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We are excited to announce our first publication of the ENSC magazine! Our mission is to share the knowledge and the experience of all involved in secondary networks. We started in the year 1999, with our first ENSC conference held in Atlanta, Georgia. Since that time, the conference has steadily grown into what it is today and I think each of us learn something new from every ENSC experience. This year, because we wanted to share the knowledge before and after each ENSC event , the ENSC magazine was developed to bridge the gap between conferences. This first publication will coincide with our 2018 ENSC in Madison, WI with the second issue coming out in the fall of the same year. From this time forward, our planned publication will be two times per year.

As always, we hope you like what you see and we are always looking to deliver valuable information to the group, so if you have an idea or topic for discussion at the ENSC or in print, please reach out to Tony Oruga.

Thanks goes to all of you who contribute and support the ENSC by coming and spreading the word!

I look forward to seeing you in San Francisco for our 20th anniversary ENSC, co-hosted by Pacific Gas & Electric, in 2019.

Respectfully,

Mark Faulkner
Product Line Manager
Eaton

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ENSC Magazine

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ENSC – The Network Solutions Magazine

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Network Protector Gray Spool Failures and Mitigation

Mark Faulkner, Eaton, Product Line Manager

During the last five or so years, Eaton has noticed a rise in catastrophic failures in Westinghouse type CM-22 Network Protectors. All of these failures that we are aware of have been protectors produced in 1980 or prior, equipment life exceeding the 30 year expected life of the product. The materials used prior to 1984 can be prone to di-electric breakdown due to age and condition of the material. The insulating material used in this era consisted of asbestos material in the backboard, barriers and splitter baffle plates of the arc chutes. The top suspects based on the area of arcing origin of these units that were inspected are mainly the cross bar and the grey transformer spool standoff used in the design prior to 1984. In each case that we analyzed, the results showed that the source of fault was either the cross bar or the through spool insulator, never both as far as we could determine. This is the good news, the bad news is that all CM-22 designs prior to 1984 have both and there are many network protectors in this era still in service today.

Let's start with the cross bar construction, the cross bar is produced from steel bar and ties all phases together through "C" clamps on the breaker. The only median utilized to insulate against a phase-to-phase fault in the "unprotected zone" is wrapped tape and sealed with varnish, the ends of the bar are capped with insulating material but the bars are steel. Our forefathers did their due diligence to test this design on units that were brand new back then and prescribed annual inspections with recommended Meg-Ohm values to insure that the product met safe criteria. However, a few things they did not realize….. the age of units in service today are well beyond the manufacturers published life and worse, in a few cases, failed to imagine a day where inspections would cease in its entirety or annual inspections would begin to stretch over many years. It certainly did not help the cause that many experienced network crews were stretched very thin or had to wear many hats, on top of that the fact that experienced personnel had moved on or retired. Some even experienced a change from the original inspection procedures, probably arising from changing of the guard or a miss-interpretation of what was required, almost like the "telephone game", where the actual meaning is reduced or even lost as it changes many hands. In any event, what was lost in some cases was the use of electrically inspecting the cross bar for resistance values during the routines. Age, thermal cycling and moisture can cause very adverse effects on the tape used during that period, so it is highly recommended that those units have both a visual inspection and an electrical one.

Before I discuss the second area of concern, I mentioned the "unprotective zone" and wanted to spend a little time explaining that defined area in a network protector. The definition of this area is the section of bus from Low Voltage terminals of Network Transformer to the moving contact assembly (contains crossbar) inclusive of both the transformer bus (grey spool) and the fuses in the network protector. A fault in this area would **NOT** be cleared by the phase or ground over current relays from the substation and the Network relay may not operate. This is described in the IEEE 57.12.44 Secondary Network Standard in the appendix section. Also realize that the fault current in this area current would typically **exceed** the interrupting rating of the Network Protector and Fuses.

The second area of concern is the transformer bus produced prior to 1984. The bus was mounted to the internal network protector tank wall using a grey spool. The significant of the spool is that it required a steel bolt to pass through the copper transformer bus and associated spool, the bolt would then thread into a welded boss on the inside of the tank wall. The transformer bus weight floated on the spool, which was the dielectric medium between the phase copper and the steel tank ground in which the bolt was mounted into. The issue is that if the material of the spool would break down or crack, the fault would be phase to tank ground in the "unprotective zone".

Westinghouse realized this and issued a technical advisory bulletin on this subject and described the new design that eliminates the spool.

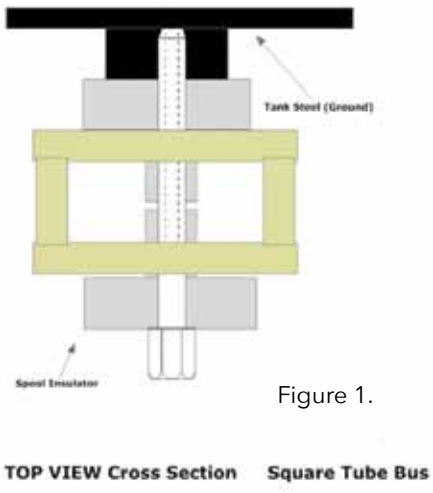


Figure 1.

Figure 2.

The photo above is from a protector manufactured in 1980.
Figure 2 shows all that is left of the grey spool is the glass strains due to the heat of the fault.

The design was changed to an isolated insulator that provides no path to ground. Figure one on the previous page, is a top view of the copper bus (not to scale) and the grey spool arrangement for a general description of the design.

In the event of Figure 3, this protector (circa 1976) was completely melted down, notice the hole in the bottom of the tank, the tank is produced from .25" thick steel. In this case the heat at the top of the tant was above 327 degrees C because the lead that bonds the porcelain terminator to the mounting brackets had melted allowing the weight of the cables to drop the porcelain insulators down causing extreme damage externally and internally, in short every part of the unprotected zone of this protector was damaged.

Figure 3

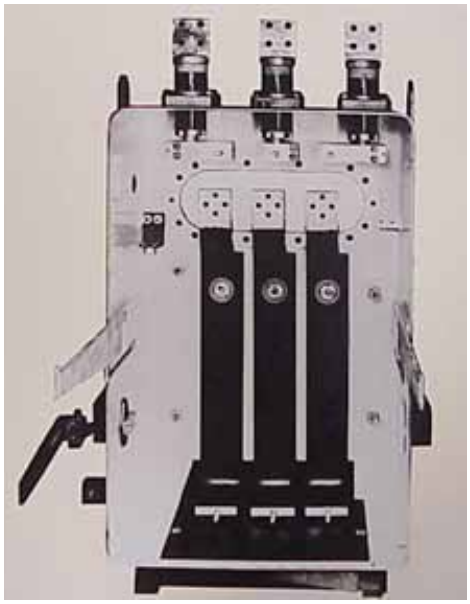


Figure 4- Bus Design circa 1960

Figure 5- Stand Off Insulators

Figure 5 shows the standoff fully isolated bus design that replaced the grey through spool in the early 1980's due to the propensity of failure to ground acerbated by age or damage.

It is very easy to visually check to see if your protectors have the grey spool design, the bad news is that there is no way to easily electrically verify that the dielectric of the spool is sound because in order to do so you would have to isolate the secondary of the transformer shunt to conduct a resistance check. Our recommendation is that you could disconnect the transformer and slide a barrier between the transformer bus bar and transformer flex shunt connector to fully isolate while you perform an resistance test on each bus bar. The best plan of action is to develop a change out plan over time to remove those units , at least those manufactured prior to 1984 , from service. The rationale is that not only is the insulation suspect but all those older units contain asbestos, mostly bonded but friable in the arc chute area. Those units could be replaced with newer CM-22s that have the standoff design and no asbestos or with more advanced models available. The other mitigation options for the unprotected zone are placing interruption devices on the primary ahead of the transformer with the proper coordination or having a fire protection system with internal heat probes inside the Network Protector. In any case, with today's technology , the unprotected zone in Network Protectors can be eliminated or at least mitigated.

Some Perspective Regarding Energized Electrical Distribution Equipment

Mel Terk, BDM/IRISS, Inc. | Rudy Wodrich, VP Eng. Svces./IRISS, Inc.

I want to offer a few perspectives, food for thought if you will, which hopefully make the day-to-day work a bit safer and the results more reassuring for the maintenance professionals who keep our electrical infrastructures humming every day across all aspect of our daily lives. The critical tasks performed every day by these individuals are vital, frequently dangerous, and ever essential to their own and everyone else's lives, livelihood, and well-being. Whether your work takes you inside a building, 200' up in the air, or in a confined space or underground vault electrical infrastructure problems, failures, and personnel injuries can happen anywhere.

Today you have an array of technology at your disposal which, individually or collectively, adds very measurable levels of safety together with vital task efficiency and the ability to preempt electrical distribution equipment failures and unscheduled shutdowns before ever occurring. There are numerous opportunities for achieving measurable savings to precious O&M budgets when managed properly.

FIRST, ***don't UNDERESTIMATE the value nor importance of the 'Walk-Around'–the visual inspection capability which we may not routinely regard as a 'technology'.*** The visual inspection is among the most useful tools available to us. A good set of eyes, our ability to see and comprehend the implications of subtle changes in equipment is invaluable. For over two decades, PdM (Predictive Maintenance) technicians used best practices to walk around equipment seeing, smelling, and listening before they open their PdM toolbox and begin an infrared, ultrasonic, vibration, power quality, ultrasound or partial discharge inspection. A new ***drip pattern*** on the floor… ***a change in sound***… ***a smell of chemicals*** or ***something burning***… could each be signaling a developing problem.

If your attempting to optimize your existing PdM program, then visually inspecting the condition of Transformers, Switchgear or MCC (Motor Control Center) cabinets regularly, for instance, to make sure nothing has deteriorated, no tooling left has been behind, and pests have not made the cabinet their new home, can be critical.

When the cabinet is open, it is an established best practice to take a digital photo and document the reference points for your IR (Infrared) survey if you intend on performing one. If the cabinet is not regularly inspected, failures will sneak up on you. However, it is not always practical to de-energize a cabinet and perform a visual scan of components. Furthermore, certain failures modes can be present within the cabinet but not yet show changes in their heat signature with thermography. Where you have truly critical equipment, regular visual inspections are strongly advised to find problems such as wiring and insulation breakdown or annealing–in these conditions or circumstances, installing a qualified visual inspection pane is again very strongly recommended.

