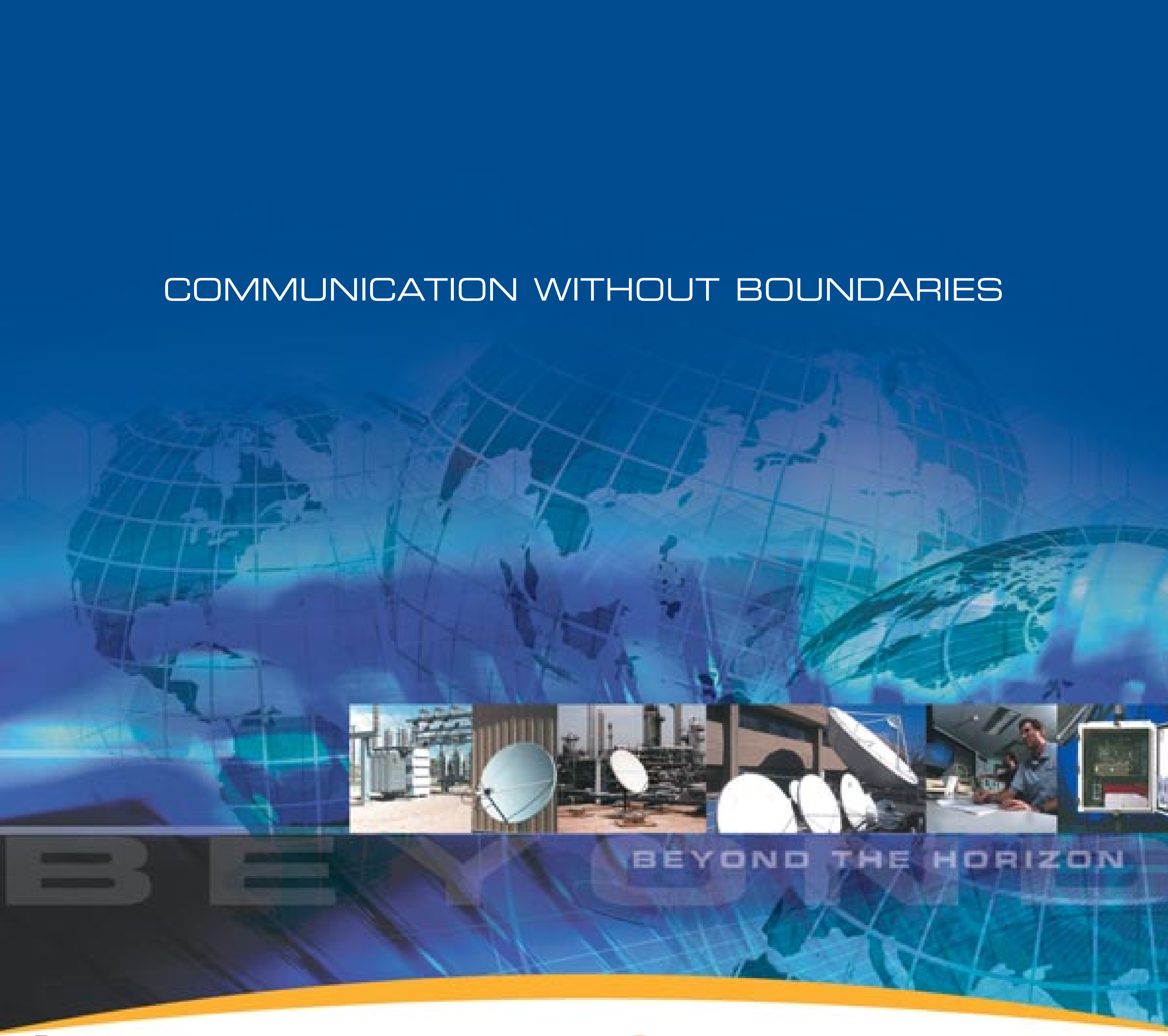
Table IV.
Diagnostic Gas Ratios.

Heating to Arcing Ratios			
$\frac{\text{Ethylene}}{\text{Acetylene + Hydrogen}}$	$\frac{\text{Ethylene}}{\text{Acetylene}}$	$\frac{\text{Metane + Ethylene + Ethane}}{\text{Acetylene + Hydrogen}}$	$\frac{\text{Metane + Ethylene + Ethane}}{\text{Acetylene}}$

Temperature Dependent Ratios	
$\frac{\text{Ethane}}{\text{Methane}}$	$\frac{\text{Ethylene}}{\text{Ethane}}$

Table V.
Advantageous Aspects of Gas Concentration Ratios

- Independent of Operation Count
- Resistant to Change due to Loss of Gasses to Atmosphere
- Change with Contact Condition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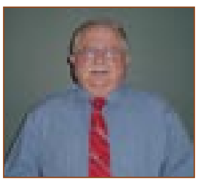
Great success has been achieved in identifying LTC's that require maintenance. At this time no false positive problem indications have been encountered.

In summary, non-invasive DGA is a valuable tool to identify the small number of LTC's in your system that require maintenance in the immediate future. Identifying units that were previously scheduled for maintenance, which can now be postponed, results in very significant reductions in maintenance costs and concurrent reduction in outages. ●

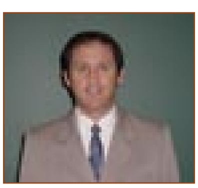
About the Authors



Dr. Fredi Jakob is Director of Laboratory Services and Director of the Educational Division for Weidmann-ACTI Inc.

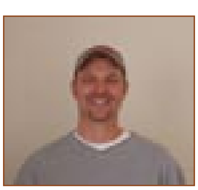
He is responsible for all technical aspects of the laboratory. Prior to his current position, he was a founder and Laboratory Director of Analytical ChemTech International, Inc. (ACTI). He is Professor Emeritus of Analytical Chemistry at California State University, Sacramento.

He received his B.S. degree in Chemistry from CCNY and a Ph.D. degree in Analytical Chemistry from Rutgers, the State University of New Jersey.



Karl Jakob is the Director of Business Development for Weidmann-ACTI Inc.

He holds a Bachelor of Science in Electrical and Electronic Engineering from California State University Sacramento and is a Registered Electrical Engineer in the State of California. He was a co-founder of Analytical ChemTech International (ACTI) and is an active member of the IEEE Transformer Committee.



Simon Jones is currently finishing his Masters of Science degree in Chemistry from the California State University at Sacramento where he previously received Bachelor of Science degrees in both Chemistry and Molecular Biology in 1999. He began working for ACTI in 1997, and is instrumental in the development of testing methodologies and diagnostics for Weidmann-ACTI.

Circle 10 on Reader Service Card

50-Year Warranty on CCA Poles

The licensor of Wolmanized® wood has announced a 50-year warranty on CCA-treated utility poles. The warranty requires no paperwork and there is no charge for it.

Arch Wood Protection, leading manufacturer of CCA (chromated copper arsenate) preservative and licensor of the Wolmanized brand, is backing utility poles produced by its licensees with a 50-year warranty against damage from termites and fungal decay.

Prior to the announcement, Arch licensees offered a warranty but the purchaser was charged a fee for the assurance. It has been replaced with the new warranty, which costs nothing beyond the price of the pole.

If, within 50 years of purchase, a warranted utility pole should suffer damage from termites or fungal decay which makes the pole unfit for supporting lines, the owner will be reimbursed for the original purchase price. This is in effect without registration or paperwork; the utility pole brand serves as proof of purchase.

"We are confident in the longevity of CCA poles," said Grady Brafford, business manager for industrial chemicals at Arch Wood Protection. "We hope that this warranty gives utilities similar confidence. The top utility pole producers in North America are part of this program." ●

More information can be found at www.wolmanizedwood.com/utilitypoles.shtml.

Circle 11 on Reader Service Card

Clarity to Show New Displays for Electric and Water Utilities at DistribuTECH 2005

At the upcoming DistribuTECH conference (January 25-27, 2005, in San Diego) Clarity Visual Systems (booth #1838) will give the electric and water utility industry its first look at the newest displays the company is offering for centralized network monitoring. The displays, which set new design and performance standards, represent compelling alternatives to conventional monitoring products, including plasma-based displays and CRTs.

Among the products Clarity is featuring at DistribuTECH is Bay Cat. This is the largest direct view LCD display on the market, offering a 46-inch screen size. With its 46-inch image area, high resolution (1920 x 1080) and 170-degree viewing range, Bay Cat gives plant operators the best overall view of their network conditions and better enables them to see and act on situations before they become problems.

Clarity Visual Systems provides large-scale display systems to support the digital messaging application needs of business, government and other institutions worldwide. The privately held company, established in 1995 and headquartered in Wilsonville, Ore., sells through selected value added reseller partners. It holds numerous display technology development patents. For additional information, www.clarityvisual.com ●

Circle 12 on Reader Service Card

ThermalSpection 724

Over the past two decades, the commercial market for thermal imaging/inspections has been the use of hand held/portable instruments. The largest of these markets has been the inspection of sub-stations/distribution and transmission/in plant electrical distribution. It can certainly be widely documented the cost savings resulting from scheduled inspections by trained Thermographers using state of the art infrared cameras.

With recent advancements in the thermal camera technology, the packaging/size of the instruments, thermal resolution and costs of cameras have come down dramatically. What

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used to cost $75,000 only a short few years ago is now under $20,000 today. Advancements in software operating systems/platforms and computer hardware is also contributing to the opening of new markets for thermal imaging. The largest of which is the use of infrared for on-line process control and remote monitoring.

To this point, Mikron Infrared, Inc. has developed a comprehensive remote monitoring package called ThermalSpection 724. As the name denotes, this system is installed in remote locations and is capable of thermally monitoring targets on a seven day a week, twenty four hours a day. Using either wired or wireless data transfer, the application specific software collects thermal data, analyzes the data and effects outputs based on operator defined parameters.

To appeal to additional markets, we have added high resolution CCD cameras and long range directional Ultra Sound capabilities to the system as options. The visual CCD cameras are integrated directly into the thermal imagery to provide a level of security not available with just visual cameras alone. The Ultra Sound capability provides the ability to locate and identify equipment exhibiting electrical arcing and corona…which is not able to be "seen" using either thermal or visual inspection techniques. The added capability to the ThermalSpection 724 package is further identified as the DualVision/Ultra.

Mikron Infrared, Inc. is a full system/solution provider, manufacturing an extensive line of both hand held and fixed thermal imaging cameras and systems, in house software development and support, solution engineering and after sales support and training. ●

For more information on this system…please call Mikron Infrared, Inc. at 888-506-3900 or find us on the web at www.irinfrared.com.
Circle 55 on Reader Service Card

Multi-Function Recorders – Expanding Capabilities Beyond Oscillography

Since the application of solid-state technology to traditional oscillograph functions in the early 1980s, there has been a constant evolution from simple transient recorders – devices that recorded only sinusoid data. The original transient recorders took advantage of available technology to record high-speed data for analyzing protection operations, helping power engineers determine if the overall protection system of relays, breakers and other devices operated as expected, and if not, why not.

In the early 1990s some vendors introduced stand-alone disturbance recorders, modified the existing functions to extend recording times or added a parallel capability to their transient recorders. This new function now acquired several seconds to many minutes of recording so storing the traditional sinusoid data wasn't appropriate as this would consume available memory and require long transmission times over phone lines.To overcome this, the most useful and economical designs offered parallel capability with new types of triggers dedicated to power and frequency swings needed for this longer-term data and stored either power per circuit or phasor data per channel.This reduced the volume of data while still providing the necessary information to analyze these unique disturbances.

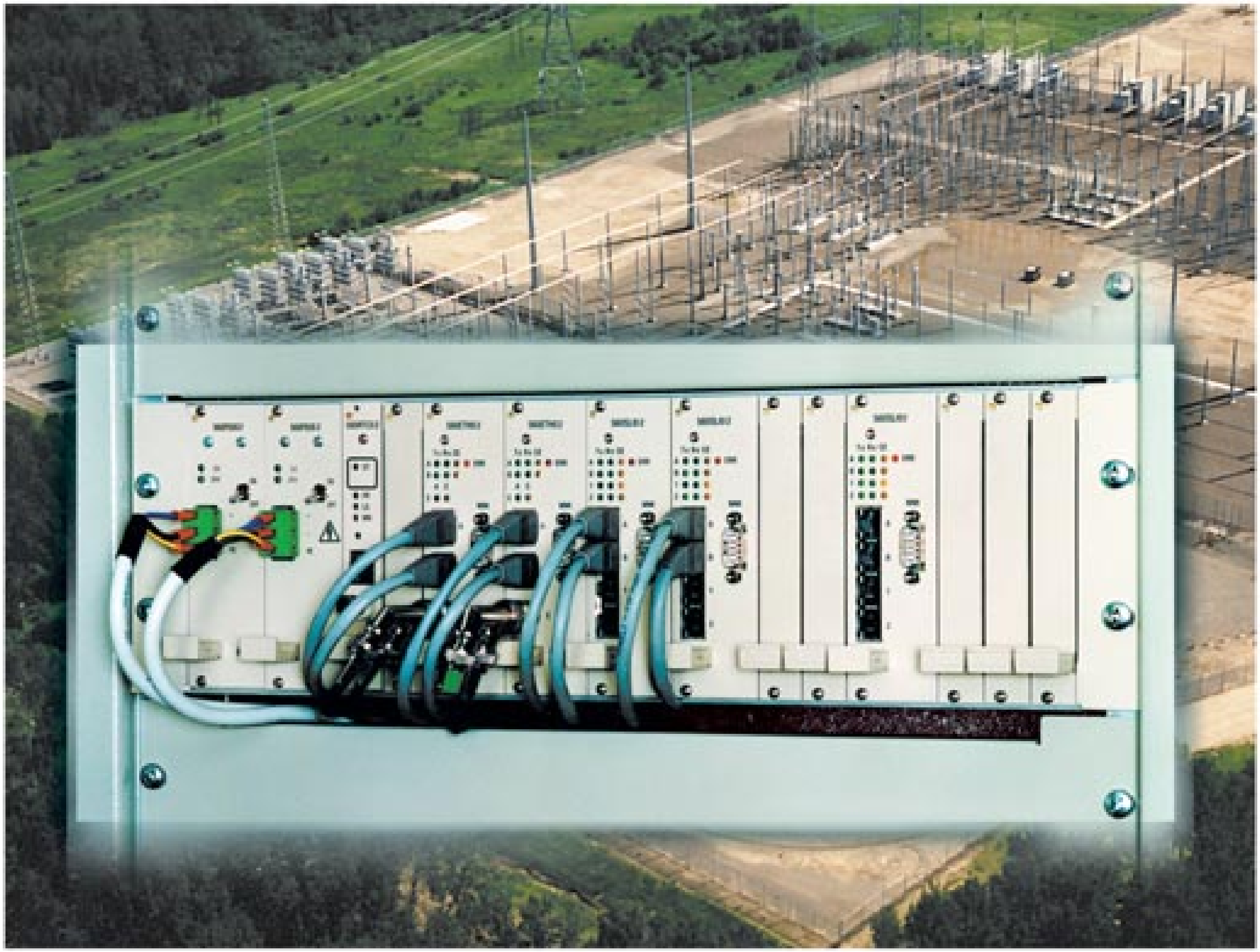
Examples of this data can be seen in the waveforms below.The very low-level oscillations of the system frequency (recorded in New York) can be directly tied to lines tripping in Ohio an hour or more before the actual blackout.

