



MAGAZINE

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23rd Annual ELECTRICAL NETWORK SYSTEMS CONFERENCE

Colorado Springs, Colorado

April 15 - 18, 2024



Colorado Springs Utilities
It's how we're all connected

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The 23rd annual ENSC is upon us and in the beautiful state of Colorado! We are all thankful for all the ENSC supporters to make it one of the best conferences that you could attend. This conference has grown leaps and bounds since its inception in 2000 and we are incredibly pleased that it has educated hundreds of people in different facets of the electrical underground. This year we are super excited

that Colorado Springs agreed to host us and to top it off at a nice resort!

As many of you may be aware, Colorado Springs had a network vault fire in 2023 that started in their network secondary and then propagated to the primaries leading to a multi-day outage. Network distribution is the most reliable form of power delivery in the world and outage events in this redundant system are extremely rare but sometimes age finds a way to catch us off guard. The best solution is to always learn and adapt for the future, and we are incredibly lucky to have seasoned experience that attend this conference every year, so we all should leverage and take advantage of this by asking questions during our round table sessions or making the right connections during the conference.

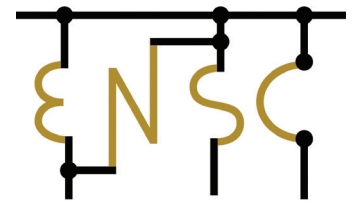
Today, the focus of the modern electrical infrastructure should be more on the predictive side which would avoid and minimize reactive responses. This is especially important for network distribution, where 90% of the time, the application of transformers, network protectors and associated cables are underground, out of sight and out of mind.

With the advent of communications monitoring equipment in the vault and the exciting emerging area of equipment diagnostics and early predictive alarms and warnings, we are in better shape now to address hidden issues than ever before. The equipment has become much safer, and the technology is continuing to improve and provide the necessary information to get ahead of any pending trouble to protect our mutual customers managing the most critical loads.

Lastly, I want to reiterate my point to thank all of you who support the ENSC by coming every year and support the conference by word of mouth and aid in getting new colleagues and suppliers involved. Together, we can expand education of underground distribution networks and take it to levels of growth and expansion this system deserves.

Respectfully,

Mark Faulkner
Product Line Manager
Eaton



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- Sean Stevens-SMUD

ENSC Magazine

Jason Nutt
Eaton
1520 Emerald Rd.
Greenwood, SC 29649
JasonNutt@Eaton.com



ENSC – The Network Solutions Magazine

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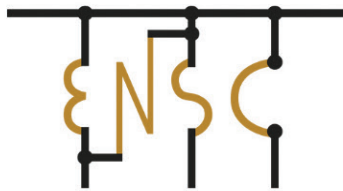
SAVE THE DATE

24th Annual Electrical Network Systems Conference
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Colorado Springs Utilities

Written by: Natalie Eckhart

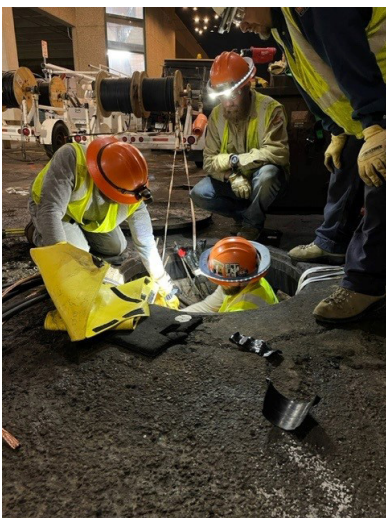


Pictured: Steve Schaarschmidt (“Schaar”), Scott Golomski, Mike Nelson, Mario Sanchez, Matt Caudle, Nito Romero, Cory Hazen, Bob Deutsch, Dylan McCain and Shaun Dillon.

Kiowa Street Underground Fire

In the early morning hours of Sept. 11, 2023, downtown Colorado Springs was shaken. Starting at 2:21 a.m., callers to 911 reported booming sounds, active flames and smoke billowing from beneath the ground a block from City Hall, adjacent to the downtown City Bus Terminal and Kiowa Parking Garage. Without question, there were memories of the Day of Terror in the United States on the same date in 2001.