If you need visual inspection and IR inspection capability combined into a single installed point of access then exercise care in selecting a product which, by engineered design and subsequent testing, complies with the mandatory requirements of IEEE C37.20.2 and UL746C. These are the Standards which spell out the impact, load and flammability requirements for IR windows in medium voltage applications. When properly selected, this type of qualified inspection panel will enable Visual inspection as well as Infrared and Digital photography through a single access point. Do not ignore your senses when conducting PdM inspections of electrical distribution equipment. Rely on your training, trust your judgment. Head off problems early on before they become big. When you walk through the plant, take on a heightened sense of awareness of what is going on around you. Be sensitive to any thing or condition that does not seem right. Rely on your senses, as well as your PdM tools, to inspect and diagnose equipment problems and be SAFE!

SECOND, ***what about OSHA rules and guideline? Does this organization figure into or influence our work patterns, methodologies, practices and implementation techniques when it comes to Energized Electrical Distribution Equipment?*** Should you be mindful of OSHA's perspectives in your and your work place calculus of how you go about your day-to-day inspection and maintenance tasks? The answer is an unequivocal YES! Their perspective is concise and to the point when it comes to safety while performing these very critical tasks.

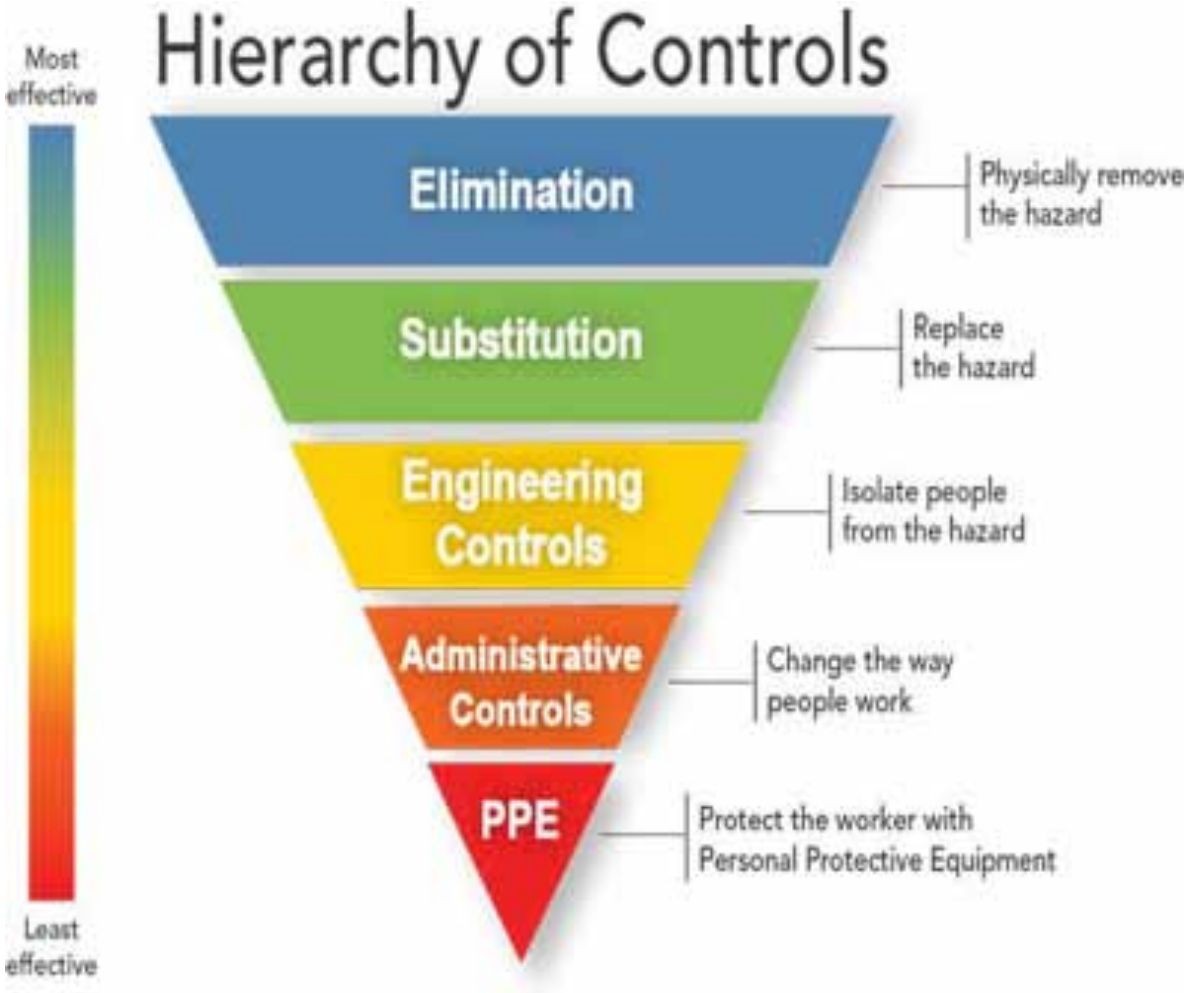
OSHA already does, and will continue, issuing punitive

Infrared, Visual, Ultraviolet, Ultrasound / Partial Discharge Testing Capability Combined In A Single Point Of Access On the Electrical Gear.

monetary fines to companies for Noncompliance with the requirements outlined by NFPA 70E. The Occupational Health and Safety Administration (OSHA) enforces electrical safety regulations in the United States [and with significant cross-border effect in Canada as well via the largely parallel CSA Z462 Standard]. Although OSHA has not adopted and does not mandate NFPA 70E compliance specifically, it is possible-even likely-you'll be cited and/or fined for non-compliance alone when a reportable incident may have occurred and, especially when a reportable incident has occurred with HUMAN-injury involved. OSHA's authority to cite both companies and individuals stems from the occupational Safety and Health Act, specifically Section 5(a)(1) and 29 CFR 1910.2(g).

Section 5(a)(1) **"The general Duty Clause"** of the Occupational Health and Safety act, states that employers *"shall furnish to each of his employees a place of employment which is free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees".* This is the clause most cited by OSHA where unsafe work conditions are found to exist.

Another area where OSHA can fine companies or individuals is for not adhering to the national consensus standards which, in this case, can clearly reference back to NFPA 70E. A consensus is a method by which an entire group of people can come to an agreement. The input and ideas of all participants are gathered and synthesized to arrive at a final decision acceptable to all. Section 29 CFR 1910.2(g) states a **"National consensus standard…** "means any standard or modification thereof which has been adopted and promulgated by a nationally recognized standards-producing organization under procedures whereby it can be determined that persons interested and affected by the scope or provisions of the standard have reached substantial



agreement on its adoption". OSHA considers NFPA 70E to be ***THE*** national consensus standard and non-compliance leaves employers and some individuals open for citation under Section 29 CFR 1910.2(g) if they are found to be noncompliant. So, BE SMART, BE SAFE and avoid the risk of an OSHA penalty.

Safety concerns for electricians and other maintenance personnel have come to the forefront of health and safety in recent years. Both NFPA70E (2018 edition) and the equivalent document in Canada, CSA Z462, call for utilization of the Hierarchy of Control Concept as a framework when considering work on energized equipment. The Hierarchy realizes that in some instances, like when performing condition based inspections of equipment, it is necessary for the equipment to be energized and under load. However, the Hierarchy prioritizes how personnel should think about performing their duties.

1. Eliminate Hazards: Avoid working on energized equipment altogether unless absolutely necessary. In this way, there is no risk of arc flash and electrocution to personnel. If this is not practical…
2. Reduce the Risk by Design: Also sometimes called "substitution", design equipment with features that allow tasks to be performed while maintaining a closed and guarded condition or that reduce the risk to personnel in the event of a failure. Electrical Maintenance Safety Devices (EMSD) like infrared viewing windows fit into this category as do Arc Resistant switchgear designs, Arc Suppression systems etc. If this is not practical…
3. Apply Safeguards: Isolate the hazards from the personnel with barriers and mechanical / electrical interlocks. If this is not practical…
4. Implement Administrative Controls: Policies, procedure, work practices and training to help reduce the risk to personnel and ensure only qualified personnel undertake tasks. If this is not practical…
5. Use Proper PPE: As a last resort, utilize Personal Protective Equipment in alignment with the available Arc Flash incident energy labels on the equipment in question to help minimize risks to personnel.

With electrical equipment, maintenance personnel typically interact in a variety of ways to perform inspection tasks including opening and closing doors, removing or replacing covers, reaching into or leaning into equipment, removing or replacing internal barriers, operating switches or circuit breakers, racking circuit breakers and using tools and test equipment. All of these tasks present a potential arc flash hazard and many of these hazardous tasks can be eliminated altogether with the proper implementation of EMSD technologies.

FINALLY, **are 'Certifications' purposeful, of value, or play into any aspect of your day-to-day work with energized electrical distribution work?** Of course, Certifications are extremely important whether applied to personnel to document and confirm an individual's Training and Qualifications for specific categories of work but also for documenting and confirming the Safety Conformity and Intended Application suitability for specific categories of electrical Equipment and components. Among the many energized electrical gear inspection means and equipment items in the market place today are, of course, Inspection and Maintenance Windows & Panels for energized electrical gear.

Technology-wise, these may be utilized individually for single purpose inspection tasks, **Visual or Infrared** inspections alone as example or, with multiple technology capabilities built in to a single point of access panel for numerous inspection capabilities combined. Currently though, a single standard for infrared windows by a recognized body (UL, IEEE) ***do not exist!*** Rather, there are a series of different standards and certifications that may be applicable depending on the window design, voltage level of the equipment to which it is being fitted and several other factors. The remainder of this article intents to provide you with these for IR Viewing Windows/Panels and their Recognized variations which are more and more being implemented across innumerable applications and market sectors globally.

The following Certifications are used by manufacturers to provide ***confidence*** and ***assurance*** that a given IR Viewing Window / Panel is suitable for use in Electrical Switchgear, Motor Control Centers, and many other energized electrical equipment applications. If you are considering implementing an Inspection and Maintenance Window program at your facility these are the recognized global Testing Standards and Certifications that may apply. This is the only assured means of acquiring a product that is safe to install, made of qualified materials which will be OEM and UL / CSA compliant, safe for personnel to interact with, and therefore up to the task…***SO PLEASE CHECK THE APPLICABLE CERTIFICATIONS!***

Conclusion

Electrical Maintenance Safety Device (EMSD) technologies should be used as part of a Condition Based Maintenance program to ensure personnel are kept as safe as possible while performing critical inspection work on electrical assets under normal load conditions. The Hierarchy of Control concept encourages us to employ a "safety by design" approach as the next best protocol in instances where it is not possible to perform the necessary work with the equipment de-energized. Care should always be taken when specifying and procuring EMSD devices to ensure they comply with the relevant standards.