More advanced recorders that are now available such as Ametek Power Instruments TR-2000 also have the ability to continuously store data from the power system.As with the triggered disturbance data, power or phasor data needs to be stored to reduce the data volume to something that can be handled by memory in the recorder and the communication channel.The TR-2132 will store 2 weeks of data at a 30-Hz storage rate, requiring 6GB of memory to store the rms, phasor magnitude and angle for every channel and 2 frequency values.

Several experts involved in the investigation of the blackout have stated that some of the most valuable data came from devices that stored data continuously before, and more importantly after, the blackout.This allowed them to see what the system was doing without depending on devices triggering and clearly showed what parts of the system were still operating.These continuous high-speed logging devices also made the analysis easier by having several minutes to hours worth of data in a single file, eliminating the need to paste together several different records.

Another feature available on the more advanced recorders are a variety of power quality and equipment condition monitoring.Since the devices are connected to the power system, monitoring key parameters, steady-state values such as minimum, maximum and average values can be stored.RMS and frequency log files can be used to replace circular chart recorder functions.These same devices can also replace flicker meters, trend MW and voltage imbalances and store the individual harmonic spectrum on many different channels.Another way to expand a transient recorder into power quality applications is to analyze the voltage sags and swell recorded during normal operations and plot them against standard curves such as CBEMA

ABB's RTU560 – suits your application



ABB's RTU560 Remote Terminal Unit is ideally suited for North American RTU applications:

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- Wide variety of industry-standard communication protocols supported, including DNP 3.0, IEC 60870-5-101, -103, -104 -105, Modbus, DNP on Ethernet LAN/WAN TG800, as well as common proprietary protocols such as RP570, 571, SPABus, Indactic 1323, 133.
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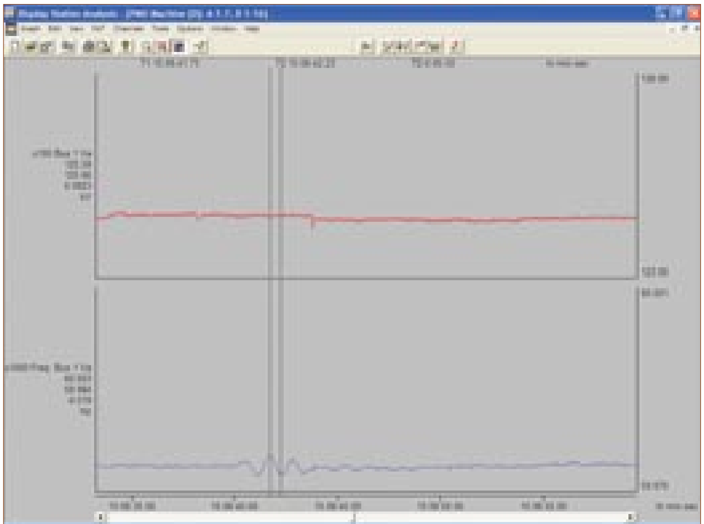


Figure 1: Frequency oscillation in NY caused by lines tripping in Ohio

or ITIC.If the process is totally automated, this information is basically free, not requiring any additional hardware ot time to create these reports or plots.All of these functions are provided with better accuracy, resolution and flexibility than the traditional devices it is replacing.

When a device like the Ametek Power Instruments TR-2000 recorder is synchronized to the GPS system, the time accuracy and internal algorithms are able to provide synchronized phasor data both in real time and as a post-processing feature.By knowing and comparing the positive sequence voltage phasor angle and magnitude at multiple locations on the power system, overall system stability can be analyzed, control decisions can be made and stability models verified or corrected.As with the aforementioned functions, the same input signals are used to provide this data.By complying with recognized standards defined by the IEEE, very precise phasor data is provided in post-processing of both sinusoid and disturbance records providing a very flexible tool for analyzing the power system with superior accuracy.

By linking the real time calculation of phasors to a communications port, the data is now available in real time.The evolution of the IEEE C37.118 standard for Synchrophasor data will allow vendors to s write applications to take advantage of this data and use it for faster, more accurate state estimation calculations, control decisions and real time displays of overall power system stability.

As you can see, with increased processing power and application specific uses of data, not only do today's transient recorders provide a complete picture of the power system during misoperations or severe problems, they can also provide a variety of other useful information from fault location, to power quality reports to synchronized phasor data. ●

Circle 56 on Reader Service Card

The Role of Testing
in the Practice of Good Grounding
—Part 2—

By: Jeffrey R. Jowett, Megger®

Simplified Fall of Potential

Simplified Fall of Potential applies a mathematical proof to the fundamental concept already described. Rather than taking the time and work of plotting at regular intervals across the full span from test electrode to current probe, the initial measurement is made at the midway point, then two more at 10% of the distance in either direction. This is a lot less time consuming, and its success is determined by whether or not the three readings were taken on the plateau of the underlying Fall of Potential graph, or on the rising curve. To make this determination, a simple mathematical procedure is applied, derived from calculus and based on rate of change of slope. The calculation yields a percent accuracy of the average of the three readings. If the readings are not sufficiently grouped within a narrow tolerance, the average falls outside an acceptable accuracy, and they were likely made on the rising curve. The procedure must be repeated at greater distance.

The worldly-wise will ask, "Why don't we just look at a few successive readings and see if they agree?" This represents a non-descriptive procedure that is widely performed, and might be called the "eyeball" method. If the technician is sufficiently experienced, it may be reasonably reliable. However, it lacks objectivity, and won't likely stand up to third-party scrutiny. The readings may fall on the rising curve or may reflect only random variations, and the operator's judgment may be tainted by optimism. Invoking the mathematical proof of the Simplified Fall removes this potential source of error.

"62% Rule"

Simpler still is the widely known "62% Rule". This is a single measurement, taken at 62% (actually 61.8) of the distance to the current probe. Remember that on a classic Fall of Potential graph, the current probe superimposes its own sphere of resistance. Therefore, at some point, the graph must coincide with the value of the true theoretical resistance, if it were possible to measure the entire planet from the point of the test ground. That coincidence has been mathematically determined to occur at the 61.8% distance. Why isn't all ground testing done to that point, then? The reason is because the determination is based on an ideal model. In actual practice, the current probe may not be far enough away, there may be a pipe or power cable directly under the potential probe, or the spot may have been filled with some non-representative material. For these reasons, the 62% Rule should not be relied upon at unknown sites, but is a good backup test at areas that have already been rigorously proofed.

"Dead Earth"

The final simplified method is again one of limited reliability, and should not be employed generally; that is the "Dead Earth" Method. This technique is quite popular because of its simplicity. Only two leads are used, one hooked to the test ground and one to a reference ground (Fig. 5). This is essentially the same as using a multimeter, and was described earlier in this article. The use of a ground tester can eliminate the interference problem for reasons already presented, but the unreliability of the reference ground and the problem of insufficient separation still exist. Accordingly, IEEE 81 advises, "…This method is subject to large errors for low-valued driven grounds but is very useful and adequate where a 'go, no-go' type of test is all that is required."

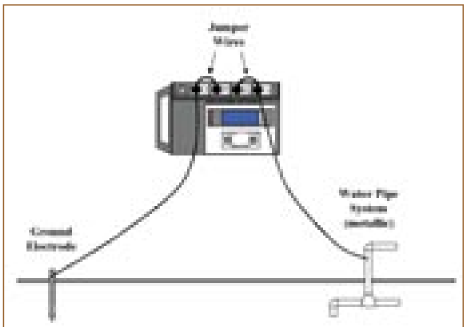


Figure #5: "Dead Earth" Test

"Clamp-on" Method

Ground testers of the clamp-on style have only been available for about ten years. These units combine form and function so that the tester and method are one and the same. "Clamp-on" jaws contain both voltage and current windings. They can be clamped over a ground rod or grounding conductor and will inject a test current into the system. The current travels through the soil, seeks its own return through a parallel ground, and loops back through the system neutral. The voltage transformer senses the voltage drop around the loop and the tester calculates resistance. It's disarmingly simple to use, and thereby lies both its strength and danger.

The astute reader will already have noticed the parallel with the multimeter technique. By injecting a current signal, the clamp-on takes advantage of the electrical system to provide a return, thereby removing dependency on an arbitrary "dead earth" reference. Some peril still remains in the return path and, lacking control of test probes, the operator is at its mercy. An oscillator produces a distinctive frequency and filters help suppress interference. The resultant measurement is a series resistance, which should be comprised almost entirely of the contribution from the soil. The method also simultaneously checks the bonding of grounding conductors, so that an open or corroded bond would show up in a high measurement.

Early models had shortcomings regarding accuracy, especially at the lower readings associated with commercial grounds, and were even banned by some authorities. However, technological improvements have corrected these failings to the extent that modern units are highly accurate and reliable. Some caveats remain, however. A traditional model can be utilized anywhere, but not a clamp-on. They obviously cannot be used for commissioning of new grounds that have not been connected. The operator must have a thorough understanding of the electrical plan, so that there are no feedback loops that short-circuit the soil altogether. Multiply connected grounds can circulate test current within their own structure, providing no more than a continuity test. Yet operators may be all too willing to accept these as "proof" of a good ground. Finally, the method does not afford the protection of a reference to an independent standards organization.

Slope Method

Other methods have been devised to cope with the other major problem of ground testing, limited space. To develop a full Fall of Potential graph, leads may have to be run out hundreds of feet, and tests have even been performed for miles! Such practice may be unacceptable or impossible for a variety of reasons: property lines, obstructions like highways, waterways, and railroads, congested urban sites, or large ground grids, especially in areas of poor soil. The most prevalent method of dealing with this problem is the Slope Method. Again, a mathematical simplification derived from calculus is employed, this time to find the point on a graph such as shown in Fig. 4 where the resistance of the test ground stops and that of the current probe takes over. This obviously cannot be read from the graph, so a mathematical exercise is employed to find it. Readings are taken at 20, 40 and 60% of the distance, and a calculation made to determine a slope coefficient. Tables found commonly in the literature are referenced for a corresponding ratio of potential probe distance to current probe distance (dPT/dC), and when multiplied by the known distance to the current probe gives the position at which the potential probe should be placed to derive the correct reading. If the current probe is so close that it is within the field of the test ground, the mathematics will prove unintelligible and indicate to the operator that a better test position must be found.

Star-Delta

If this latter condition prevails, and room is so limited that an acceptable spacing cannot be derived even with the Slope Method, it may be necessary to resort to Star-Delta. Named for the configuration of the test probes and lines of measurement (a graphic of it resembles the familiar symbols for “delta” and “star” windings), this method saves space by employing a tight configuration of three probes around the test ground (Fig. 6). Separation of potential and current circuits is abandoned, and a series of two-point measurements made between all pairs of probes and probes to test ground. This results in six measurements that are then put through a mathematical “crunch” of four series equations to calculate the resistance of the test ground. As with all mathematical methods, a faulty or unreliable setup produces unintelligible calculations (e.g., “negative” resistances), and so the operator knows that the procedure needs to be spruced up.

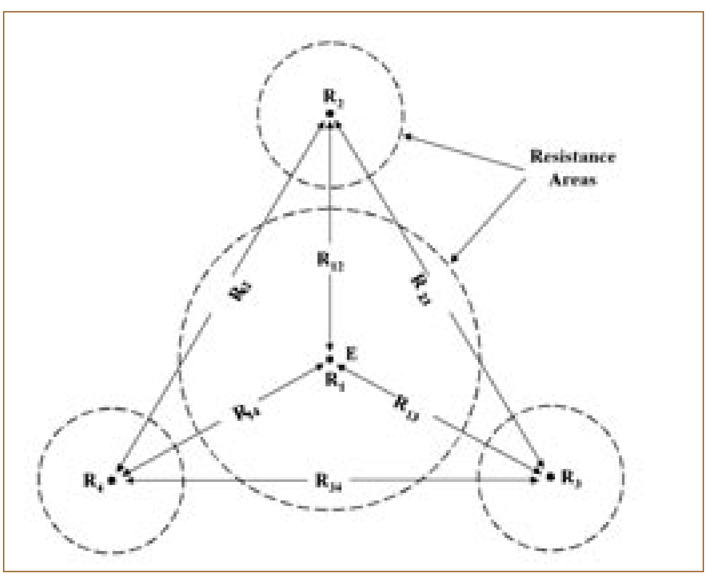


Figure #6: Star-Delta Method

“Intersecting Curves”

A very difficult and tedious method, but ideal for those who welcome a challenge, is that of “Intersecting Curves”. Very large grids are not only likely to have commensurately large electrical fields that require impractically long leads in order to test, but also compound the problem by having indeterminate electrical centers (which do not necessarily coincide with the geometric center). Obviously, for measurement purposes, a single rod can be treated as a point, and a small grid or array doesn’t offer enough of an error to be significant. But with large grids, the uncertainty as to the actual distance of separation from the current probe can become a complication. In the Intersecting Curves method, a number of resistance-versus-distance graphs are first constructed at different lead lengths. The unknown distance between the convenient point of attachment and the electrical center is assigned a number of arbitrary values, and using the 62 % rule, the corresponding positions are calculated for the potential probe. The corresponding resistances for each of these points can then be read from one of the graphs. These resistances are then plotted against their arbitrary unknown distances on another graph. This process is repeated for each of the measurement graphs, and additional lines constructed on the second graph accordingly. If the test setup were ideal, these dreivative graphs would all intersect at a single point. In the real world, they are more likely to form a tight triangle, the center of which corresponds to the actual resistance of the test ground (Fig. 7). The correct unknown distance can also be read, and if this is plugged back into the equation for distance to the potential probe, a measurement can be taken at that actual point and should agree with the one read from the graph.