Cory Hazen, Colorado Springs Utilities Crew Supervisor for the growing city's downtown electric network, was awakened by two calls back-to-back from the Distribution System Operator. They reported spiking currents and an opened breaker. At 2:34 a.m. the northern segment of the downtown network and almost half of the downtown customer load tripped offline. Something was amiss. He needed to quickly respond onsite.



9/11 Heightened Awareness

The events of Sept. 11, 2001, led to uncertainty and fear for most citizens -- especially in large metropolitan areas. Perspectives and practices changed for agencies who knew they were targets for terrorism: businesses, government agencies, military agencies, and utility providers. Although Colorado Springs wasn't considered a large city then, it had a large military presence, which was believed to make it a terrorist target. The city is home to United States Air Force Academy, Peterson Space Force Base, Cheyenne Mountain Air Force Station, Schriever Space Force Base, North American Aerospace Defense

Command and Fort Carson Army Post. Within a month of America's Day of Terror, the Department of Homeland Security was established, including a presence in Colorado Springs.

Since 2001, Colorado Springs metro area has grown by 45% to a population of about 700,000 and added even more significant military presence. The rapid growth, coupled with technological advances and the increased necessity to support military resiliency for the region and the nation, led to studies for capacity and expansion in the city's core downtown area in the early years of the 21st century. Those factors have also increased belief that the southern Colorado city is a prime target for terrorist attacks. That made fire coming from below the streets in the heart of downtown while the lights went dark in the early hours of Sept. 11, 2023 particularly surreal.



closed. City government leaders decided to close City Hall. Other area businesses and the Downtown YMCA closed for the day because of the electric outage. City Council business and meetings were relocated for two days to Colorado Springs Utilities executive offices and Board Room a few blocks away.

The priority of the incident response is a core value of Springs Utilities - the safety of the community and employees. While incidents like this are uncommon, a standard operating procedure for Springs Utilities is to partner with CSFD in annual training specific to the downtown network. This education is in addition to annual hurt man rescue training and regular safety awareness meetings where the two entities meet to cooperatively learn and share awareness on trauma and basic utilities emergency response.

The second response priority was for the downtown network team to restore power to as many customers as possible while containing the activity to as small a footprint as safely achievable.

Fortunately, the thoughts that haunted many about terrorist activity had been eliminated. An electrical short circuit was suspected to have caused the underground fire.

By the afternoon of 9/11, a few downtown network customers' power was restored. Still, citizens and visitors were encouraged to avoid the area to ensure a safe and secure worksite for utilities crews.

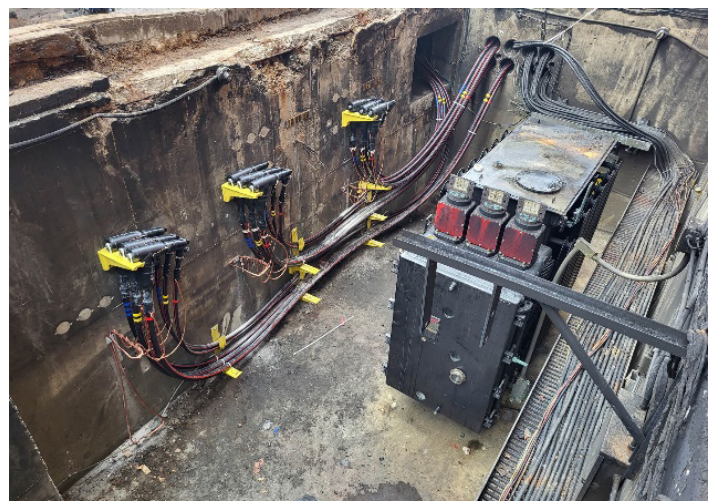
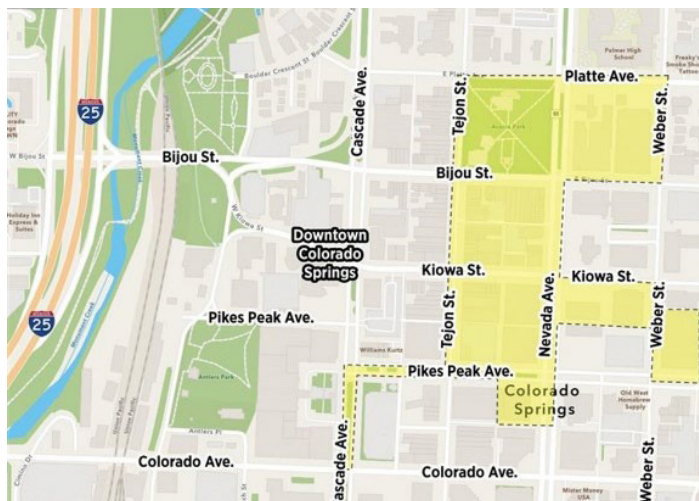
By the morning of day two, most traffic signals on the roads east and west of the incident scene were back in operation and power was restored to 150 of the 280 customers affected. The objectives for day two were to restore electric service to customers north of the incident scene and City Hall to the east. By 4 p.m., crews began energizing primary cables, which allowed for restoration to all but the 10 customers in the immediate vicinity.