UL1558
A standard covering metal-enclosed low-voltage (<600V) power circuit breaker switchgear assemblies. This standard covers low voltage assemblies and allows the impact resistance (static load and impact) of the assembly to be tested with the window cover closed.

UL 508A
These requirements cover industrial control panels intended for general industrial use, operating from a voltage of 600 volts or less. This equipment is intended for installation in ordinary locations, in accordance with the National Electrical Code, ANSI/NFPA 70, where the ambient temperature does not exceed 40°C (104°F) maximum.

UL746C
A standard identified by UL which sets the impact and flammability standards for polymeric materials used in electrical equipment up to 1500 volts. Any plastic or polymer forming part of an infrared window must pass flammability tests at room temperature, and must remain intact during an impact test performed at 0°C (32°F).

Note: Of the crystal optics capable of transmitting in the long wave portion of the infrared spectrum (8µm to 14µm), there are no fluoride-based crystals capable of passing the impact tests required in 746C.

However, because they are classified as "glass" under the standard, they are not required to test for impact so long as they are thicker than 1.4mm.

IEEE C.37.20.2 section a.3.6
This is the IEEE standard and test procedure for viewing panes mounted in medium and high voltage electrical equipment (up to 38kv metal clad and 72kv station type gear). It requires the viewing pane to withstand impact and load. Both sides of the viewing pane are subjected to the impact and load test and neither side can crack, shatter, or dislodge. Until a recent downgrade revision, the standard specifically identified that the viewing pane must withstand the impact and load from both sides (inside and outside) and the viewing pane must not "crack, shatter or dislodge. No infrared crystal, with the possible exception of very expensive and rarely used man-made sapphire, could withstand the impact requirement of this test. However, IRISS patented reinforced polymer could easily pass this test. The standard was revised (weakened) in 2017 to allow crystal windows to be tested with the cover closed and locked.

Lloyds of London Type Approval
Lloyd's Register provides independent, third-party approval certificates attesting to a product's conformity with specific standards or specifications. It also verifies the manufacturer's production quality systems through a combination of design reviews and type testing. There is growing international awareness of the importance of third-party certifications such as those offered by Lloyd's. Similar certifications are available from DNV and ABS. For marine applications, any products under consideration should be certified by at least one of these bodies.

IP / NEMA Ratings
This is an ingress/integrity proof standard. IP65 is issued by an independent test facility while NEMA is a self-certification. IRISS VP models are certified IP65/NEMA 4 while IRISS CAP products are either IP65 or IP67 rated both open and closed. You should typically install viewing panes with only an equal or higher IP/NEMA rating than the enclosure it is going into.

Arc Rating – Arc Testing
An arc rating can only be given to a completed assembly and not to a single component within that assembly. Electrical cabinet designs and dimensions are infinite and we therefore CAN NOT or MUST NOT use the data from one cabinet design to another design unless they are identical in every way. This is the reason why components can never carry a generic arc rating and must be subjected to industry standard tests in each application by the OEM to confirm that they conform to the minimum required level of mechanical strength and environmental properties for the electrical cabinets and assemblies which they are going to be fitted.

CUBEFuse Solution Surpasses Utility Substation Needs

Jason Ezzell, Eaton's Bussmann, Product Field Application Engineer

Utility electrical distribution system design can be complicated. No matter what section of the distribution system is being considered, a few of the foremost considerations are reliability and safety. Specifying the right overcurrent protective device can be paramount in achieving these goals. In the example below, we'll review a major utility's obstacles in instrumentation protection at the substation level and how they overcame these application demands.

Several years back, a large utility came to Eaton's Bussmann division looking for a solution to meet their circuit protection needs across more than 700 utility substations. They were looking to standardize on an electrical distribution system design for their low voltage instrumentation. The source of these instrumentation controls were battery banks with system voltages of 125 Vdc and 250 Vdc. The instrumentation circuits were typically low amperage loads, under 6 amperes, but could require overcurrent protection upwards of 60 amperes for certain loads. Unfortunately, each of the traditional overcurrent protective device solutions they had used in the past had limitations in one way or another.

Molded Case Circuit Breakers:

This traditional solution bottoms out at a 15 ampere rating. A 15 ampere rated molded case circuit breaker (MCCB) may never see enough fault current to trip when upstream of instrumentation with normal loads of 1 and 3 amperes. Using this solution would risk damage to sensitive and vital instrumentation, reducing system reliability.

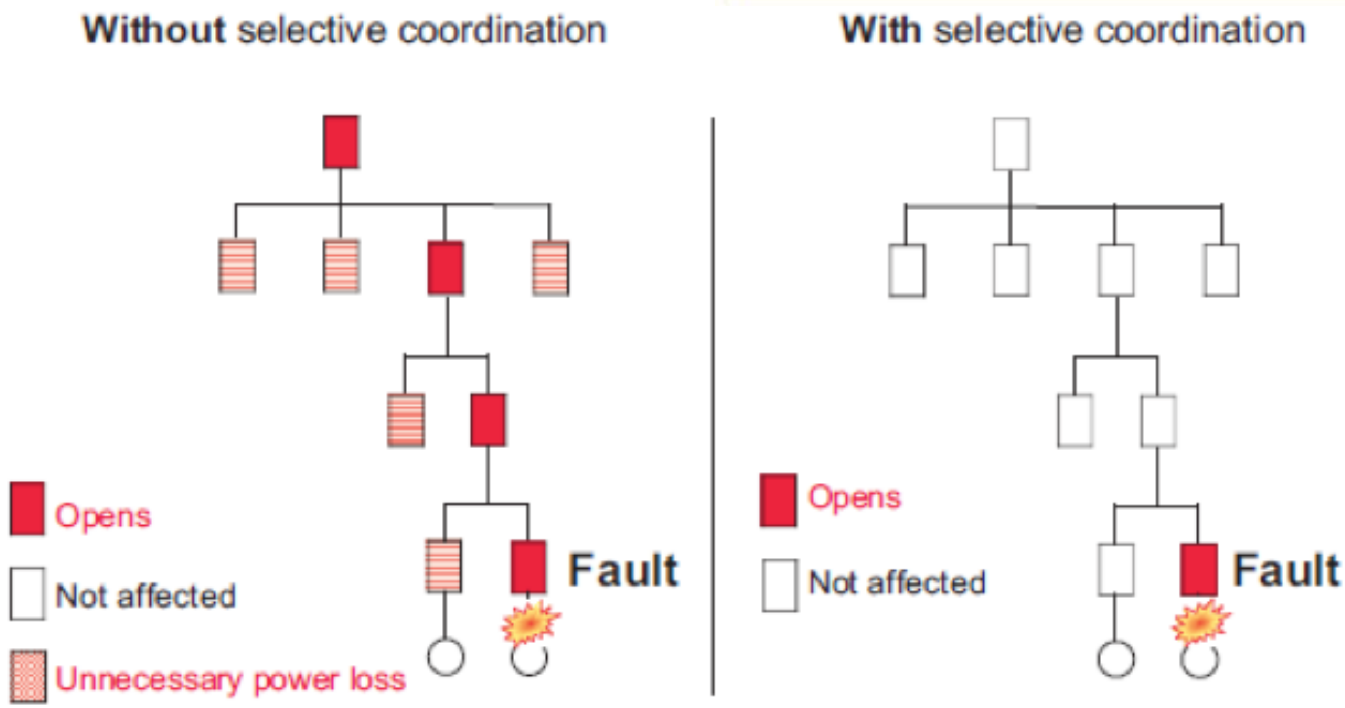
Additionally, instrumentation with larger loads, and therefore a larger ampere rated MCCB could compromise selective coordination with the upstream feeder circuit breaker. A circuit with selectively coordinated overcurrent protective devices allows only the nearest upstream overcurrent protective device to open under any overcurrent condition. Selective coordination increases the reliability of a system to deliver power to the loads.

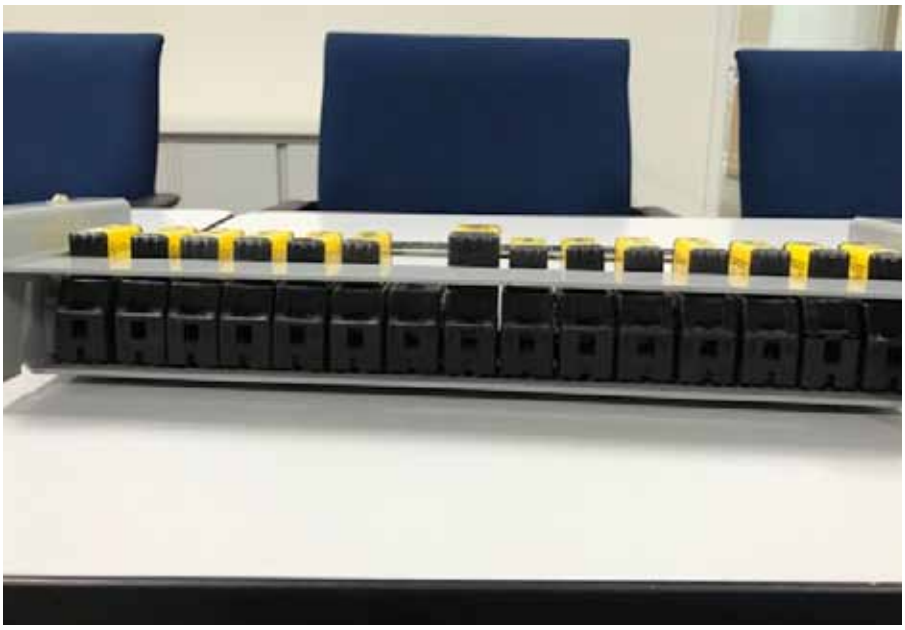
Selective coordination is mandatory per the National Electrical Code (NEC®) for the circuit paths of some vital loads on specific systems including Emergency Systems (700.28) and Legally Required Standby Systems (701.27). While utility substations do not fall under the purview of the NEC, selective coordination is a desirable goal for substation low voltage distribution due to the ultimate result being increased reliability.

The NEC® definition in Article 100:

Coordination (Selective). Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the selection and installation of overcurrent protective devices and their ratings or settings for the full range of available overcurrents, from overload to the maximum available fault current, and for the full range of overcurrent protective device opening times associated with those overcurrents.