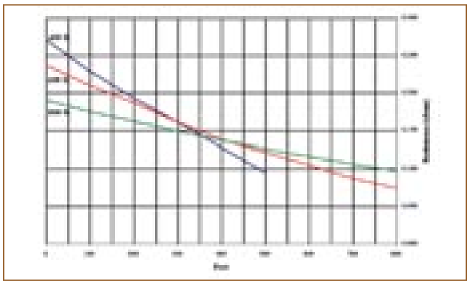


Figure #7: Intersecting Curves Graph

Soil Resistivity

If measured resistances are unacceptable, the test ground must be improved. This is accomplished by driving deeper rods, adding more rods, or applying various chemical treatments or backfills. This can be done by trial and error, but a more efficient method is to first take electrical measurements of the properties of the soil itself, and then apply this data to the construction, location, or improvement of grounding electrodes. A number of standard procedures exist, but by far the method of choice is the "Wenner" Method. Four probes are arranged at equal distances, and driven 1/20th of their horizontal separation (Fig. 8). Such an arrangement will measure average soil resistivity to a depth equivalent to the spacing. The tester is then energized and a reading taken. This is plugged into the "Wenner Formula":

$$r = 2paR$$

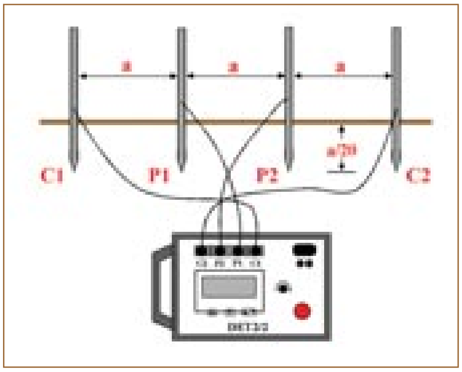
where:

r = average soil resistivity (typically in units of ohm-cm)

a = probe spacing (typically in cm)

R = resistance reading

The data is called the resistivity of the soil, as opposed to the resistance of a buried electrode. It indicates how the soil will respond to the flow of electric current, and is invaluable to any effort to establish maximum grounding protection.



Figure#8: Wenner Method

Conclusion

While the NEC is indispensable to electrical safety, its recommendations are not all inclusive. For commercial applications, it is wise to establish ground protection to its maximum level, not simply conform to a minimum. This cannot be accomplished without testing, and it cannot be accomplished properly without proper instrumentation and procedures. ■

ABOUT THE AUTHOR

Jeff Jowett is a Senior Application Engineer with Megger. He has been with Megger for over 30 years specializing in electrical testing applications in the areas of insulation resistance testing, ground resistance testing and low resistance ohmmeter testing. He is a regular speaker at industry events and dozens of articles authored by him have been published by various magazines worldwide.

Real-Time Performance Management

By: Mary McDaniel, Senior Director of Marketing, Indus International

"To achieve operational excellence, energy companies must adapt to change and optimize business processes in real time."
— META Group[1]

Driving Business Value

Energy companies today face increasing pressure to achieve outstanding performance in the delivery of services – and at a lower cost. The ability to meet this challenge hinges on personnel having the right information, at the right time, where the information is needed to make decisions and provide answers. For true operational excellence, however, this information must provide more than just data on what has happened in the past. It must help us understand what is happening as it happens (or even before) so that a more effective job can be done of managing risk and avoiding critical shortfalls in asset availability and customer service. Managing this on-demand information and delivering it to the appropriate points in the workflow to drive business value is defined as Real-Time Performance Management.

Real-Time Performance Management comprises five critical business areas, which must be successfully addressed to drive true business value and become a world-class organization.

1. Improve Asset Performance

It is imperative to control and reduce all asset lifecycle costs, as well as budget and plan more accurately. Assets must operate at peak performance to avoid unnecessary downtime and shorten planned outages. This requires that the utility have real-time visibility into the health and condition of facilities, equipment and/or critical parts.

2. Maximize Financial Performance

World-class organizations must have the right tools to analyze and balance the financial impact of strategic and operational initiatives across the organization – and to determine best-case alternatives. Real-time performance management furthers this goal by transitioning organizations from reactive to proactive decision-making in order to optimize performance and maximize financial gain.

3. Optimize Workforce Efficiency

Progressive utilities must operate their workforces at optimum efficiency, addressing planned and unplanned work requests without missing a beat. Instant field communications and feedback is vital. The utility must have real-time visibility into resource availability, skill sets, parts, tools, customer requirements, and documentation.

4. Ensure Customer Loyalty

Customer Loyalty is the most accurate barometer of true world-class performance. Loyal customers are those whose requests have been responded to quickly, whose issues have been resolved promptly, and whose interactions with us have left them desirous of purchasing additional services. To make this a reality, the utility must be able to instantly access and analyze enterprisewide information to rapidly respond to customer requests and make timely and accurate decisions. Accurate billing and collection cycles and precise scheduling, dispatching and optimization of mission-critical resources are required.

5. Streamline the Supply Chain

The supply chain must operate leaner than ever, with better planning and streamlined logistics. Utilities must increase visibility into the availability of spare parts, optimize inventory levels, and cut down on the number of suppliers if they are to deliver the right parts to the right place at the right time, and at the right cost.

The Dependency Chain

While each of these five areas brings its own imperative for business optimization, the essence of Real-Time Performance Management is managing all of these key processes simultaneously. There is a dependency chain of interrelated key performance indicators and their associated activities, which cuts across the organization's functional silos. Figure 1 shows how an event in one operational segment impacts all other functional areas. Recognizing these cross-functional processes, and taking steps to manage them in light of their interdependencies, is key to achieving world-class performance.

Figure 1

The Real-Time Enterprise

Enabling and managing the matrixed, real-time performance of an organization is challenging, but essential for success. Examining the concept of the "real-time enterprise," Rick Nicholson, META Group Vice President, emphasized the importance of "the combination of real-time information and business processes,"1 two essential ingredients for Real-Time Performance Management.

The first ingredient seems self-evident. How can you have a real-time enterprise without real-time information? However, "real-time information" is not necessarily defined as instantaneous access to all information as measured by absolute time. It is more accurately defined as having access to the precise information required in the context of a specific business event.

In other words, it is more valuable (and cost-effective) to have the right information delivered to you at the time that you need it than to have continuous immediate access to a wealth of information you don't need. So, latency is only important when it impacts the accuracy or reliability of a decision, a transaction, or some other interaction point.

This point ties into the second ingredient focused on "business processes," since the real-time challenges of an organization are found in the upstream and downstream processes leading to a point of interaction. Consider the customer service representative on the phone trying to answer a customer's question regarding service that is to be performed today. The CSR needs to know whether the technician has been dispatched, if he will arrive on time, and whether he will be able to complete the work once he is there. Similarly, the technician needs to understand the details of the commitment that has been made, the work that is required to be performed, and the supplies and tools that are needed. These business process handoffs – between segments of the organization and between software applications – are where the vast majority of real-time challenges lie.

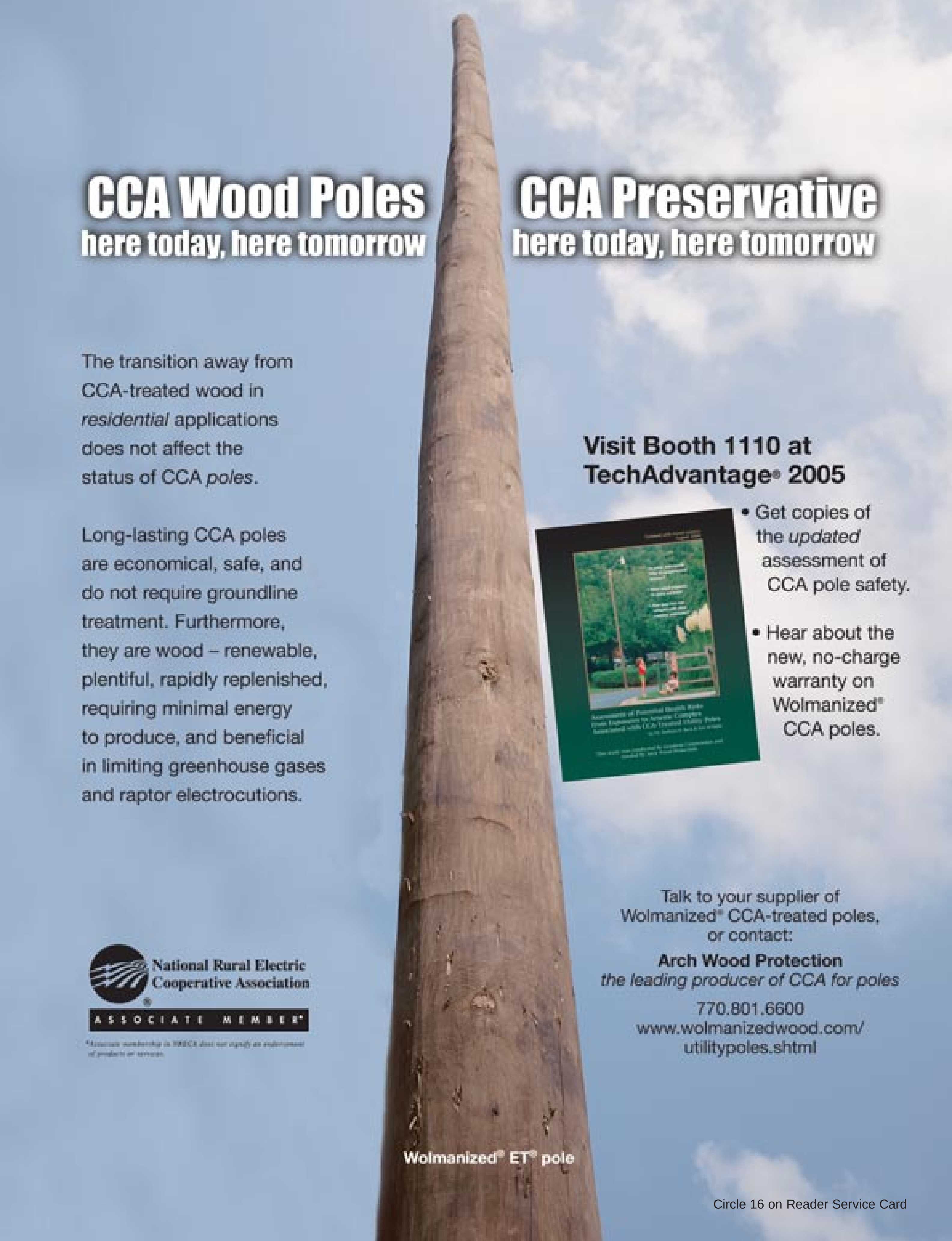
Therefore the key to real-time performance management is not in having immediate access to all information across the organization. They key is having only the information required from each segment and software application at the point where that particular information is needed by another segment or software application to optimize a business process.

Instrument, Analyze, Optimize

Obviously, traditional methods of managing the organization must be adjusted to leverage the combination of real-time information in a business process environment. A revised focus is necessary to enable management to view and measure the key performance indicators of the organization, analyze the metrics, and optimize the results. The key is to take a holistic approach to optimizing 'services' across the enterprise – incorporating customer service, field service, design service, construction service and maintenance service into the overall equation. While incremental improvements in these isolated areas may be beneficial, the synergies of optimized information flows involving the utility's customers, assets and workforce simultaneously will produce newly defined efficiencies and help build the world-class organizations we are all striving to create. ■

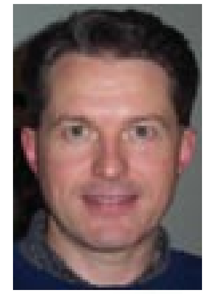
For more indormation about Indus,
visit the company's web site at: www.indus.com.

1 "Building the Real-Time Energy Enterprise." Rick Nicholson, Bill Davis. META Group, Inc. September 3, 2003.



Circle 16 on Reader Service Card

AMR
for a Cooperative World



By: Robert Turnbull
Manager, Utility Solutions Business Development
National Rural Telecommunications Cooperative

Electric utilities have long sought to find ways to reduce costs associated with meter data collection. In the early 1980s, hand-held meter reading devices were deployed to replace manual recording of meter information. Like UPC bar codes and scanners, hand-held meter readers reduced the recording time and more importantly, reduced transcription errors. Ten years later, wireless transceivers were being fitted into meters and fixed wireless infrastructure was built to allow metering data to be brought directly into billing systems thus eliminating the need for manual or drive-by meter scanning. For utilities that serve areas with high consumer densities, costs are easily justified to install fixed wireless AMR technologies. Utilities such as rural electric cooperatives may have very low consumer densities and cannot justify the deployment of wireless AMR communications equipment to adequately cover their service territories. Fortunately, there are AMR technologies more suited to the rural utility.