Restoration work continued for two more days to install secondary cables to the buildings remaining out of power -- those in the immediate vicinity of the equipment failure. Springs Utilities' staff worked directly with the building owners and tenants to coordinate their connections, ever mindful of safety, the emotion and concern felt for the historic properties and our customers' livelihoods. All customers were back in power by 11 p.m. Sept. 14.

Response and Restoration

By 3 a.m., Cory Hazen was downtown, alongside the Colorado Springs Fire and Police Department (CSFD and CSPD) responders. After the power source was removed, the electrical fire died out and equipment slowly cooled. Hearing that fire was in a transformer vault (TV-7), local news media speculated the cause was a transformer failure near where pressure from the underground fire had lifted manhole covers and shot flames into the air. While CSFD determined this was not an intentionally set fire, it would take some deep digging to determine the root cause. As the crew supervisor continued to assess the situation, support from other members of the downtown electric infrastructure specialty team and emergency management personnel was requested.

While most customers in the immediate area were closed for business and commercial properties were empty when the fire broke out, three downtown residential properties and a few business personnel were temporarily evacuated as a safety precaution. Streets and alleys in the immediate area were closed and traffic signals were dark in much of the central business district. Metro Transit, the City's bus system was running, but their downtown station and parking garage were





Melted secondary copper wire removed from top center conduit.

Recovery and Analysis

Following 92 hours of continuous emergency response, the downtown network crew and supporting staff from across the four-service utility were able to transition out of 24/7 operations, into daytime (12 hours, seven days a week) incident recovery.

Long-term repair work began at the start of day five as the failure investigation continued. Digging for details and clues was complex, as there were multiple communication service lines and other utilities crossing and in parallel with the electric infrastructure. It was a bit of an archaeology project as some of the very first utilities pipes and wires for the 152-year-old city were uncovered.

After the tricky excavation, it was determined that a failure on a secondary cable may have been the first domino to fall in a line of events that caused fire and loss of electrical service.

Some evidence of external damage to the secondary cable, caused prior to the event, was revealed. Points of ignition were identified based on where the highest amount of heat appeared to have been sustained. At that spot, heavily darkened concrete, large quantities of melted copper, burned insulation, disintegrated conduit, and melted rebar were seen.

Key objectives of the recovery operation were:

- Ensure a safe, coordinated, and effective recovery from the downtown network outage.
- Ensure critical support continues until the system is restored to full functionality.
- Continue to assess, repair and/or restore infrastructure in the downtown electric network.
- Update infrastructure records.
- Capture lessons learned and complete after-action review.

The primary efforts to meet these objectives included repair or replacement of infrastructure in vaults, replacement of fire-damaged duct banks and restoration of system health monitoring equipment (VaultGard™). Speculation was that it would be mid-November, a full eight weeks after the fire, before these projects could be finished.

Acknowledging the inconvenience and impact the excavation and ongoing repairs would have on local businesses and the citizen-owned utility's budget, Springs Utilities' CEO Travas Deal challenged his team to look for opportunities in the face of the challenge. Money could be saved and customer impact over time could be minimized by replacing everything possible while trenches in the street and alleyways were open.