Figure 5. Electrical system selective coordination





Traditional Fuses:

While traditional low voltage current limiting fuses like Class J, RK, and CC solved the two major design concerns mentioned in the MCCB section, there were other design considerations for this utility substation application that these traditional fuses did not meet. Yes, they can be sized down to 1 ampere allowing for maximum circuit protection for their sensitive loads. Also, as a result of their current limitation, they are much easier to selectively coordinate with upstream overcurrent protective devices, in this case a feeder MCCB.

Beyond the reliability of a traditional fuse, though, the design engineers were looking for the smallest possible package to standardize on no matter the load size. The issue at hand was that the instrumentation circuit panel used in the field often had either changing or varying load requirements over time or the load requirements were not known until the equipment was already installed. Traditional fuses meant traditional fuse blocks that changed in physical size when the ampere ratings went from 30 amperes to 35 amperes. No traditional UL branch rated fuse could use the same fuse block when making this jump in ampere rating without using fuse reducer accessories which are not preferred in critical applications such as this. The only way to make this jump up or down from 30 amperes to 35 amperes was to change out the old fuse blocks with the appropriate ones in the field. De-energizing equipment to make equipment change outs like this were undesirable in the utility substation environment.

Bussmann series CUBEFuse

Enter the Bussmann™ series TCF time delay CUBEFuse™. The finger-safe UL Class CF CUBEFuse and holder is the world's first finger-safe current-limiting branch rated fuse system that delivers the smallest footprint of any Class CC, J, T, or RK fuse solution. Additionally, while the fuse and fuse holder have size rejection features built in, the 60 ampere fuse holder allows for any Class CF fuse 1-60 amperes to be placed within it. This feature allowed for the utility customer to standardize on the 60 ampere fuse holder (TCFH60N) for their circuit protection distribution panel design, giving them added flexibility, while still providing the smallest footprint possible, all in a finger-safe package. Add in the fact that they were able to still enjoy the reliability, reduced downtime, and optimal protection for sensitive controls and this was a slam dunk solution.

Today, several years later, the Bussmann series TCF CUBEFuse and holders are still the standard for all substation distribution for control instrumentation throughout this major utility.

Protecting Submersible Network Transformers with Anodes

Jane Shin, Con Edison, Department Manager/Distribution Engineering

The insidious effects of corrosion have plagued submersible network transformers for decades. In the most severe cases, a corroded transformer tank can release oil into the environment and catch on fire. Con Edison has been tracking the causes of transformer failures since 2005 and almost two-thirds can be traced to tank corrosion. The use of "sacrificial" anode cathodic protection is one of the many tools that can be employed to effectively combat the deterioration of a transformer tank. Under Con Edison's current protocol, anodes are required on all submersible network transformers and the company has seen early indications of success.

There are several other techniques that can be used to maintain the integrity of a transformer tank in a corrosive environment, including coating the tank with a zinc-rich primer, which is typically used in conjunction with cathodic protection. In this process, the tank is welded using 0.5" thick copper bearing carbon steel, which is subsequently coated with a zinc-rich primer and then an epoxy top coat. The zinc/epoxy coating inhibits corrosion by sealing the unit, providing an effective physical barrier between the carbon steel and the environment. The downside to the process occurs if the coating gets chipped, known as a holiday, which can expose the underlying steel and act as a point source for corrosion.

Stainless steel is another effective way to combat corrosion, although the 30% cost premium compared to a carbon steel transformer precludes its use in the 27,000-plus submersible network transformers at Con Edison. In addition, stainless steel is more difficult to weld than copper bearing steel. Cathodic protection is a much more cost effective method to extend the life of a transformer than stainless steel as the cost of the anodes for the largest unit is less than $400 per transformer which is less than a 1% cost premium on the network transformer.

Submersible network transformer with zinc/epoxy coating.

Cathodic protection

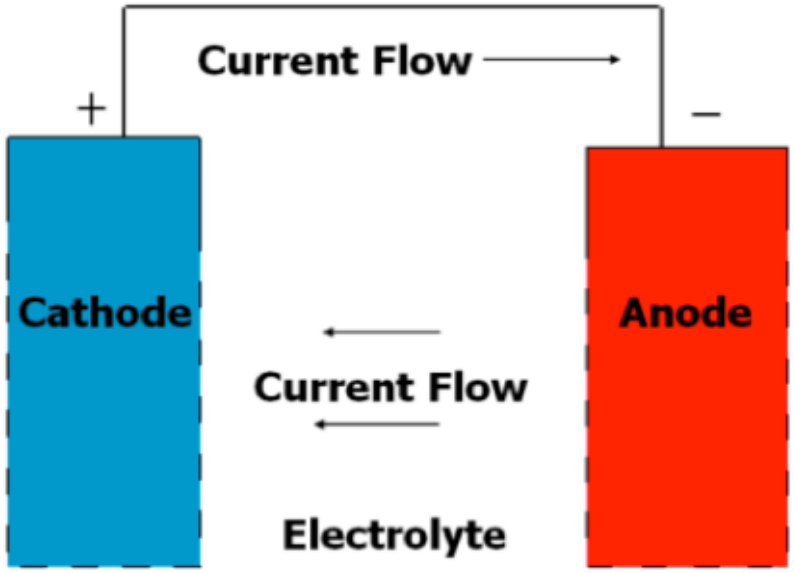
When the transformer tank is initially installed the iron in the steel is the most chemically reactive material on the transformer. The tank is typically exposed to a dirty, muddy, and/or salt water environment. If there is a holiday in the protective coating, moisture will come in contact with the carbon steel tank. As water comes in contact with the iron, oxygen combines with the iron and draws the iron out of the transformer tank. The loss of the iron during this reaction is what compromises the integrity of the tank. The visible rust is composed of oxygen and iron.

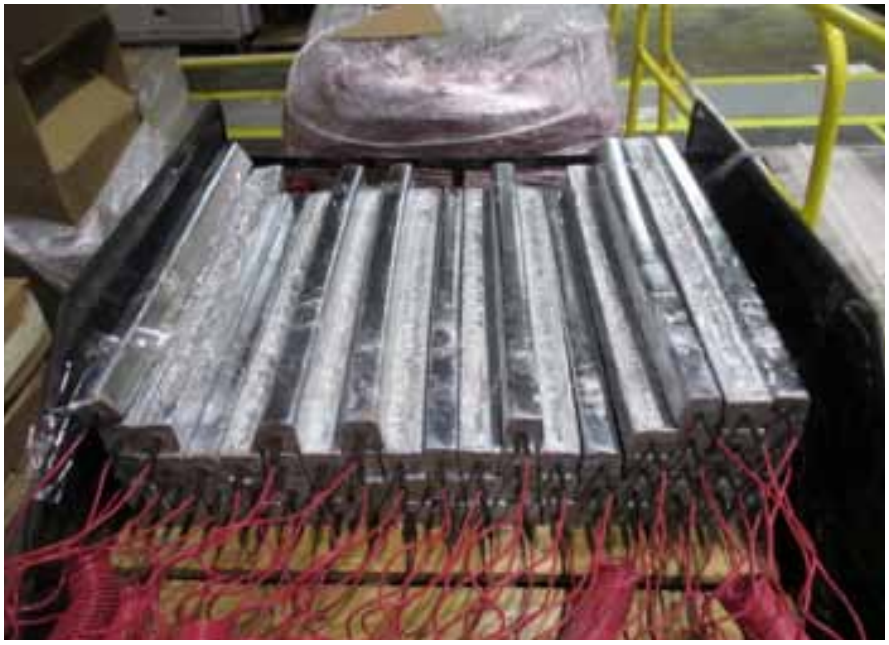
Cathodic protection works by allowing a material (the "sacrificial" anode) other than the iron in the transformer tank to be consumed by the corrosion cell (See schematic on next page). The anode material must be more chemically reactive than the iron for the corrosion protection to be successful. Common anode materials used to protect iron are magnesium and zinc because they both give up electrons more readily than iron.

In order to effectively protect the transformer the zinc or magnesium must be electrically connected to the iron and both the anode and the iron must in direct contact with the same electrolyte (i.e. dirty, muddy, salt water). In this process, the corrosion protection will last until the anode material has been completely consumed by the chemical reaction.

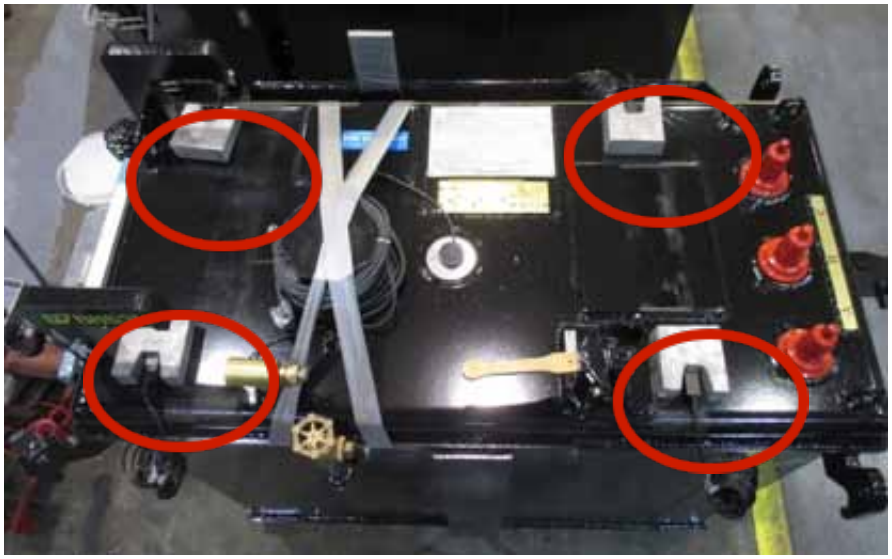
At Con Edison we have sized the anodes to last more than five years in a worst case corrosive environment but, in practice, the anodes often last longer. As an aside, buried anodes provide substantially more corrosion protection than is possible with a submersible transformer because the buried anodes can be placed at a distance in the same medium, while anodes used in submersible transformers are constrained by both the size of the vault and the uncertainly of the electrolytic debris. There are four different shapes for the various anode locations in a submersible transformer: the floor, cover, throat (between the transformer and network protector), and between the radiator panels (See photographs)

When inspecting a transformer, field crews are expected to add anodes to the transformer if less than half of the existing anodes remain. Ideally, the transformer vault is also cleaned unless there is debris that cannot be removed, in which case the crews are encouraged to simply add the anode and drop it in the electrolytic debris directly. Below is an example showing a consumed anode that is installed in the throat, which is a known problem location.