PSTN or POTS, which stands for ”Public Switched Telephone Network” or ”Plain Old Telephone System,” still represents one of the lowest cost methods of carrying meter data in rural areas. Modems are installed into meters and share the consumers' telephone lines. These devices are configured to dial out at a certain time of day, establish contact with the meter data collection computer and transfer their readings. While in contact with the host computer, the meter devices may receive new instructions such as a change in reporting schedule. This technology takes advantage of an existing communications infrastructure so there is no cost associated with having to build and maintain a dedicated network. The main disadvantage is that the telephone service may not be located close to the electrical service so that a phone line would have to be trenched in or a short-haul wireless link would need to be deployed. The system may be inconvenient for the consumer, as it must tie up the consumer's phone line while communicating to the host computer. With a phone connection, the meter is now connected to both the electrical and telephone systems which may have grounding issues that can cause failures due to lightning-initiated surges. When choosing a telephone-based AMR system, be sure to ask if the product uses isolation relays to minimize the connection time between the phone and power systems. Telephone-based AMR systems are particularly good for those consumers who cannot be reached with other technologies. They also quickly report power outages as long as there is phone service.

Power Line Carrier (PLC) is the most practical communications technology for serving areas with low consumer density. PLC takes advantage of the utility's existing power lines to transmit and receive data, eliminating communications wiring or wireless infrastructure. PLC has been used since the 1930s (called Ripple Signal Carrier) for load control and switching. Modern PLC differs in several important ways: it's faster, supports two-way communications and it's more reliable. The old ripple systems could transmit only a few bits per second. Some forms of PLC were even slower and only transmit a few bits per hour!

PLC signaling technologies can be grouped into two categories: low bandwidth and high bandwidth. High bandwidth is in the realm of Access BPL and today is used to provide broadband Internet access at frequencies between 2 MHz and 80 MHz. At these frequencies the signal is subject to significant attenuation and multi-path distortion, requiring a large investment in signal repeaters and conditioning equipment which make it economically impractical for areas with low consumer densities.

Access BPL has other technical hurdles which must be overcome before it may be widely deployed. One of the most significant of these is interference with other users of the frequencies employed by the technology. As BPL signals are injected into power lines, they tend to radiate away from those lines as a radio signal that has the potential of interfering with licensed users of the same spectrum. This interference may disrupt critical communications needed by government, military, business and volunteer users of various radio technologies. Access BPL continues to be very appealing to utilities as it promises to offer Broadband services, AMR and operational communications over the company's power lines.

PLC frequencies up to 500 KHz are considered low bandwidth and are the most practical for rural AMR applications. This spectrum is further categorized as 0–3 KHz, 3–9 KHz, 9–95 KHz ("A" band), 95–125 KHz ("B" band), 125–140 KHz ("C" band) and 140 –148.5 KHz ("D" band). Most PLC-based AMR communications fall in between 0 Hz and A band as this frequency range represents the best tradeoff between bandwidth and signal propagation for utility distribution networks. The higher B, C and D bands are used for low voltage, short-range applications such as X10 home automation and industrial automation communications such as CEBus and LonWorks.

In North America, distribution power lines are designed to transmit power at 60 Hz and present low impedance up to around 400 Hz. Frequencies higher than 400 Hz will be attenuated at a much greater degree resulting in reduced coverage. To compensate, repeaters and capacitor blocking units are used to extend the signal. PLC modulation techniques that keep below 400 Hz or inject at zero crossing will propagate the furthest. However, at this low frequency, very little bandwidth is available for transmitting and receiving data. Repeaters do provide the ability to pass signals to very hard-to-reach locations and can be used to pass the PLC signal around normally open feeder switches eliminating the need for additional substation PLC communications equipment.

Data rates of about 15 bits per second can be reasonably expected for 60 Hz-based modulation techniques. PLC modulation in the A band can produce data rates of about 75 or greater bits per second. By injecting the PLC signal on each phase the overall speed can be improved by reading each phase in parallel (this will not improve out-of-cycle, individual read times, however). A side benefit of reading individual phases makes it possible to determine which phase a particular meter is on.

The PLC signal can be coupled to the power system either by transformers or capacitors. Transformers installed at a substation can be more costly to purchase, install and maintain. Consider also the cost of substation PLC signal injection and receiving equipment. Some equipment is temperature sensitive and requires installation into climate-controlled substation buildings. The annual cost to operate this equipment may also be significant as power requirements vary substantially between PLC vendors' equipment. PLC provides a communications path from the meter to the substation. A different communications media is required to get the data from the substation to the host computer. The substation PLC equipment should be able to support a variety of communications paths, including PSTN, wireless, broadband and satellite. It should also have ample intelligence and local memory to operate independently of the host computer should the host to substation communications be interrupted.

The devices installed into billing meters for two-way communications are called transceivers or transponders. These devices can retrofit existing electro-mechanical meters or electronic meters. Transceivers installed into electro-mechanical meters must measure disk rotation to determine energy and demand. Transceivers in electronic meters read the meter's energy registers directly. The indirect method of reading electro-mechanical meters can lead to discrepancies between the transceiver and meter dials. Is it better to retrofit existing electro-mechanical meters or purchase new electronic meters with AMR transceivers already installed? The AMR transceivers cost around $50 to $80 depending on features and options. A new electronic meter will cost another $35 to $40. Once the labor cost to retrofit and test an existing meter is added there is little difference in cost. Solid-state meters offer much higher accuracy, don't need periodic recalibration and provide the convenience of direct reading for consumers (no billing multipliers are needed to determine actual energy usage).

Three-phase meter reading for commercial and industrial accounts have additional requirements such as demand and time-of-use billing parameters. Modern electronic three-phase meters also provide a vast amount of non-billing data such as voltage, current and power quality. Many of these devices have their own communications interfaces such as RS-232, telephone modem, and Ethernet. AMR transceivers must be able to handle, at a minimum, the demand and time-of-use registers. Because there is no standard interface for adding internal AMR transceivers to various vendors' three-phase meters, a separate internal interface card has to be developed for each type of meter. Alternatively, an external AMR transceiver can be used to connect to the meter's serial port or KYZ outputs. The advantage of an external interface is that only one type needs to be stocked to interface with many different types of meters. Other features such as I/O can be added to remotely monitor and control loads.

The cost of PLC-based AMR deployment has declined significantly in the past five years. It is however, still hard to justify deployment to rural areas based only on the benefits of automating meter reads. Having two-way communications coverage of the utility's entire distribution system opens up possibilities for many operational efficiencies. Some AMR meter transceiver manufacturers have incorporated several features that can help reduce losses and improve system reliability and consumer satisfaction. Service voltage can be monitored and even recorded with time and date stamps, which are used to indicate tampering, over- or under-voltage conditions, and to verify that a consumer's service is present. Demand can also be determined and profiles logged that can be used to resolve high bill complaints and calculate coincidental peaks and diversity factors to aid in system planning.

Other devices can be monitored and controlled using two-way PLC communications. Remote disconnect collars can be added between the meter and base allowing the utility to remotely disconnect and reconnect or even current limit a service. Load control receivers can be added to control air conditioning and hot water tanks using sophisticated algorithms that minimize discomfort and optimize peak reduction. Industrial and agricultural loads such as oil pump jacks and irrigation pivots can also be controlled to reduce peaks. Capacitors, voltage regulators and even pole-mounted reclosers can be monitored and controlled providing a comprehensive distribution monitoring and control system.

Two-way, real-time communications also makes it possible to support interval metering. Instead of collecting monthly readings, interval metering requires energy to be recorded on intervals of typically fifteen minutes. This matches the demand interval for most wholesale markets and allows the retail consumer to participate indirectly through demand response programs. Although not widely implemented today, FERC is actively promoting demand response as a viable method of demand reduction.

Two-way PLC communications technologies provide more benefits when operational elements are added. However, as more operational information is generated, higher bandwidth is needed to prevent congestion. The higher the PLC communications data rate the more useful it is for collecting operational and billing data and sending control signals.

An often overlooked but very critical aspect of an AMR system is the meter data collection software or host system. Since information stored in the meter data collection software will be shared by nearly every group within a company, it must have the appropriate functionality, utility, expandability, scalability, supportability and ability to be integrated with other applications.

Basic functionality should include a relational database for storing meter and operational data from one of the major database vendors to ensure reliability, performance and interoperability. A meter data collection system built on a three-tier architecture model such as Microsoft's .NET architecture separates the user interface from the business logic and Database Management System (DBMS) access layer. This architecture takes advantage of web browsers to provide simple and user-friendly application interfaces that can be used from any desktop computer. It's also easier to maintain and support as the business logic need only be changed in one location instead of every desktop. Databases can also be added or changed without affecting the desktop clients.

The software should be modular so that it can be ordered with only the functionality needed but can be easily expanded later. For example, AMR data collection would be included in the base platform and load control or capacitor control could be added later. The base software should also include configuration screens, alarming and basic reporting. Most PLC AMR systems rely on the host computer to poll the substation communications equipment, which in turn polls the remote transceivers. In the event of a power outage, the affected transceivers will not be able to respond, as they no longer have power. The host computer should detect this condition and report it as an outage. Preconfigured demand and energy reports should also be included along with a simple-to-use report builder. The host computer software should be able to detect when feeders have been re-configured so that services that were fed from one substation are now being fed from another substation.

The host software should provide pre-built interfaces to most popular Consumer Information Systems or billing systems and support standards such as MultiSpeak, XML and ODBC to ease integration with other applications such as Outage Management, GIS and SCADA. Another important feature is a scripting language that can be used to extend functionality and create robust connections with other applications. The scripting language should support constructs to handle exceptions caused by unexpected errors. For example a script could be written to move meter data to a remote billing system but be able to handle errors returned from the interface without stopping.

Two-way PLC AMR systems can be justified by the rural utility if the communications backbone can be leveraged through additional operational functionality. Communications bandwidth is the critical limiting factor for retrieving increased volumes of meter and operational data at near real-time speeds. Therefore, PLC technologies that provide higher bandwidth will deliver more combined value today and in the future. Host software is critical to the operation of an advanced AMR system and must receive the same or more scrutiny during the evaluation and implementation process. ■

Finding the Root Cause of Power Cable Failures

By: Vern Buchholz, P.Eng., Director of Electrical Technologies, Powertech Labs Inc.

Almost all utilities and large industrial facilities have extensive systems of power cables. Many of these cable systems are ageing and failures are becoming common. Finding the root cause of cable failures can lead to better maintenance practices and produce more reliable operation in the future. This in turn will lead to lower operating costs.

As an example, the final result of a cable failure may be that the insulation failed and the cable flashed over. The root cause may in fact be a building contractor removing thermally conducting back-fill around the ducts thereby causing local overheating. Determining the root cause of the failure can help prevent future failures.

Root cause analysis requires a systems approach. To help us in understanding this I will discuss cable components and the function of each of these components. I will also review cable systems, which include the cables, their accessories and operating environment. I will discuss electric fields within cables. I will then go over with some examples how evidence discovered in the analysis may lead to the root cause of the failure.

In this article, I will limit the discussion to medium voltage AC, 5 kV to 45 kV class cable systems. Keep in mind when we speak of the cable voltage class we mean the three-phase, line-to-line, nominal voltage of the system. I will cover only polymeric insulation, either polyethylene or Ethylene Propylene Rubber, because these are the most common insulations still in place.

Cable Components

Figure 1 shows a modern polyethylene cable designed to be used in a 25 kV system. The basic components from the inside out are:

- Conductor
- Conductor shield
- Insulation
- Insulation shield
- Metallic Shield
- Jacket or sheath (optional)

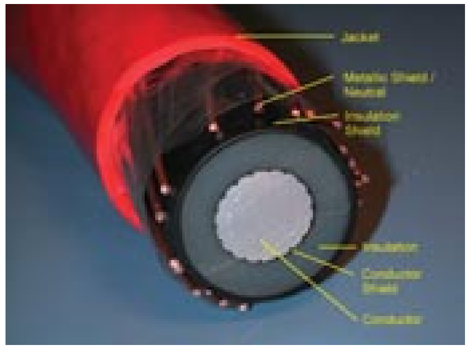


Figure 1. **Primary distribution cable showing the cable components**

The conductor is the current carrier of the cable and the most necessary part of any cable. Conductors are usually either copper or aluminum, and some may have plating. They can be solid in small sizes or stranded in larger sizes for better flexibility. The size of the conductor is determined using ampacity tables or computer based studies, and depends on current carrying requirements and cable surroundings. Fortunately very little can go wrong with a properly designed conductor, except for corrosion in some unusual cases.

The conductor shield is required particularly over stranded conductors in medium and high voltage cables. The conductor shield provides for a smooth, radial electric field within the insulation. In cables with polymeric insulation, the conductor shield is usually the same polymeric material as the insulation, but impregnated with carbon particles to make the material a semiconductor. The resistivity of the semicon is required by standards to be below 100 Ohm-meters, but modern semicons have lower resistivity, generally below 10 Ohm-meters. Semicon resistivity often increases with temperature, especially in older cables. Keep in mind that pure copper has a resistivity of about 18 x 10-9 Ohm-meters, and therefore is much more conductive than any semicon.

The insulation is arguably the second most important part of any cable, next to the conductor. Most cable insulation encountered today is polymeric, either polyethylene (PE) or ethylene propylene rubber (EPR). The majority of modern PE is cross-linked (XLPE). Almost all polymeric insulation compounds have proprietary additives to improve their expected life. An example is the "tree retardant" compound used in XLPE to slow the growth of water trees (TR-XLPE).

The insulation shield, like the conductor shield, is required in medium and high voltage cables. The properly functioning insulation shield provides for a smooth, radial electric field within the insulation. Materials used in the insulation shield are similar to those in the conductor shield. One important aspect of the insulation shield is its "strip-ability". The insulation shield must be easily strippable in order to be terminated and spliced. However the semicon must remained firmly bonded to the insulation during operation to prevent small air pockets in which damaging partial discharges may occur.

The metallic shield is applied over the insulation shield and serves several purposes including:

- Providing a path for the flow of charging current
- Providing a path for the flow of fault current
- Reducing the touch potential in the event of a dig-in into the cable.