Floor anodes

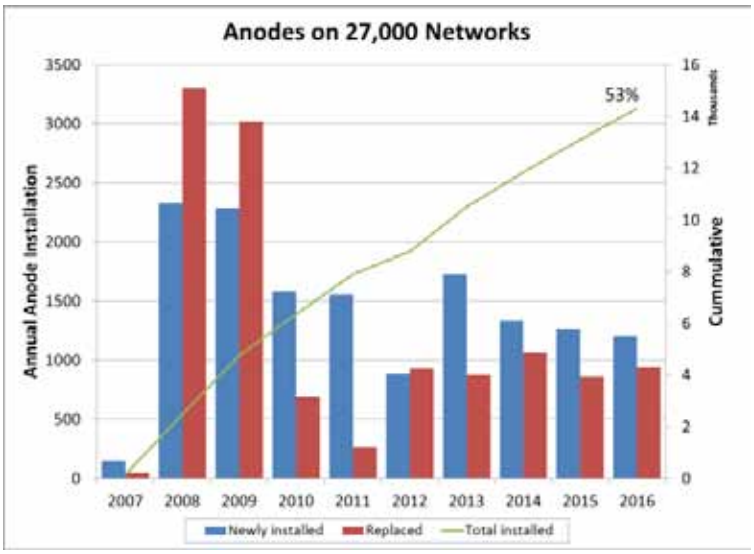


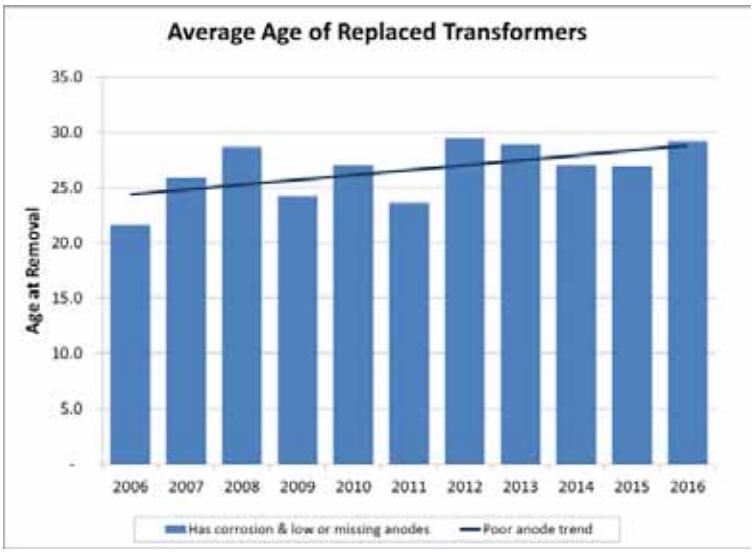
Cover anodes

Throat anode

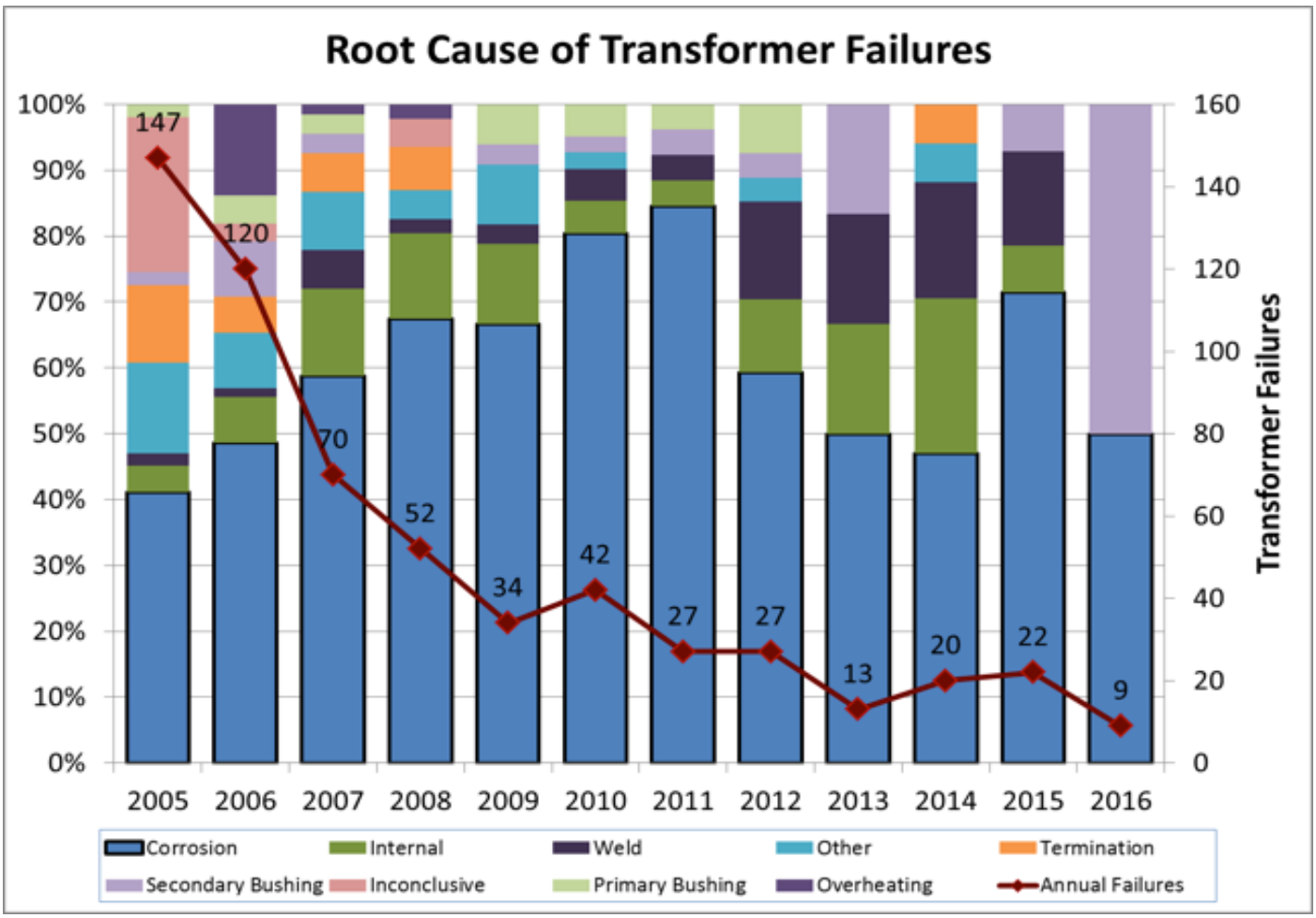
Ribbon anodes for radiator panels

Consumed throat anode with tank material intact





Con Edison has renewed their focus on anode installation for submersible transformers since 2008 and cathodic protection has proven to be a cost-effective, reliable way to mitigate in-service transformer failures. Although corrosion remains a serious issue, the frequency of failures due to corrosion has dropped significantly over the last several years. Failures have gone down predominately through pressure sensors detecting leaking transformers. However for units removed from service because of corrosion, the average age has gone up with increased anode use. Anodes show a positive relationship with the higher average age of corroded units.



Using VaultGard for Field Applications

Rick Kernan, Xcel Energy, Network Supervisor

In 2012, Xcel Energy embarked on a project to update the Denver Network with MPCV communication relays and the Vaultgard monitoring system. At the time, Xcel had over 700 protectors. Vaultgard was initially slated to become an engineering tool. Allowing field workers access to Vaultgard was an afterthought. General Patton once said "If everyone is thinking alike, then somebody isn't thinking." As the project progressed, it became very apparent Vaultgard could become an effective tool for the field worker. Today, VaultGard is being used by Xcel field workers to identify legacy construction flaws, for instantaneous email notification from relays when problems occur and in the apprentice program as a training and monitoring tool.

As each Vaultgard came on line, more legacy construction flaws were identified by the workers in the field. In 1986, Xcel was in the middle of replacing transformers filled with PCB oil. At one location, transformers were set with miss-matched impedance. This caused the low impedance transformer to "hog the load". This problem was identified as soon as this location came on line in 2013. At another 3 transformer location, employees found 2 transformers with a negative power factor. After further investigation, the workers found the tap on one transformer was installed in the wrong position, causing a voltage differential and the negative power factor. This vault was constructed in 2007. Other problems identified included a bad transformer, bad inline limiters and blown amp traps.

The Vaultgard emails the field workers when problems arise. The relay settings allow a wide variety of email alarms. The emails are sent as the issue occurs. The field employees can take the unit off line immediately or they can change relay settings from remote locations if needed. In one instant, a protector filled with water. The water started to boil and the relay sent a high temperature alert via email. The employee was able to remotely open the protector and save the breaker from a catastrophic failure. This single incident saved the company about $30,000.

Vaultgard has become an integral part of the apprentice training program at Xcel Energy. Apprentices in the Denver network are required to view their assigned Vaultgards once a week. Apprentices are trained to identify any abnormalities. If an apprentice does find a problem, they are the one who gets to trouble shoot the issue. Apprentices are also trained to use Vaultgard as a voltmeter, amp meter and to phase secondary. Xcel Energy apprentices are also tested on Vaultgard knowledge during their journeyman test.

Originally designated as an engineering tool, the Vaultgard monitoring system has become a field worker friendly tool at Xcel Energy. Field workers have used VaultGard to find and correct legacy construction issues. Field workers have programed Vaultgard to send emails when problems arise. This function gives instantaneous notification and has saved the company thousands of dollars in preventative maintenance. Vaultgard is also used as a training and testing tool for the Denver network apprentices. These are just a few of the ways the Vaultgard monitoring system is being used by the field worker at Xcel Energy. Don't limit the abilities of Vaultgard. Let the workers in the field use it.

Spokane Network Rebuild Project

Ryan Bradeen, Avista, Network Supervisor

Headquartered in Spokane, WA, Avista Utilities provides electric service to 379,000 customers and natural gas to 343,000 customers in three states. Touting a unique underground delivery system in downtown Spokane's core, one of only a few such networks in the country, this hidden system was constructed in the early 1900s by Washington Water Power, known now as Avista.