If the metallic shield is of sufficient size and conductivity, it can provide a path for the return current and thereby acts as a system neutral. The metallic shield/neutral is usually made of copper, but in some cases aluminum is used. There are a number of designs of metallic shields including round wire, flat strap, taped, and Longitudinally Corrugated (LC). An LC shield, shown in Figure 2, can also act as a hermetic seal, and prevent water from entering the insulation.

Figure 2. **Longitudinally Corrugated (LC) metallic shield/neutral**

Sometimes a number of single-phase cables are put together in a multi-phase cable. Figure 3 shows a cable in which three single-phase, shielded, EPR cables are contained in a three-phase cable. The metallic shields on each phase are thin copper wires called drain wires. There are also three unshielded secondary cables used as neutral wires in the system.

Figure 3. **Three-phase EPR insulated cable.**

The outer layer of any three-phase or single-phase cable may be a metal sheath, a plastic jacket or both. The cables in Figures 1 to 3 have only plastic jackets. The purpose of the jacket or sheath is for mechanical protection. If the sheath is solid metal, it also protects the cable from water ingress. The plastic jacket mechanically protects the cable and slows the ingress of water. Keep in mind that no plastic material will hermetically seal a cable from water ingress.

Some cables have special components other than those already discussed. These may include:

- Strand blocking material to keep water from flowing through the conductor to the insulation
- Water absorbing materials under the jacket to absorb or at least slow moisture ingress
- Layers needed to aid in the cable manufacture.

Power Cable Systems

One of the fundamental aspects of the cable system is the method of installation. Cable systems can be installed in various ways including:

- In trays or troughs, either in or out doors
- Suspended from poles, bridges, or walls of vaults or tunnels
- Buried in ducts or conduits, or direct buried (See Figure 4.)
- Under water as a submarine cable
- In special situations as mine trailing cables, crane cable etc.

Always keep in mind the installation when looking for the cause of a failure.

Figure 4. **Installation showing direct buried cables and ducts.**

Cable accessories are often the most prone to failure of any part of the cable system. Accessories include terminations and joints, also called splices. Terminations are required to connect the conductor of the cable to a bus or other cable conductor. Within the termination the cable's metallic and semicon shields must also be properly terminated. Splices may be simply considered two terminations, connected back to back.

A type of medium voltage termination, called a load break Separable Insulated Connector (SIC), is designed to be disconnected from and reconnected to equipment under full load. SICs consist of an elbow, bushing insert and bushing well. SICs are some of the most complex medium voltage accessories, and can be prone to failures if not installed and operated correctly.

Another aspect of the cable system is the operating environment. Some points of the operating environment, which must be considered, are:

- Cable current loading compared to cable ampacity
- Ambient temperature
- Type of backfill around direct buried cables or ducts
- Moisture or chemicals in contact with the cables and accessories
- Lightning impulses and other system induced over-voltages
- Switching operations.

Electric Fields in Cables

Before we get into failure analysis in cable systems, I would like to review electric fields within cables. It is important to examine some of the normal magnitudes and orientations of e-fields in cables, to understand how variations from the normal may lead to failures.

Figure 5 shows a color contour plot of the electric field strength in a 25 kV cable (14.4 kV l-g) with an AWG 2/0 solid conductor, 6.6 mm of PE insulation and an insulation shield. In this case the field varies radially from 4 kV/mm at the conductor to 1.3 kV/mm at the insulation shield. Figure 6 shows a similar cable, without an insulation shield, near a grounded metal point. In this case the field near the point in the insulation is 7.4 kV/mm and near the point in air is 17.5 kV/mm.

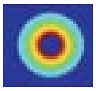


Figure 5. **E-Field Color Contour Plot - 2/0 Conductor, 6.6 mm PE and 14.4 kV**

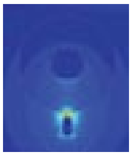


Figure 6. **E-Field Color Contour Plot - No Insulation Shield near metal point.**

The idea I'm trying to get across here is that cables or accessories with missing or even partially damaged semicon or metallic shields may experience very high and possibly damaging electric fields. Since air breaks downs above about 3 kV/mm at power frequencies, the field seen just outside the insulation in Figure 6 would cause local discharge. Modern, newly manufactured polymeric insulation may withstand 50 to 60 kV/mm at power frequencies, as long as the field is confined within the insulation. With age and under different environmental conditions, insulation will deteriorate, and will break down at considerably lower magnitude.

Final results of a Failure

A cable failure almost always exhibits itself as either an open circuit or a short circuit. Open circuits are more common in low voltage cables than at medium or high voltage. Open circuits are usually the result of failed connectors, or broken and/or corroded conductors. The reason that open circuit failures are rare in higher voltage systems is that arcing will occur in the conduction path, leading to overheating, failure of the insulation and a short circuit.

From now on I will concentrate on short circuit failures. Short circuit failures will most often cause the protection system to operate and interrupt the current flow to the load. There are times when the flash over at the fault may result in more serious consequences like fire or even explosion.

Root Cause Failure Analysis

Root cause failure analysis is the process of examining a failed sample, along with the operating and environmental information, to determine the fundamental cause of the failure. During the failure analysis, various tests may be conducted on the failed sample, on pieces of nearby unfaulted cable, or on accessories removed

from adjacent un-failed phases. Each bit of evidence is looked at as an effect, which had a cause. Then each cause is looked at in turn as the possible effect of a previous cause. This cause/effect trail is followed to the fundamental or root cause.

The amount of evidence that can be gathered will depend on the condition of the sample, what has happened to the sample since the failure, and the availability of information about the failure and previous conditions that the cable or accessory has undergone. Often direct evidence at the failure site is destroyed by the fault. An important factor in failure analysis is of course the amount of time and money one can spend on the analysis.

In this short article I cannot hope to cover all aspects of failure analysis. That would take a book. What I hope to cover are some of the things to look for and some of the tests that may be used in a failure analysis. I will attempt to illustrate the process by example.

Two important things that must be done in any failure analysis are a close visual examination of the sample at and near the failure site, and talking to or reading accounts of the failure from the personnel involved. Depending on the circumstances more investigations or tests may be required, or more information may be requested from the cable user.

If the failure occurred in a polymeric cable, other work may include:

- More detailed examination of the conductor including possible metallurgical examination
- Dissecting the insulation close to the failure and cutting wafers
- Measuring insulation resistance
- Performing ac breakdown level tests on a long sample near the failure site
- Performing chemical tests on the insulation
- Measuring semicon resistivity at elevated temperature near the failure site
- Performing metallurgical tests on the shield or sheath if present
- Performing chemical tests on the jacket if present

During the examination, look for signs of overheating. These may include discolored metal, or cracked and distorted polymers. Figure 7 shows an embrittled and cracked polyethylene wafer caused by overheating. Remember to look at samples sufficiently far from the fault site to be sure they were not damaged by the arcing fault. Overheating may indicate a possible root cause of failure of the system protection, incorrect determination of the system ampacity, thermal runaway, or lack of thermal backfill. Signs of over heating may warrant further chemical or metallurgical tests to determine the maximum temperature reached. Further investigation into system operations may be necessary to determine the true root cause of this type of failure. Examples of root causes of over heating may be poor initial ampacity calculations, improper breaker settings, removal of proper backfill, or change in ambient conditions like the adding of a steam pipe.

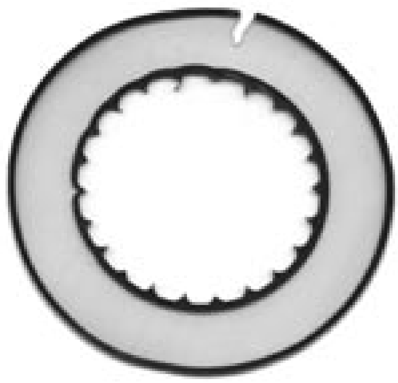


Figure 7. **Cracking of embrittled insulation.**

Voids or inclusions in the insulation, or protrusions from the semicon may be seen in the wafer examination. Figure 8 shows a cable wafer with extensive voids. Voids are simply bubbles in the insulation, while inclusions are foreign matter. Protrusions are sharp points extending into the insulation from the semicon. These are all forms of cable manufacturing defects. All cause high local e-fields, which may lead to partial discharge at the site or rapid growth of water or electrical trees near the defect. Any of these observations indicate a manufacturing defect as the cause of failure. Unfortunately the defect, which may have caused the failure, is usually destroyed by the fault, but the presence of nearby defects may give sufficient evidence of poor manufacturing. Since modern cables can be produced with super-clean insulation and semicons, and very few defects, one might conclude that the root cause of these types of failures occurring in newly purchased cables is poor specifications or acceptance testing.

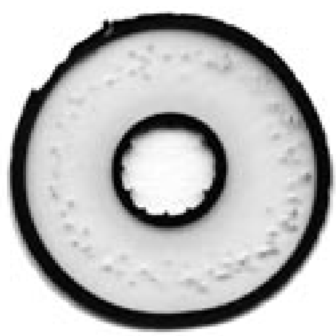


Figure 8. **Cable wafer with extensive voids**

Water trees can grow in both polyethylene and EPR insulation. Figure 9 shows a large vented water tree growing from the insulation shield. This water tree has a fault through it. Figure 10 shows a cable with a forest of water trees, which can be seen without dissecting the insulation. Water trees require both moisture and an electric field in the insulation to grow. If the cable is an older design made and installed before or about 1980, and has extensive water tree growth, one may conclude that the root cause of failure is simply that the cable has reached its normal end-of-life. If newer TR-XLPE has extensive water treeing, a manufacturing problem may be the cause. If the cable is supposed to have strand blocking, water absorbing tape, or a hermetically sealed LC shield, and develops extensive water treeing in a short time, investigate the possible root cause as a manufacturing problem, mechanical damage or shield corrosion.

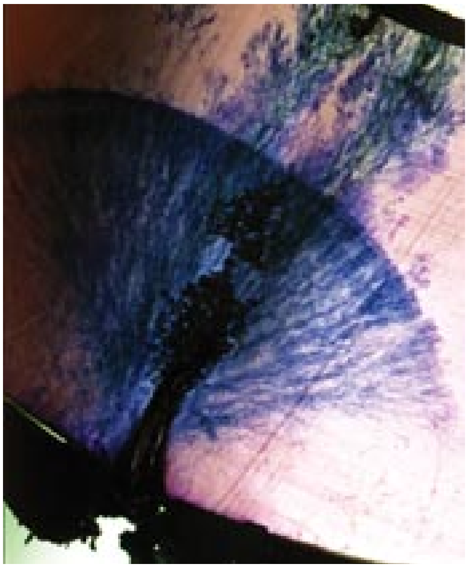


Figure 9. **Large vented water tree at a fault site.**

Figure 10. **XLPE cable with a forest of water trees**

Another type of failure is evidenced by signs of burning or arcing on the surface of the semicon. If the burning or arcing becomes extensive, the cable can fail from the outside in, as seen in Figure 11. The cause was determined to be a damaged jacket, which led to corrosive ground water entering the cable and causing severe corrosion of the metallic shield.

Figure 11. **Cable failing from the outside in**

Compounding the problem of a damaged metallic shield can be high resistivity in the semicon insulation shield. The volume resistivity of the semicon in older cables often increased with elevated temperatures. This effect was demonstrated in the lab as shown in Figure 12. Figure 12a shows a break made in the taped metallic shield. In Figure 12b, the conductor was energized and carrying current. As the current was increased the cable temperature rose. At about 50º C, the semicon resistivity had increased to the point where arcing took place across the break in the metallic shield.

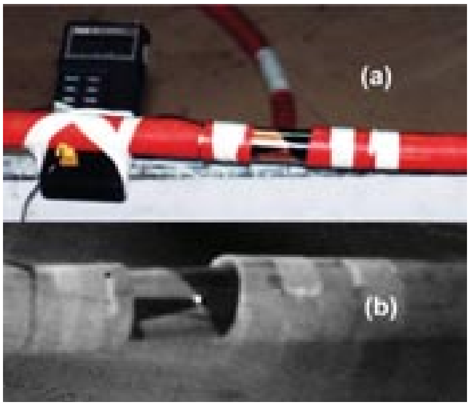


Figure 12. **Lab test showing shield arcing due to elevated semicon temperature**

To investigate a failure in an accessory, in addition to the usual visual examination and gathering of environmental and operating information, other work specific to accessory failure analysis may include:

- Comparing the failed accessory with undamaged accessories in adjacent phases
- Measuring contact resistance in connectors
- Careful dissection of the accessory comparing dimensions with assembly drawings
- Looking for signs of poor workmanship
- Looking for signs of surface tracking
- Looking for electrically floating metal electrodes.

Problems in connectors are a common cause of accessory failure. Figure 13 shows a drawing of a load-break separable insulated connector (SIC). Within the elbow, bushing insert, and bushing well that make up the SIC, there can be up to eight electrical contacts. Usually problem connectors overheat, which is evidenced by a discolored or burned conductor or insulation. Root cause of the failure is often improper installation including bad connector crimps, cross threading of the elbow probe, or a broken stud in the bushing well. Some older load-break SICs had design flaws in the contacts in the load break mechanism.

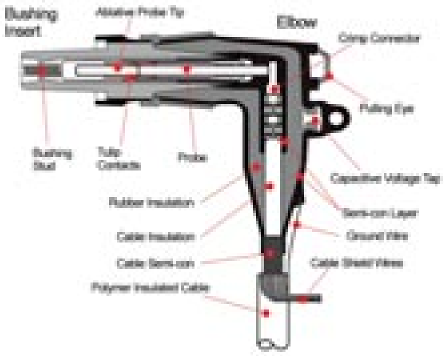


Figure 13. **Elbow and Bushing Insert Drawing**

Figure 14 shows an XLPE cable end, which was removed from a failed pre-molded splice. The results of arcing can be seen on the insulation surface. When the installer penciled the insulation, burrs were left on the end of the insulation and the surface was very roughly sanded. When the insulation was inserted into the splice body, semicon material was dragged over the surface. The semicon material led to surface tracking and eventual flashover. The cause of the failure was poor workmanship. One might conclude that the root cause is poor training, installation processes or standards.

Figure 14. **Poor Workmanship Leads to Failure in Pre-molded Splice Installation**

Summary

Determining the root cause of a cable failure can lead to better maintenance practices, produce more reliable operation, and lower operating costs. Root cause analysis requires a systems approach, which includes understanding the cables, their accessories and operating environment. ■

ABOUT THE AUTHOR

Vern L. Buchholz, P.Eng.

After completing his Bachelors degree, Mr. Buchholz worked for 7 years as a research associate at the University of British Columbia, Vancouver, Canada, designing television systems for remote sensing. He joined BC Hydro in 1981 performing electrical design work on overhead and underground transmission systems. He came to Powertech Labs Inc., a research and testing subsidiary of BC Hydro, in 1984 were he is now the Director of the Electrical Technologies Business Unit. His group's major work covers power cable and large generator and motor testing, and operation of the High Current Lab.

He is a Senior Member of the IEEE, and is a member and chairman of a number of standards working groups under the Insulated Conductors Committee. He is a Professional Engineer registered in the Province of British Columbia Canada.

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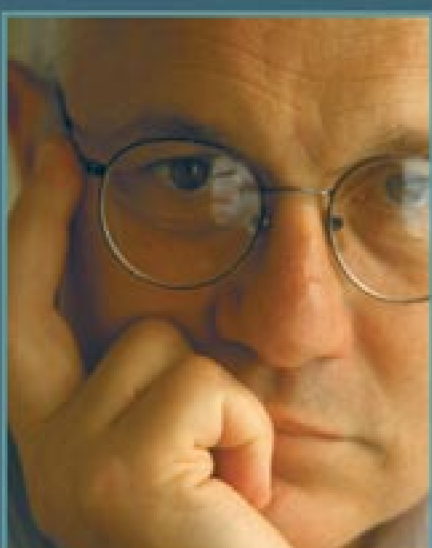

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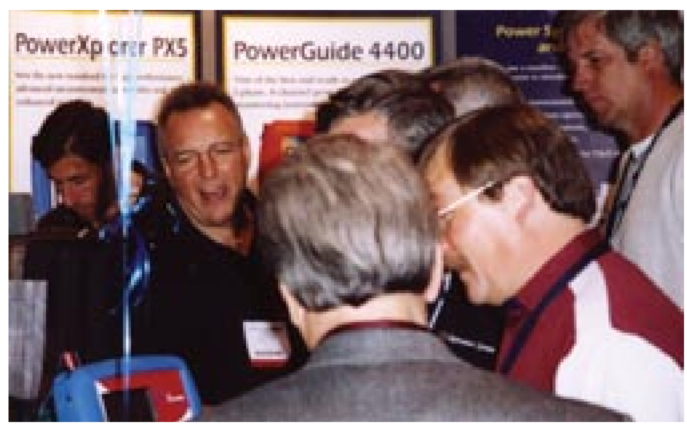

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PROFESSIONAL ADVANCEMENT COURSES

SUNDAY, NOVEMBER 14

9:00am to 5:00pm

- **PAC 21** – **Troubleshooting and Solving Power Quality Problems** – David Mueller, Electrotek Concepts, Inc.
- **PAC 22** – **Lightning & Lightning Protection** – Michael Stringfellow, PowerCET

9:00am to 1:00pm

- **PAC 23** – **The New IEEE Emerald Book** – Vladi Basch, BG&E; Doug Dorr, EPRI PEAC
- **PAC 24** – **Grounding & Harmonics: Case Studies and Practices** – David Brender, Copper Development Association

2:00pm to 6:00pm

- **PAC 25** – **Distributed Generation** – Vladi Basch, BG&E; Doug Dorr, EPRI PEAC

MONDAY, NOVEMBER 15

9:00am to 5:00pm

- **PAC 26** – **Power Quality 300 - Advanced Power Quality** – Doug Dorr, EPRI PEAC; Vladi Basch, BG&E
- **PAC 27** – **Wiring and Grounding Solutions for Power Quality and Data Integrity Issues** – Thomas Shaughnessy, PowerCET
- **PAC 28** – **2005 National Electric Code & Upcoming Code Changes** – L. Keith Lofland, International Association of Electrical Inspectors

9:00am to 1:00pm

- **PAC 29** – **Establishing a Successful Power Quality Business** – Ram Mukherji, Mukherji Consulting

2:00pm to 6:00pm

- **PAC 30** – **The Power Quality Standards Landscape** – Erich Gunther, EnerNex Corp.

THE CONFERENCE

TUESDAY, NOVEMBER 16

8:30am to 9:45pm – FREE

KEYNOTE ADDRESS AND AWARDS: Kurt Yeager, President - EPRI ***Power Quality & Reliability in The 21st Century*** **& Patrizio Vinciarelli, CEO & President - Vicor Corporation** ***Where Should the 'Buck' Stop?***

10:00am to 11:00am

- **PQS01** – **What Do Upcoming Economic Conditions Mean for the Power Quality Industry?** – David Mueller, Electrotek Concepts, Inc.
- **PQS02** – **The State of Superconducting Technology** – Swarn Kalsi, American Superconductor Corp.
- **PQS03** – **Distributed Generation Communications & Control Requirements** – John Brogan, Encorp

EXHIBIT HALL OPENS 11:00AM

12:00pm to 1:00pm – FREE – **Round Table Discussions with Industry Authorities – in the Exhibit Hall**

2:00pm to 4:00pm

- **PQT01** – **Power Quality as a Business** – Chair: Anthony Hoevenaars, Mirus International, Inc.
- **PQT02** – **Grounding Practices** – Chair: Larry Petersen, Varian Medical Systems
- **PQT03** – **Power Quality Technologies – Distributed Generation, Micro-Turbines & Fuel Cells** – Chair: Mohan Ray, Northrup Grumman Corp.
- **PQT04** – **Power Quality Reliability - Equipment Technologies** – Chair: John Johnson, Strategic Facilities, Inc.

THE CONFERENCE

WEDNESDAY, NOVEMBER 17

8:00am to 10:00am

- **PQT05** – **Reliability - The Next Wave** – Chair: Mark Zuber, Advanced Power Systems
- **PQT06** – **Power Factor** – Chair: Mark McGranaghan, EPRI PEAC
- **PQT07** – **Power Quality Technologies - TVSS & Conditioning** – Chair: Larry Petersen, Varian Medical Systems

EXHIBIT HALL OPENS 10:00AM

10:15am to 11:15am – FREE – **Poster Sessions in Exhibit Hall**

11:30am to 12:30pm

- **PQS04** – **An Introduction to Nanotechnology** – Mike Beehler, Burns & McDonnell
- **PQS05** – **Power Quality Considerations For Wind Generation** – Thomas Key, EPRI PEAC
- **PQS06** – **Reality Checks on Surge Protective Devices Applications** – Francois Martzloff, Surges Happen!
- **PQS07** – **A Fuel Cell Based UPS System** – Alan Katz, MGE UPS Systems, Inc.

2:00pm to 4:00pm

- **PQT08** – **Power Quality & Reliability - International Monitoring** – Chair: Greg Evans, WelComm, Inc.
- **PQT09** – **Harmonics** – Chair: Mark Zuber, Advanced Power Systems
- **PQT10** – **Power Quality Technologies - UPS and Industrial Batteries** – Chair: Allen Byrne, American Power Conversion
- **PQT11** – **Power Quality Technologies - New Backup Power Systems** – Chair: Bob Schuerger, EYP Mission Critical Facilities, Inc.

THURSDAY, NOVEMBER 18

8:30am to 10:00am – FREE – **General Session: Join Past Mungenast Award Winners for a discussion on The Future of Power Quality**

EXHIBIT HALL OPENS 10:00AM

10:30am to 12:30pm

- **PQT12** – **Power Quality & Reliability - Monitoring** – Chair: Greg Evans, WelComm, Inc.
- **PQT13** – **Power Quality Technologies - UPS** – Chair: John Sears, Active Power
- **PQT14** – **Power Quality Technologies - VfDs & Motors** – Chair: Paul Bakke, US DOE
- **PQT15** – **Current Issues in Power Quality** – Chair: Mark McGranaghan, EPRI PEAC

1:30pm to 3:30pm

- **PQT16** – **Power Quality - Healthcare Issues** – Chair: Nihal Kularatna, U of Auckland
- **PQT17** – **Power Quality - Data Centers/Institutional Issues** – Chair: Dan Carnovale, Eaton Electrical
- **PQT18** – **Power Quality - Heavy Industry Issues** – Chair: Steve Cotton, Data Power Monitoring

PQS Preceding Course number indicates 1 hour Seminar

PQT Preceding Course number indicates 2 hour Technical Paper Presentation

Conference program subject to change.

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EXHIBIT HOURS

Tuesday, November 16	**11:00 am-6:00 pm**
Wednesday, November 17	**10:00 am-5:00 pm**
Thursday, November 18	**10:00 am-3:00 pm**

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Applying Customer Information Systems to Credit and Collections Issues

Let Good Customer Information Prevent Bad Debt

By: Guerry Waters, CTO and SVP Product Strategy, SPL World Group.

When it comes to collecting overdue consumer debt, America's electrical utilities are at a peculiar disadvantage. Faced with uncollected debt, businesses like banks can foreclose on mortgaged properties or collateral assets. Automobile dealers and major appliance vendors can repossess their merchandise. But utilities can't recover electricity that has already been consumed. And their ability to compel payment through sanctions like termination of service is often constrained by consumer protection regulations.

So it's not really surprising that bad debt write-offs at America's electrical utilities are skyrocketing. In 2003, write-offs of consumer debt at U.S. utilities grew to 0.5 percent of all revenues – a 20 percent increase over historic levels. Individual utilities sometimes fare far worse. One major gas utility in the Northeast has been obliged to write off 1.7 percent of its revenues for every year between 1999 and 2002.

Clearly, American utilities face two closely-related and critical challenges. How can they recover more revenues from write-offs? And – more importantly – how can they prevent customers from falling so far behind in the first place?

One place they can start looking for relief is in their own customer information and customer relationship management systems. By adroitly leveraging these critical in-house resources, utilities can identify potential bad debts early in the payment cycle. Then, with early warnings in hand, they can institute more effective strategies to prevent write-offs and recover lost revenues.

Determining the Appropriate Response

If you've ever worked in a utility's credit and collections operation, you've noticed that all delinquent customers are not alike. Some are forgetful seniors who will pay in full as soon as they remember where they put last their bills for the past several months. Others are honest individuals who are temporarily short on cash because of unemployment, illness or natural disaster. Still others are chronic delinquents attempting to game the system through frequent relocations, name changes and other unsavory tactics that often border on fraud.

Obviously, the bare-knuckle strategies appropriate for chronic deadbeats are not appropriate for forgetful grandmothers. The key to preventing bad debt, then, lies in is a utility's ability to identify these different types of customers accurately. Once it has segmented its overdue customers successfully, the organization is free to apply remedies that have proven effective with each particular segment. And it can apply these remedies at the earliest possible opportunity in the collections cycle, when the chance of preventing or recovering a write-off is greatest.

For the forgetful senior, the best remedy is usually simple: a reminder in the form of postcard or phone call. If forgetfulness becomes chronic, then the utility can assign a CSR to negotiate other remedies, such as payment by automatic bank draft. For seniors on fixed incomes, a good option might be a budget pay plan that levels out seasonal spikes in cost and usage. Some utilities may even identify responsible relatives who can be automatically notified if payments fall too far behind.

In the case of the customer who professes himself willing but unable to pay, it helps if the utility has good historical data. Given comprehensive payment records, firms can maintain de facto credit ratings on all their customers. Such a rating would indicate whether the overdue customer is a reasonable candidate for cooperative remedies like deferred or partial payment arrangements. If the utility wants to take a more proactive stance, it can even provide these customers with contact information for appropriate social assistance programs.

Customers on fixed incomes, a segment that includes many of the elderly and the disabled, may fall behind when their utility bills exceed their monthly budgets. In these cases, a utility can offer remedies like energy audits. Audits can pinpoint opportunities for use reduction through improved insulation, more efficient appliances and plumbing repairs as well as through changes in consumer behavior. In many cases, publicly funded programs may subsidize the cost of improvements, either directly or through loan guarantees. In the not-too-distant future, new technologies like “smart” meters may allow residential customers to control their bills through time-of-use billing plans and other product innovations. (Assuming, of course, that the utility’s CIS applications can support new metering and pricing practices.)

As these scenarios suggest, utilities don’t necessarily have to take an adversarial position with overdue customers. They can structure their remedies to help genuinely distressed customers while simultaneously safeguarding revenues. These proactive programs will pay added benefits in terms of regulatory relations, since they tend to drive down consumer complaints along with bad debts.

Rightsizing the Collections Cycle

Of course, socially-proactive responses can’t address the problem of serial defaulters. In these cases, there are more aggressive prevention and recovery strategies that a utility can apply, provided its CIS systems can maintain the accurate and comprehensive payment histories needed to identify and track these offenders.

For many utilities, that’s a big “if.” Many legacy CIS systems are premises-based, maintaining payment records by address or meter location rather than by customer. Unfortunately, customers who don’t pay their utility bills often get behind on the rent. So chronic delinquents usually present moving targets, relocating frequently and opening new accounts that will also end up in collections.

With many legacy systems, it can take several monthly cycles to transit from an initial notice of overdue payment to a service termination or write-off. That’s far too long. It does a utility little good to terminate service at an address the defaulting customer has abandoned, or to turn bad debt over to a collection agency when the debtor has disappeared. With delinquents like these, the utility must be able to accelerate the collections cycle so that remedies are prompt enough to be effective.

The payoff for shortening the collections cycle with these customers can be substantial. One large Midwestern utility overhauled its collections operations as part of a larger CIS initiative. Its old software had mandated lock-step collections procedures that took up to four months for the actual collections effort to begin. As a result, its collections operations recovered only about 7.5 percent of its write-offs.

The new collections solution enabled the firm to institute more flexible procedures based on individual customer attributes like payment history. These procedures allowed the collections staff to shorten the credit cycle significantly when circumstances warranted. Over the next six months, the firm’s recoveries more than doubled to approximately 17.5 percent of write-offs. The net impact of this improvement has been an annual increase of more than $1 million in recovered revenues.