Avista's underground downtown network consists of 147 transformer vaults and 1,000 manholes, ranging in size from 1½ boxcars down to spaces barely large enough for two Avista crewmen. These vaults and manholes are connected by a grid of 3-inch pipes encased in protective concrete through which electric cable is stretched. Incredibly, much of the cable system that was installed in the 1920s is still in use today. Avista is slowly upgrading this network to accommodate increasing technology, using a newer style of cable and updating transformers. Manhole and vault locations are being moved away from streets and into sidewalk areas, creating a safer working environment for the crews.

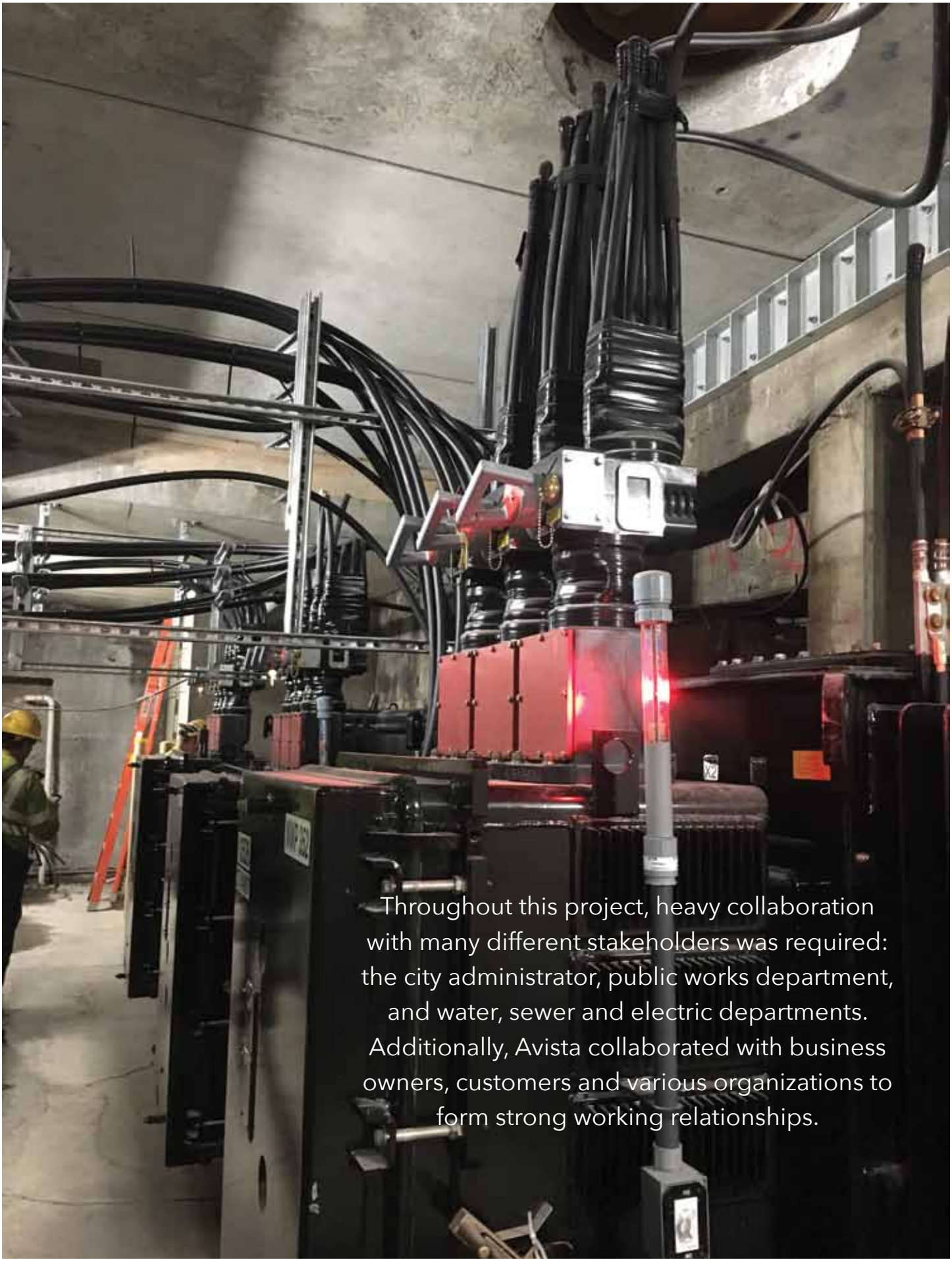
A recent project that features these important changes was done in conjunction with the City of Spokane. The city's $22,000,000 water and sewer upgrade was kicked off in the heart of Avista's Downtown Network. The completion of Lincoln and Monroe project would set the City of Spokane up well for the much needed installation of the combined storage overflow tanks. Older cities are needing to install the tanks in order to capture the large amounts of rain water that previously would have overflowed into nearby rivers. With the installation of

the sewer pipes and water pipes, the Lincoln Street and Monroe Street would need to be excavated. Since the streets were going to be torn up, the timing was great for the city to also beautify the sidewalks, streets and rebuild the road. The task for Avista on this project, was to also consider timing and the age of infrastructure to replace or rebuild nearly 60 Avista underground facilities, most of which date to the early 1900s and located in middle of both streets. These facilities roofs, over time, have changed depths and most had significant wear and tear. As the corridor was to be reconstructed by the city, this meant it was now time to move all facilities below grade in order for the road to be constructed to current road construction standards.

Presenting a challenge was the short window of time in which the project needed to be completed along with the limited availability of crews who were required to work extended hours, all while maintaining good relationships with businesses in downtown Spokane. Among the biggest challenges faced was locating real estate to install new vaults, manholes and duct lines. Working with Avista and the City of Spokane on the project were upwards of 15 contractors, and at times, nearly 300 people with countless pieces of heavy equipment working in the streets. Hazards such as open ditches, other contractor's work and equipment, pedestrians, and traffic had to be managed safely.

Throughout this project, heavy collaboration with many different stakeholders was required: the city administrator, public works department, and water, sewer and electric departments. Additionally, Avista collaborated with business owners, customers and various organizations to form strong working relationships.

When work began to remove and/or move the vaults and manholes, Avista took the occasion to utilize state-of-the-art equipment and technology manufactured by EATON. The EATON equipment installed provided some of the greatest opportunities for learning and advancements. Network crews worked diligently to install multiple CM52 network protectors in new vault locations. These network protectors were coupled with the Visoblock isolation disconnects in several locations, making it much safer for crews to do routine maintenance as well as providing a visual opening for our customers. Also, installed was the EATON ARMS system at strategic locations to better protect network employees from the hazards of 277/480 volt spot vaults. This type of build-out allows for communications in the future with the network protectors and the functionality and features that it offers. Ultimately, the strategic and future-oriented approach of this project will positively transform Avista's work and standards going forward.



Throughout this project, heavy collaboration with many different stakeholders was required: the city administrator, public works department, and water, sewer and electric departments. Additionally, Avista collaborated with business owners, customers and various organizations to form strong working relationships.

Gain Insights to Underground Vaults without Removing the Manhole Cover

Novinium Smart Monitoring Solution

As America's underground infrastructure ages, manhole fires and explosions are becoming a critical concern for utilities. In the last six months there have been major explosions from Boston to Los Angeles and everywhere in between. Due to limited resources, most utilities rely on occasional inspection programs that rarely identify problems in time to prevent them. While they want to have a more proactive method of determining when a manhole event will occur, most utilities may not be aware of smart solutions to help utilities stop manhole events from occurring.

Utilities can gain operational efficiency and potentially save lives by applying common-sense prevention measures and using data, not just people, to track the environmental conditions across an entire network of manhole vaults. Some leading North American utilities are implementing this approach to completely prevent the fires and explosions from happening. The holistic solution includes active smart monitoring with real-time analytics to identify trends before they become a problem. The utilities can now see if carbon monoxide levels are spiking before they reach critical explosive concentration. This solution also includes active venting, and a technology-enabled cover system that allows ventilation, communication and water control. Imagine how helpful it will be for a utility manager to detect when a manhole has been entered, or to know in real-time how much water is in a vault prior to sending out a utility crew.

PreVent™ vault solution is the only holistic system that brings together all of these technologies to help prevent fires and explosions. The solution provides real time visibility and long term analytics to improve decision making and optimize underground asset management. From a utility perspective, this kind of system easily facilitates communication and action planning to address unsafe conditions before they become a problem. In this way, IOT technology and 24/7 monitoring provide the accurate and timely information needed to take preventative action with manhole events, while counteracting the high cost and potential human error of ongoing manual inspections.

To learn more about the PreVent system, including pricing and product information, visit novinium.com, stop by booth #25, or call 253-395-0200.

About Novinium

Novinium is the only full-service power cable expert that partners with utility companies of all sizes to keep their networks operating at peak performance, using the most advanced, capital-efficient, environmentally friendly methods available. Novinium's founder and CEO invented the revolutionary technology behind underground cable rejuvenation 30+ years ago, and the company continues to pioneer ways to keep power flowing to those who depend on it.

PreVent™ vault solution is the only holistic system that brings together all of these technologies to help prevent fires and explosions.

Gain Insights to Underground Vaults Without Removing the Manhole Cover

Novinium Smart Monitoring Solution

The PreVent™ smart monitoring system is designed to help utilities protect people and property from dangerous manhole events. Implementation of this system will provide a clear picture of the hidden risks and challenges in your underground electrical vaults.

- Enables proactive asset management to reduce cost and harm to communities
- Measures and detects dangerous gases for optimal ventilation
- Sends to cloud-based system for smart monitoring to prevent manhole events
- Provides secure real-time alerts and infographic reporting for quick insights

Visit the Novinium team at the ENSC Conference to gain real-time visibility and detection of dangerous underground environments.

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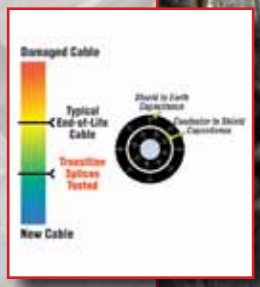
"SAFE TESTING OF LIVE SECONDARY UNDERGROUND NETWORK CABLES."

IMPOSSIBLE?

(FIND OUT HOW!)

Breakthrough in Underground Cable Testing

- Test Live, In-Service Cables Safely
- Non-Destructive Tests
- No Outage Required During Testing
- Automatically Inventory All Cables During Testing with RFID Tags
- Automatically Map Your System on Your GIS
- System Automatically Collects All Testing & Inventory Data



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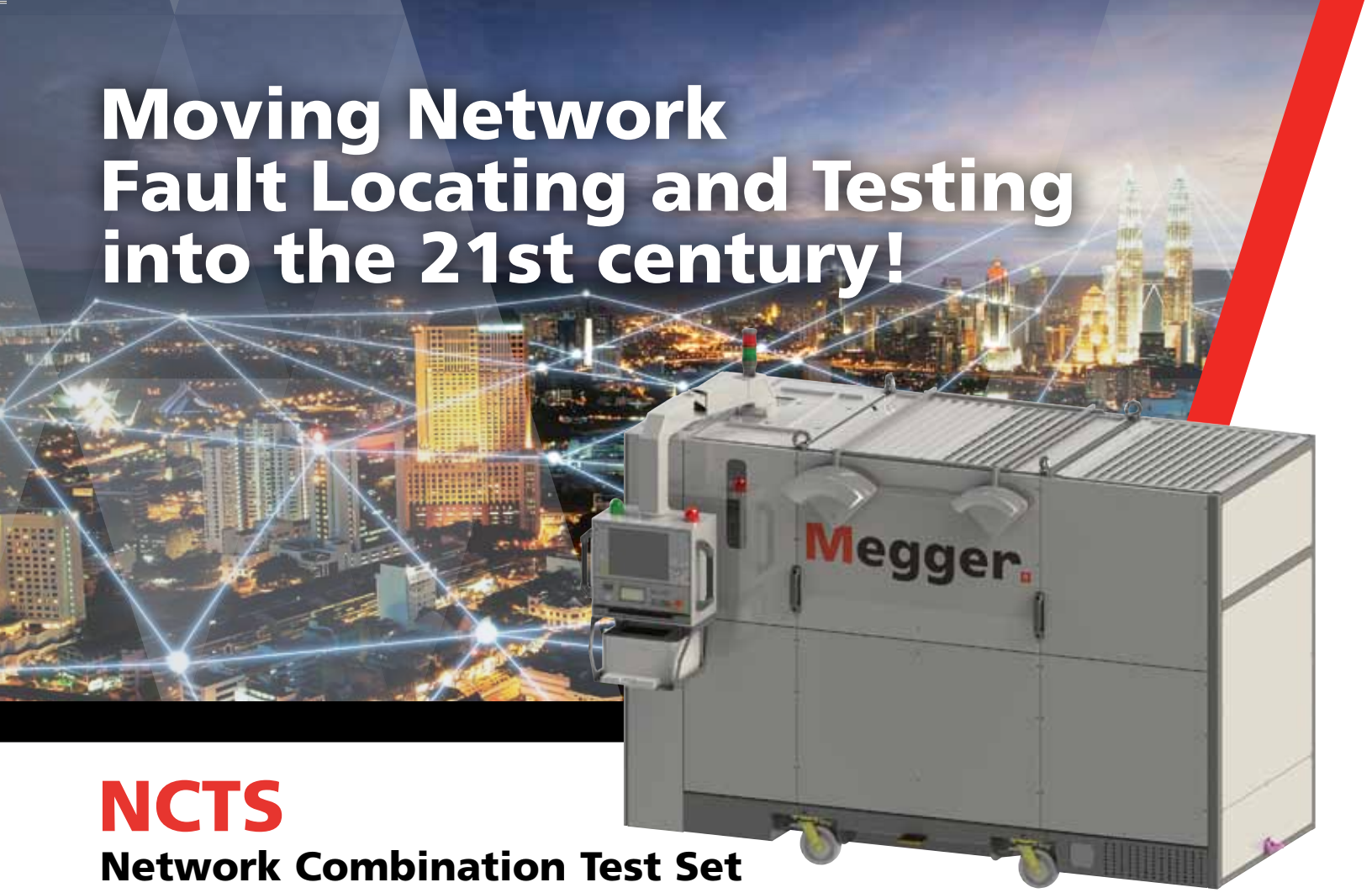
Moving Network Fault Locating and Testing into the 21st century!



NCTS

Network Combination Test Set

The NCTS is a heavy duty, fully integrated, software controlled cable fault locating and cable testing combination test set for branched downtown network applications. It comes with the most innovative, most intuitive and most convenient graphic user interface in the market. The system includes extensive safety features, e.g. visible grounding for the high voltage output, residual voltage indication in case of power loss, F-Ohm™ grounding monitoring, and many more!

- Fully automated, easiest to use navigation based on the well proven E-Tray™ philosophy with single turn&click rotary knob and step-by-step workflow mode
- Ultra high power components for second-to-none network performance:
  Thumper, Burn Transformer, Thyratron, and the most powerful VLF in the world!
  For more information and technical specifications please visit the product's landing page **us.megger.com/NCTS**
- Available configurations: Combination Test Set (fault locating + VLF), Cable Fault Locating system (no VLF), Cable Fault Locating PLUS system (with TDR based prelocation), Cable Testing system (VLF only)
- Available models: Substation installation, Vehicle installation, Container version for quick transport via land, sea, and air, e.g. offshore windfarm applications

COME VISIT US IN TUESDAY'S BREAKOUT SESSION, APRIL 10, 3:30-4:30 PM

Come see us at Booth 8 if you want to learn more about the Network Combination Test Set and other Megger/ SebaKMT solutions for your downtown network applications.

us.megger.com/NCTS

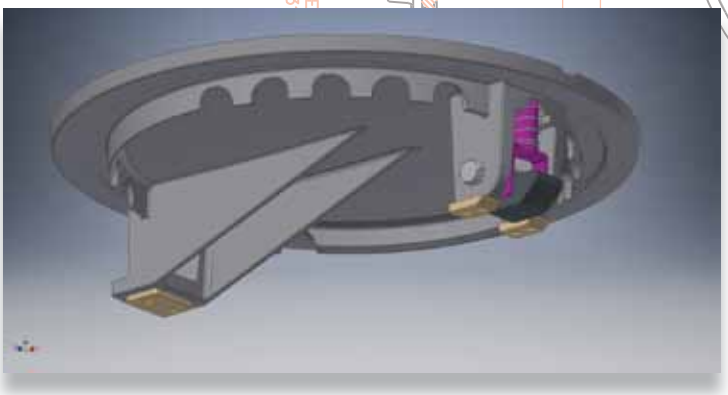
Megger

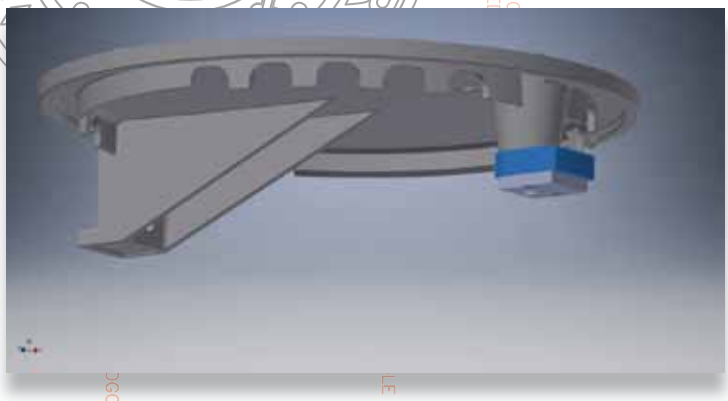
Power on

NEENAH FOUNDRY

Mitigating the Damage Caused by Underground Explosive Events

Neenah Foundry's Controlled Pressure Release Manhole Covers eliminate the inherent dangers of flying covers and add a level security to the underground infrastructure.





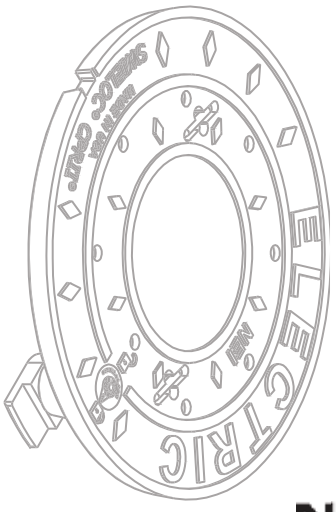
2 Latch Designs to Choose From

During an explosive event the upward travel of the CPR cover is limited to a maximum of 4" by an engineered lug and latch. With the help of specially designed exhaust ports the pressure is released 360° downward around the perimeter of the manhole opening.

With the help of several Utilities these covers have been tested extensively at EPRI in Lenox MA for over a decade.

Why the CPR cover by Neenah?

- Cover does not leave the frame during an event
- Controlled rise of cover and release of pressure
- Reduces the possibility of injury and property damage
- Successfully tested at EPRI
- Helps prevent theft and unauthorized access
- Works with many existing frames



For more information or to arrange a presentation visit us at **www.Swiveloc.com** or call us **920-252-3563**

NEENAH FOUNDRY

DNV·GL

Visit DNV GL during Eaton's 19th Annual ENSC to see how we can support your power distribution system needs for network modelling and analysis!

- DNV GL is the global leader in enterprise management of electric grid reliability and performance.
- We provide software for technical asset management, reliability, regulatory compliance, grid analysis and planning.

For more information go to www.dnvgl.com/software

Understand Secondary Networks with CYME

Powering Business Worldwide

CYME Power Engineering Software

CYME Software offers detailed distribution system modeling and has advanced analytical capabilities, which are perfect for:

- Network-wide planning using SCADA, AMI/AMR data
- What-if contingency scenarios
- Distributed Energy Resources penetration impact studies
- Protection scheme validation
- Grid efficiency optimization
- Power quality and system reliability improvement

Secondary Grid Network Analysis

Tackle the complexity of secondary grids with CYME, which offers:

- Detailed representation of secondary grid components
- Network protectors modeling, with complete relay settings and trip/close functions
- Robust power flow and short-circuit algorithms for unbalanced and meshed networks
- Single or multi-contingency scenarios study
- Load estimation through the processing of multiple measurements with the Distribution State Estimator

Come see us for a live demo at booth #1 of the Electrical Network Systems Conference 2018!

Cleer loadbreak solution improves legacy visible break technologies

Eaton's Cooper Power™ series Cleer™ loadbreak connector has proven to reduce outage time by providing reliable switching under 600 A load. This technology provides visible break and visible ground, offering a safer, efficient and reliable solution for sectionalizing, splicing and working on energized equipment.

Introducing the Cleer loadbreak bushing insert used to incorporate existing Cleer technology into any apparatus configuration. The Cleer solution has been used by utilities for many years to achieve sectionalizing points and visible break on underground electrical systems. Extending this system to apparatus such as switchgear allows electrical providers to incorporate this reliable system to improve safety, simplify apparatus designs and eliminate sources of failure.