Keeping Tabs on Defaulters

Customer systems that maintain comprehensive payment records and track individuals by unique identifiers can readily be leveraged to prevent repeat losses. So serial non-payers pose far less of a threat. If a past defaulter applies for service at a new location, the utility can immediately link the customer to the old write-off and make the new service contingent on repayment of the old debt. The utility can also impose higher deposit requirements on these high-risk individuals. And, like utilities in Europe or telecommunications firms, American utilities may soon be able to get prepayments from delinquent customers through technologies like "smart" meters and prepaid smart cards.

To invoke these more aggressive remedies, utilities must clearly be able to distinguish among customers with the same or very similar names. No utility would want to confuse the Joan J. Jones who skipped out on five months of overdue winter heating bills with the Joan J. Jones who has just moved into its service area as energy procurement manager for the largest manufacturer in the region. Accurate identification will be particularly critical when utilities decide to terminate or refuse service. Nothing puts a utility in a bad light like a wrongful refusal or termination of service. Complete and accurate customer histories will not only prevent these mistakes, they will also help utilities justify their termination practices to regulators.

Evaluating Strategies

Termination of service is always costly and sometimes prohibited, so prevention will almost always be more cost-effective than the drastic cure that termination represents. The real task that a utility faces is to create debt prevention strategies that actually work with its own specific customer populations and in its own unique market environment.

AVERAGE PERCENTAGE OF CHARGE-OFFS TO OVERALL REVENUES AMONG STUDY PARTICIPANTS

	Average percentage of write-offs to overall revenues	Estimated 2003 Revenues of survey participants	Estimated cost of Written-off revenues
Electric	[illegible]	[illegible]	[illegible]
Electric & Gas Combined*	[illegible]	[illegible]	[illegible]
Natural Gas Only**	[illegible]	[illegible]	[illegible]
Total Estimated Cost of Written-off Revenue Among Study Participants			[illegible]

*Electric and gas utility participants that did not break down write-off percentages by fuels. **Only three participants gave separate data for natural gas write-offs. This is an average of those three. Dollar amounts are stated in thousands (000).

Utilities should realize that developing effective new strategies will be an ongoing and re-iterative process. Measuring and evaluating the net benefits of each new remedy will be essential for the success of any debt reduction initiative. Do aggressively-worded notices produce better responses than friendly reminders? Are automatically-generated mailings and automated phone calls effective, or do they simply waste time and resources better spent on personal calls by trained CSRs? Do budget pay plans and flexible billing dates really reduce delinquencies among low-income consumers, or do they simply postpone the inevitable? The answers to each of these questions will vary with each utility and each customer segment. Getting those answers will be impossible without the ability to segment customers according to comprehensive payment histories and detailed customer attributes.

It should be obvious that the need to conduct continuous evaluations of debt prevention initiatives will place tremendous demands on utility CIS/CRM infrastructures. Traditional premises-based billing systems simply don't have the capability to track customer response patterns across a wide variety of trials. Many of these systems are already long-overdue for replacement. The credit and collections function is only one of the many areas where customer-related business processes and their associated IT applications may be in need of a thorough overhaul.

To defer action is to ignore the host of indirect costs that these aging legacy systems impose on collection operations; costs like excessive call-center loads, redundant document generation and postage charges, increased billings for legal and regulatory relations support, unbalanced staff workloads, and excessive field service costs related to frequent service disconnects and reconnects. Like the growing volume of write-offs, these recurring costs represent a constant drain on profits that isn't going to go away on its own.

The really bad news for the credit and collections function is that, without decisive and concerted action, customer nonpayment rates are certain to continue rising. While oil prices may eventually stabilize, the inexorable pressures of dwindling supplies and increasing worldwide demand will rule out any significant long-term relief in energy prices. As rising energy costs drive service rates up, more and more consumers will fall behind.

Several current demographic trends will probably aggravate the situation. As our population ages, increasing numbers of increasingly forgetful elders will miss monthly payments. Inflation and constraints on social spending will leave consumers on fixed incomes – primarily the elderly and disabled – with diminished abilities to pay increasing rates. Population densities will continue to increase in areas prone to recurring natural disasters like hurricanes, magnifying the impact of these phenomena on local economies and customer incomes. Termination of service will seldom be an effective collections option for customers in these groups, since politicians and consumer advocacy groups will be quick to jump on any collection practices that could be seen as consumer abuse.

In today's political and economic environments, utilities know they can't look to regulators or falling energy prices for relief. The only practical solutions will be those they can develop and implement with their own in-house resources. Developing new and more effective debt reduction strategies is the only realistic path utilities can take to stem the rising tide of bad debt. And these new strategies will inevitably require flexible and powerful new infrastructure capabilities that the industry's aging CIS systems can never provide. ■

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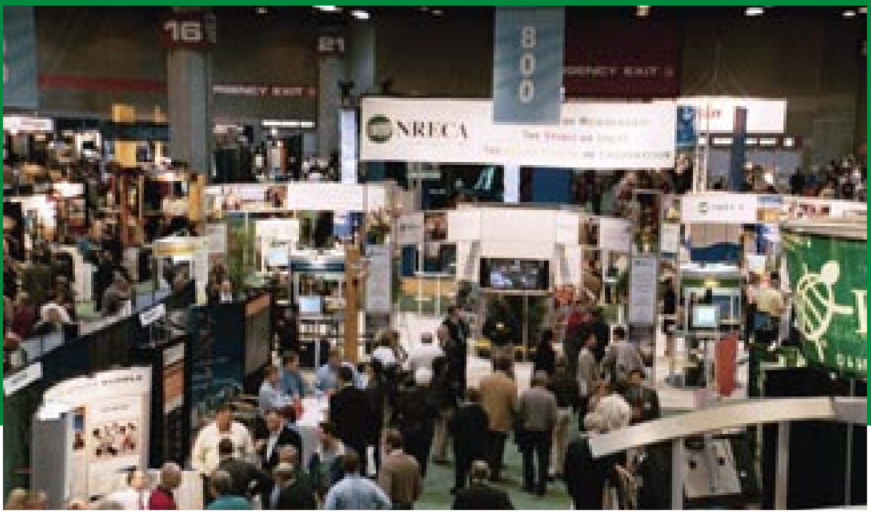

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By:
Jared Bodnar
Canyon Communications
Mesa, Arizona

Working Together:

Integrated Technologies Improve Security Efficiency

Figure 1

There will always be Bad Guys.

That's one aspect of the security business that stays the same. But some days, doesn't it feel like everything else is changing?

In our post-9/11 world, we suddenly have very different kinds of security threats, with unprecedented risks of terrorists and extremist attacks on America's infrastructure. That can create a whole new mind-set for many security professionals.

The other big change, of course, is technology. Today's security systems — microwave, computerized, digital, automated, interfaced and so on — have totally altered the landscape of how things are done, and it's a process that continues to evolve, sometimes way too quickly: Today's breakthrough might be tomorrow's old news.

"We're always trying to get the education we need to keep up-to-date, because the technology changes so fast," says security specialist Paul Ramirez. "We don't want to be chasing technology. We want equipment that will let us go into the future without being outdated… something that's going to be good for our company, and is going to meet the standards we have set."

Ramirez is the Senior Security Systems Technician for the Salt River Project Power, a public power utility serving more than 800,000 electric customers in the greater Phoenix metropolitan area. Salt River Project (SRP) covers an area of almost 3000 square miles, and Ramirez' security responsibilities include a number of sites such as large power plants and generating stations, including thermal, nuclear and hydroelectric sources. SRP also delivers water to a large part of central Arizona, using an extensive system of reservoirs, canals and irrigation lines. Understandably, security is a major concern at SRP, and it represents a tremendous range of applications.

"Every site is different," Ramirez explains. "We have a standard set to follow, but each location is unique. You have to look at the assets you want to protect, and then assess the environment to evaluate what we need to protect them."

Finding The Best System

As America's need for better security has coincided with advances in technology, it has led to more new products from more suppliers, which can also lead to more complexity and more challenges for security professionals. An efficient, integrated security system needs to have all the components work well together.

Security for SRP entails a huge range of services and systems, given the extremely diverse types of facilities and locations the company serves: urban industrial, rural, residential, remote sites with mountain winds, desert heat, animals, etc. With so many different needs, and so many available systems, what does it take to coordinate and streamline a program cost-effectively?

Jim Trujillo is a Senior Control Engineer for SRP, and he works with Ramirez to help evaluate and implement the company's various security systems.

Intrepid on Fence

"Again, it falls within your assessment of a particular site, and identifying the equipment we think we're going to need there," explains Trujillo. "Then Engineering follows up to provide the design and estimations accordingly, based on needs and budget. We try to standardize the systems simply because we support them all internally," he says.

"We like to see what's available in the latest technology," Trujillo continues, "and see if it fits in with our applications."

But when there are many good products to choose from, and an equal number of factors to consider, finding the right systems can obviously be tricky. To facilitate their decision-making, Trujillo and Ramirez go through a lot of research and specific product demonstrations, and when possible, they conduct a real on-site test of products they're considering.

"When we identify the equipment we think we need, we often try to borrow some and take it out to the actual site to see what the results will be," Trujillo says. "Then we take steps to see how we're going to integrate it with our security operations center, and we start involving ourselves in communications. We procure all the materials and do an end-to-end installation in-house," he says. "We also conduct a bench test to make sure it's going to work before we actually implement it."

"Jim and I will get together with our control C & M technicians and test a lot of products prior to investing in them," adds Ramirez.

"From an engineering standpoint, we also always look at the experience we've had with the systems currently in place," Trujillo says. "We evaluate how the components of the system have held up, what experiences we have had with the manufacturer and how supportive they were. A lot of the evaluation is based on the life expectancy of some of the equipment we currently operate."

Integration Is Key

As they evaluate various manufacturers and components, the security team at SRP is constantly aware of the need to have systems which can be integrated and work together.

"The equipment that we had out there was a various mix of models, and now we're trying to standardize," says Ramirez. "We want to get it all integrated, so we know what equipment will work with our existing access control and CCTV systems. We also have to keep in mind what kind of code we have to translate with the piece of equipment we need at that site, bandwidth situations and issues like that."

"We definitely want to automate and integrate each of the components together as best we can," agrees Trujillo, "because a big issue, of course, is response time."

With SRP's vast network, it's critical to have intrusion detection at perimeters of remote sites tied in to central CCTV, for example, as well as remote monitoring and control of the power grid. The various security functions must be compatible and easily coordinated.

That's one reason SRP has been working with Southwest Microwave Inc. of Tempe, Arizona for over six years. Specifically, SRP employs a Southwest Microwave perimeter system known as Intrepid — a sophisticated MicroPoint™ microprocessor-linked cable that's tie-wrapped to a chain link fence to detect significant vibrations and precisely locate the point of intrusion.

"At one of our most remote sites, that system has proved very useful," Ramirez says. "Up there we've got high winds, snow and a lot of cattle from the ranches around it, and our old system was constantly giving us false alarms. Southwest Microwave worked with us to filter out a lot of the nuisance alarms, and give us a reliable system at this remote site. It's tied in with our CCTV system, so whenever we get an alarm, the cameras are immediately set to the zone where the alarm occurred."

"I'm happy with the system because it's integratable," adds Trujillo. "They can actually interface the Intrepid cable technology to their microwave technology to create an entire perimeter system. Let's say you use the Intrepid system on the fences, but need to use microwave across the gates. They interface the two together to create a closed perimeter," he explains. "Then they can also provide interfaces via relay modules to give alarm conditions to our matrix, which is our CCTV"

Fine-Tuning Security

As new technology continues to come along, it also helps to make good systems better. Another factor in SRP's choice of the Intrepid system is that its level of sensitivity can be adapted to changes in conditions, such as higher winds. That helps to further reduce the problem of false alarms.

"I think the best thing Southwest Microwave has done is to design this cable technology to allow sensitivity adjustment," says Trujillo.

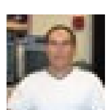

Figure 2

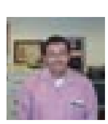
"The systems are very reliable, and the fact we've been able to eliminate a lot of nuisance alarms is significant," Ramirez says. "We've been able to integrate Southwest Microwave's systems into ours quite easily; the installations are easy for our technicians. But most of all, we get the support we need."

"We see them as part of our team," agrees Trujillo.

Security professionals are under more scrutiny and performance pressure than ever before, and having a large number of vendors doesn't simplify anything. But as Jim Trujillo and Paul Ramirez have shown at SRP, making smart decisions depends on accurate needs assessment, thorough product research and evaluation, effective comparative trials, and finding a reliable manufacturer with excellent products and support.

"You have to have a direction where you're headed," Ramirez adds, "otherwise you're getting pulled in every direction." ■


Jim Trujillo is a Senior Control Engineer for SRP who is challenged with integrating several security technologies together to protect power generating and transmission facilities.


Paul Ramirez: Paul Ramirez is a Senior Security Systems Technician for Salt River Project, a public power utility serving more than 800,000 electric customers in the greater Phoenix metro area.

For further information on Southwest Microwave's INTREPID system, visit www.southwestmicrowave.com

Photo Captions

SRP1:
Salt River Project of Phoenix Arizona has found Southwest Microwave's Intrepid system to be effective at their remote switching yards due to the reduced nuisance alarm occurrence.

SRP2:
Southwest Microwave's Intrepid Micropoint perimeter intrusion detection system is preferred by SRP because it works well in extreme weather conditions such as Arizona.

INTREPID on Fence:
Southwest Microwave's Intrepid Micropoint fence-tied intrusion detection system can precisely locate intruders within 10 feet (3 meters).

CCS - Continental Cooperative Services

By:
Russell A Straayer
President
Data Comm for Business, Inc.

CCS Finds SCADA over Frame Relay is Faster, Better, Cheaper than analog.

"Frame Relay has proven to be faster, better and cheaper than analog service" according to Dan Allen, SCADA electrical technician for Continental Cooperative Services (CCS), in Jacksonville, Illinois. CSS in Illinois has switched a number of analog links over to Frame Relay. The CCS SCADA network uses C3Ilex protocol, DNP3 protocol, and C3Ilex and DAQ Electronics equipment. After running the network over Frame Relay for nearly two years, the results are resoundingly positive.

Who is CCS?

Continental Cooperative Services (CCS), based in Harrisburg, Pa., was created in March 2000, the result of a strategic alliance between Allegheny Electric Cooperative, Inc. (CCS/Allegheny), the wholesale power supplier to Pennsylvania and New Jersey electric cooperatives; and the Illinois Soyland Power Cooperative, Inc. (CCS/Soyland). One of the goals of the alliance is to reduce General and Administrative costs. The Jacksonville office of CCS has certainly done just that by moving to Frame Relay.

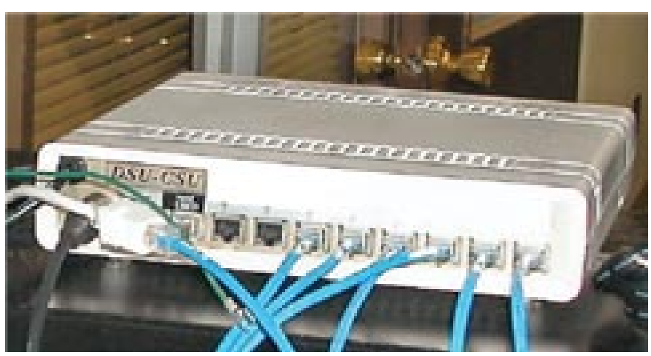
How CCS heard about Frame Relay

Jeff Tankersley of DA Solutions, a SCADA systems consultant from Waverly, Illinois was working with EnerStar, an electric and propane cooperative in East Central Illinois. It was at EnerStar where Jeff first encountered Frame Relay and Frads being used for SCADA communications. Jeff was impressed with the reliability and simplicity of the DCB, Inc Frame Relay equipment being used at EnterStar and heard good things about both Frame Relay service in general and the Frads in use at Enerstar. Jeff soon communicated this information to CCS. Jeff has worked with CCS in Jacksonville for a number of years and knew of their analog maintenance problems and the desire for a better solution. He soon convinced CCS to at least give Frame Relay a try. It was working fine for EnerStar and should for CCS, too.

Frame Relay is Faster

The analog links ran at the rather low speed of 1200 bps over 202T modems. The Frame Relay links are 56 Kbps, with the RTUs and host computer ports running at 9600 bps. This is 8 times faster than the old 1200 bps links. It means more data can be collected from more drops on a multipoint circuit in less time than before.

CCS, like most electric utilities, is moving toward a 4-second goal. Every RTU is polled within 4 seconds or less when the 4-second goal is met. With 1200 bps lines, this goal is very difficult to reach. By speeding up the lines to 9600 bps, CCS has removed the communications lines as one of the impediments to reaching the 4-second goal. There are still issues with RTUs and host computers, but those issues are separate from the communications speed now that CCS is using Frame Relay. With the communications speed obstacle eliminated, CCS can concentrate on the other impediments to the 4-second goal.



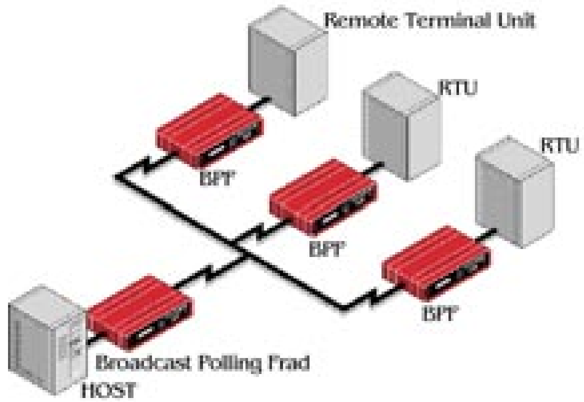
Frame Relay is better, more reliable

The digital Frame Relay service has proven to be more stable than analog circuits. Frame Relay has less down time than the analog lines, provides better diagnostics, and if interrupted, gets back on line faster.

"I know for a fact", says Dan Allen, "that there have been outages that AT&T found and fixed in the middle of the night and on weekends. They fixed some problems before we even knew about them. I know this from our system records that show the service is interrupted and restored without us being notified. This saves me from getting called out in the middle of the night or over a weekend."

AT&T, the service provider for CCS, and other Frame Relay vendors, are able to do this fast problem detection and restoration because of the Frame Relay management. All customer Frame Relay equipment sends a short "keep alive" every 10 seconds to the phone company Frame Relay network. The vendor's Frame Relay equipment responds to the keep alive. If the keep alive message from the customer equipment is not detected for about a minute, the Frame Relay management consoles at AT&T network management centers will display an alarm condition. In visual terms, the management displays go from green (good) to yellow (alarm) to red (failure). When a customer device fails, the missing keep alive shows the location that failed. Armed with this information, AT&T has been able to start repairing most problems before the customer is even aware of the failure. This is known as "proactive" network management.

CCS finds that in addition to faster response to problems, there are fewer problems per location with Frame Relay. Dan Allen says he can count on one hand the number of Frame Relay problems in the past 2 years. With the analog lines, he can count on a problem or more per month. On a per drop basis, Frame relay lines have less than half as many periodic problems as the analog lines, per Dan Allen.



Frame Relay is inherently more reliable, get fixed faster

Frame Relay service tends to have more "up time" and get fixed faster for several reasons. One reason is that Frame Relay is digital service, rather than analog. Digital service is not effected by the variety of electrical disturbances than can effect analog circuits. Further, the infrastructure of the phone network is almost 100% digital now. Providing analog service requires the addition of bridging and line equalization equipment that is not native to a digital network. In terms of the age of the phone system, the digital equipment is newer, smaller, more modular, easier to repair with spare cards than are the older analog components. Another significant issue is the thinning of the phone company ranks of personnel with analog expertise. The majority of phone company technicians are trained and experienced in digital technology. The analog savvy personnel are gradually retiring from the phone companies.

The CCS Frame Relay Network

The Illinois CCS SCADA network connects the Jacksonville, Illinois office to several electrical transmission and switching stations and to 11 cooperatives that are distribution cooperatives:

1. Adams Electric Cooperative
2. Coles-Moultrie Electric Cooperative
3. Eastern Illini Electric Cooperative
4. Farmers Mutual Electric Cooperative
5. Illinois Rural Electric Cooperative
6. McDonough Power Cooperative
7. Menard Electric Cooperative
8. Rural Electric Convenience Cooperative
9. Shelby Electric Cooperative
10. Spoon River Electric Cooperative, Inc.
11. Western Illinois Electrical Cooperative

Future savings

The Frame Relay network has been so successful, so cost effective, that it is being expanded to include all the remote SCADA sites served by CCS in Illinois. Today the analog circuits still outnumber the digital circuits by two to one, so CCS is looking forward to considerable savings and improved network service. Frame Relay pricing is now below that of analog. The remaining analog circuits will be phased out and replaced with Frame Relay circuits. Not only will costs go down, but the reliability of the communications network will go up.

Future increased speed and throughput

Frame Relay makes it very easy to further increase speeds and to add more communications channels for new applications. If CCS finds it necessary to increase the port speeds of the RTUs to get faster response times or pass more data, it is certainly easy to do. Their Frads (Frame Relay Access Devices) run over 56 kbps lines and the serial port speeds can be increased up to 38,400 bps from the current 9600 bps port speeds.

Space Savings

When CCS finishes converting from analog to Frame Relay they will nearly empty a 19-inch communications equipment bay. At the main office, a single 16-port Frad replaces 16 analog modems. Each of the analog modems is the size of a single Frad. When the conversion to all Frame Relay is finished, CCS gains the space of half of a full height equipment bay. Even if they cannot eliminate an entire bay, they will have much more working room in the bay by eliminating equipment crowding.

Future applications

CCS has a number of meters in the same locations as the RTUs. The metering data from remote locations is collected manually at this time. CCS could collect this metering data using MV90 software and dial up modems, but at a cost of nearly $1,000 per site just for the lightning protection equipment. Dial up lines also have the additional recurring monthly cost of a phone line, typically at a cost of about $40 per month. Since CCS is already running Frame Relay to most of these locations, the metering data at those locations can be collected using the DCB Frads. CCS just needs a Frad with more than 1 port at each of the joint RTU/metering locations. The DCB Frads support virtually all async SCADA and metering protocols, without the need for any special options or firmware.

More Frame Relay in the future

Dan Braden, Regional Office Coordinator in the Jacksonville office, confirms Dan Allen's assertion that Frame Relay is cheaper and better. Mr. Braden says that CCS had a 2 year AT&T contract that is now ending. At this renewal time, he finds that Frame Relay costs have dropped below the cost for analog service. In addition, there is healthy pricing competition between various vendors, such as AT&T, MCI and Sprint. This helps keep the pricing competitive. Mr. Branden is looking forward to increased savings on communications costs.

Initially, just 10 remote locations were being served with Frame Relay. The monthly costs have proven to be lower, and the CCS network maintenance burden is less with Frame Relay. Because of their successful experience, CCS will move all of their communication lines to Frame Relay. "We have better luck all round with Frame Relay", is Dan Braden's summary of the situation. ■

ABOUT THE AUTHOR

Mr. Straayer is President of Data Comm for Business, Inc., a position he has held since founding the company in 1981. Prior to that, Mr. Straayer was Vice President of Compre Comm, Inc, from 1977 until 1981.

Mr. Straayer is a graduate of the University of Illinois Springfield with a degree in Communications. Mr. Straayer has consulted for AT&T, Harris Bank and Trust, General Telephone and other major companies. He has been an instructor in data communications courses for the Federal Reserve, EDS/GM and for many public data communications courses.

Mr. Straayer was a telecommunications manager with the State of Illinois where he was responsible, in 1977, for a $35,000,000 budget. He was responsible for the 1977 implementation of a credit card calling system that included voice recognition equipment to automate the placing of credit card calls.

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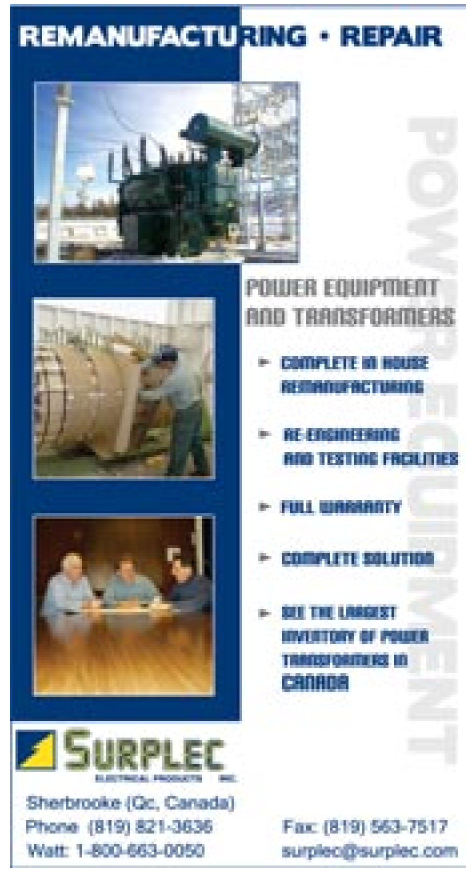

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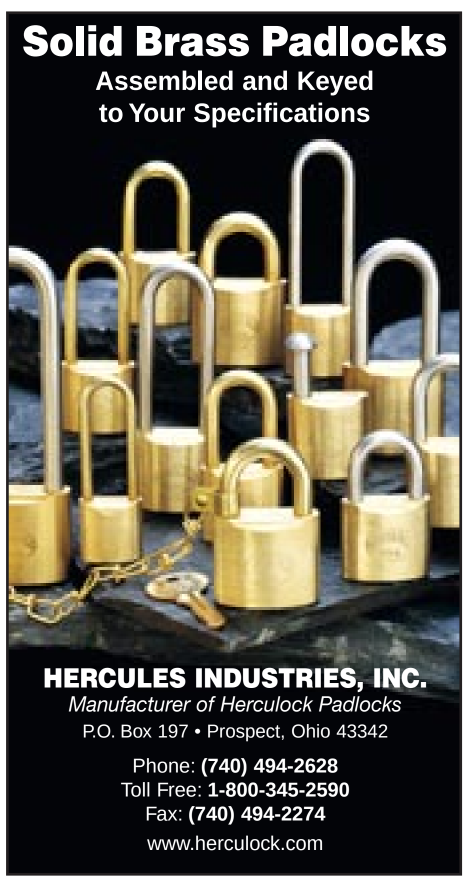

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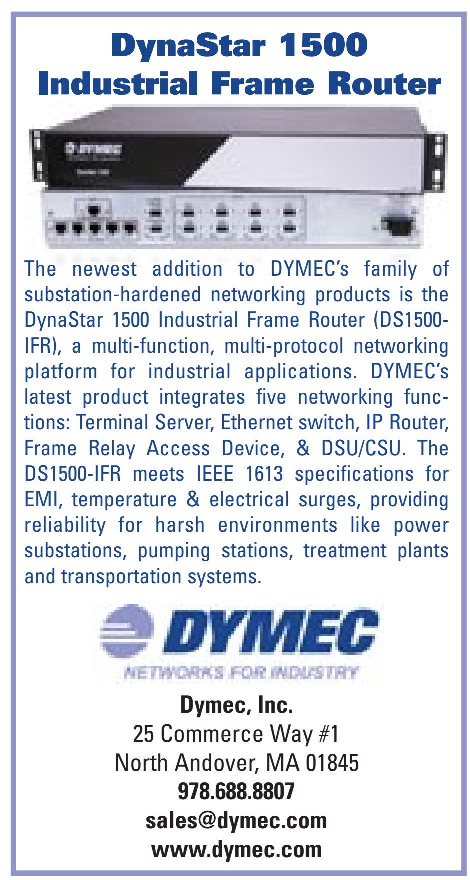

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