Removing a deadbreak tee connection under load will create a dangerous arc flash condition. This necessitates the need for visible break in operational practice that is typically achieved with a loadbreak switch under glass. These switches can be difficult to see after many years of service and can fail in ways destructive to the switchgear itself.

The viewing windows prevent the option for visible break with some gas-insulated gear. The Cleer solution offers a fail-safe solution for all insulating mediums from gas-insulated to liquid-filled to solid dielectric apparatus.

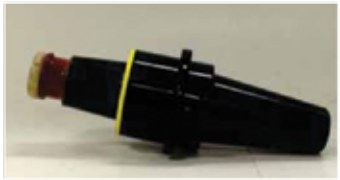
A common procedure for utilities is to install a 200 A interface on the back of a 600 A rated tee for use with ground elbows. This can cause a rating conflict though if the 200 A interface is only rated for 10 kA fault current and the switchgear is rated for more. Incorporating a Cleer solution into apparatus design provides a 600 A rated interface that is accessible without moving cables. This interface can be used with Cleer grounding elbow for achieving fault carrying ampacity of 30 kA.

Eaton's Cooper Power series Cleer visible break solution breaks the load safely and adds the benefit of fault closure protection. Should the operator attempt to energize the system into a fault, Eaton's Cooper Power series Cleer connector will control the fault current, preventing the dangerous arc flash condition. This offers a more reliable and safer visible break option to users.

- The C-shaped connector breaks the circuit in two places for twice the contact separation
- Eaton's Cooper Power series Cleer loadbreak connector incorporates field-proven POSI-BREAK™ technology that provides:
  - Increased strike distance, greatly reducing the possibility of partial vacuum flashovers
  - Added dielectric strength along the probes for superior switching performance and reliability

Eaton's Cooper Power series Cleer visible break solution is the only 600 A loadbreak technology that meets IEEE® Std 386©-2016. It is designed with many other standard features to minimize training and inherently operate similar to other loadbreak connectors.

- A yellow latch indicator is included to ensure positive connection
- Fully submersible and exceeds the applicable requirements of IEEE Std 386-2016 for use in above-ground and underground environments prone to flooding
- Cleer grounding elbow:
  - Provides visible ground on Eaton's Cooper Power series Cleer visible break solution
  - Installed directly on the 600 A loadbreak interfaces after the circuit is verified to be de-energized
  - Easy clampstick operation—lightweight C-shaped connector (only 5 lb) and no heavy cables to move



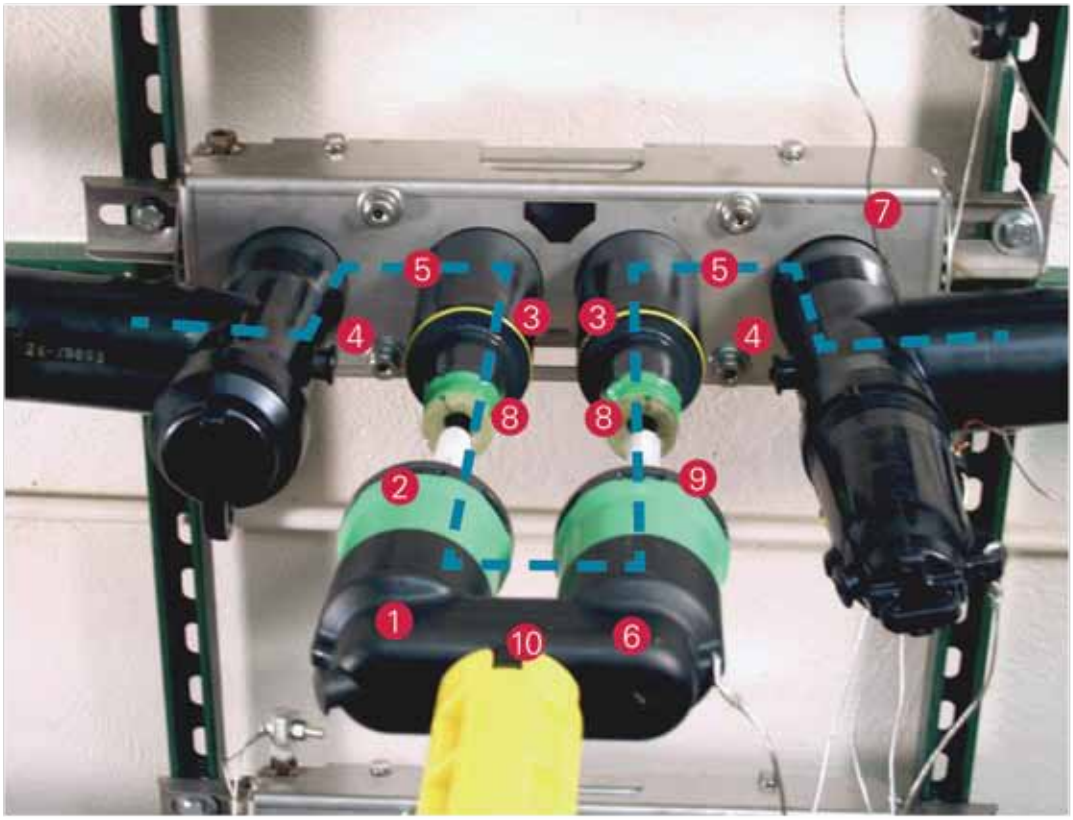
Cleer loadbreak bushing

Powering Business Worldwide

Cleer loadbreak made easy

A reliable, visual, traceable method for loadbreaking 600 A systems.

1. EPDM semi-conductive material and insulation
2. Colored cuff and nose-piece for 600 A 15 and 25/28 kV loadbreak identification
3. Loadbreak interface
4. Deadbreak interface IEEE Std 386™-2006 standard interfaces
5. Deadbreak/loadbreak junction (2) (current path indicated by dotted line)
6. POSI-BREAK™ technology inside
7. Adjustable bracket
8. 600 A loadbreak probes
9. Latch design and indication window
10. Standard operating eye



Cleer SecTER™ cabinet

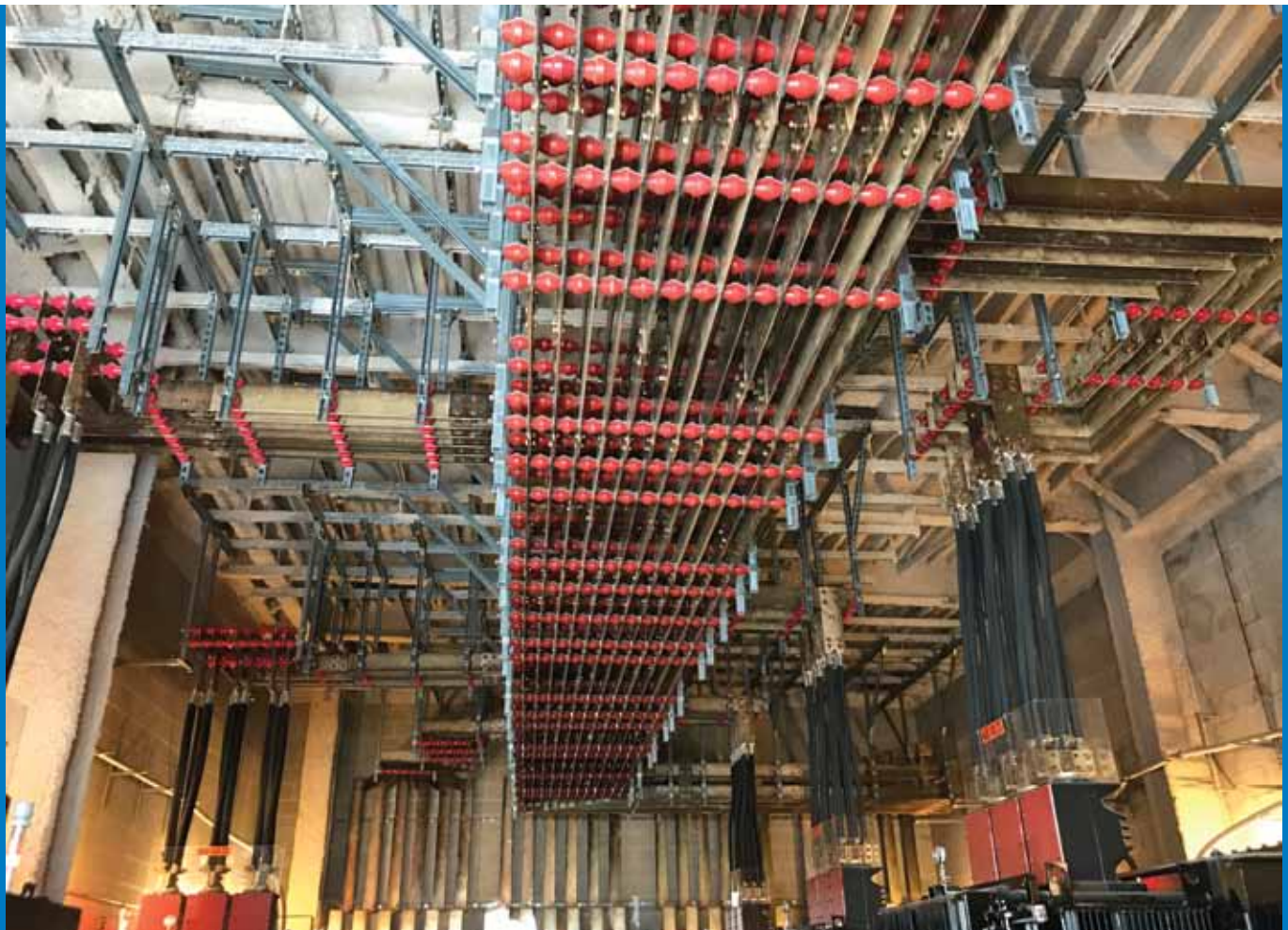
Eaton offers 600 A 15, 25, and 28 kV class Eaton's Cooper Power series Cleer SecTER™ cabinets. The cabinets are designed as cable sectionalizing centers and can be used wherever underground cable must be sectionalized or connected. Functions include:

- Sectionalizing cable
- Switching cable
- Isolating cable and feeder taps

For Eaton's Cooper Power series product information, call **1-877-277-4636** or visit: **www.CooperPower.com**

Follow us on social media to get the latest product and support information.

ENSC Magazine Recognizes CPS Energy for Engineering Excellence



Photos at Henry B. Gonzalez Convention Center