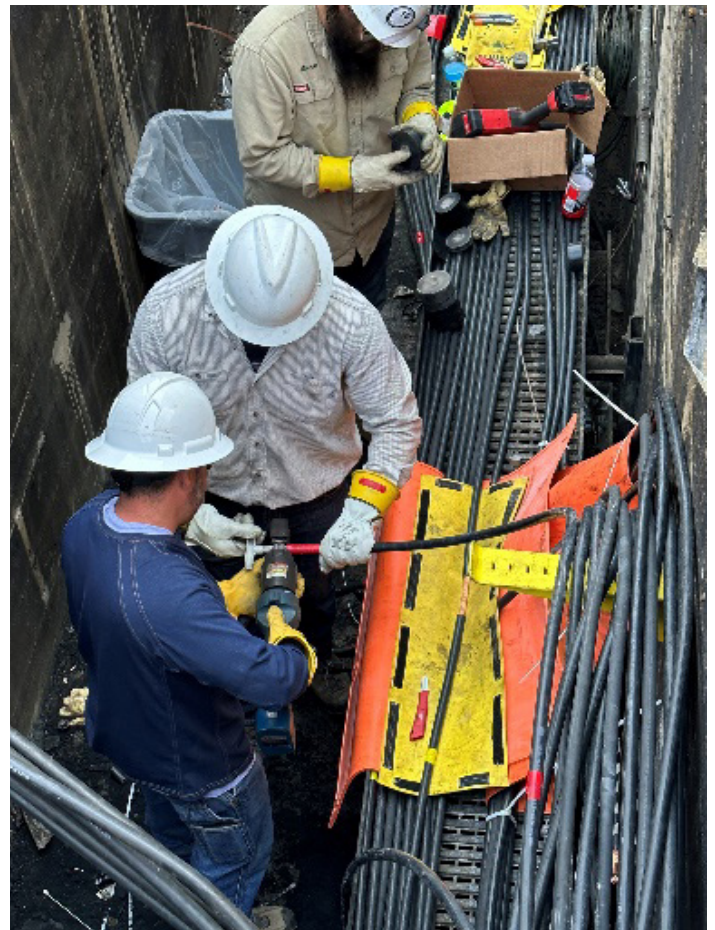
In late October, six weeks, six days and 18 hours after the early morning wake-up call, the street was completely re-opened and the downtown network was returned to its normal state with robust reliability and redundancies in place.

In addition to the extensive electric system repairs and enhancements, because they are a four-service utility, crews successfully installed new fiber optic network cables and replaced 65 feet of 1940s-era water main and several water valves.

This recovery effort could have led to additional disasters or safety incidents without extreme care of planning, diligent communication, and strong technical knowledge of the system. Other than a minor incident where an employee tripped and fell with a slight injury, the continued 24/7 operation remained incident free.

Study of the event, lessons learned and related system upgrades and changes will continue.

Scheduled Vault Tours at ENSC Thursday, April 18th, 2024



Sidebar 1 | Safety: A Powerful Justification

Wild art/Pullout suggestion- energy vision & enterprise values

Colorado Springs' Energy Vision:

Provide resilient, reliable and cost effective energy that is environmentally sustainable, reduces our carbon footprint and uses proven state-of-the art technologies to enhance our quality of life for generations to come.

Springs Utilities' Values:

Safety, People, Trust, Responsibility, Continuous Improvement & Collaboration

In a century-old, four-service municipal utility, the competition for capital budget is stiff. Safety as justification for upgrades, that will also fulfill the organization's vision, is a winning strategy for Colorado Springs Utilities.

In the early 2000's, the downtown network team set out to reduce employee exposure to the release of arc flash energy and to replace some equipment that had served the community for 50+ years.

After years of thorough research and testing, the capital expenditure request to replace all protectors in the network with Eaton's CM52 was submitted. Its dead-front design is the most advanced technology for arc flash safety. The CM52 leverages Eaton circuit breaker technology to deliver a solution that captures the benefits of robust legacy network protectors while meeting the priority objective of enhancing user and operational safety.

Leadership supported the recommendation and approved the project to replace protectors over an eight-year period. Finishing the upgrade in 2022, the downtown network at the foot of Pikes Peak, is the most modern network made and includes the Network Protector Arc Reduction Maintenance system (NPARMS) and the VaultGard™ remote monitoring and control system.

Since the completion of the upgrade, efficiency gains with switching have also been realized - as much as eight hours saved per switching event. And much work can now be done remotely, eliminating the need for entering the vault space. An additional benefit of the remote monitoring system is its ability to inform load studies, which will help continue to ensure a safe, reliable system for current and future customers.

It's expected that cost savings will also be realized over the life of the system as it uses standardized, modular components which may help reduce maintenance time, lower inventory costs, and simplify training for crews.

After the Sept. 11, 2023, incident, Springs Utilities expects its next safety upgrade investigation to explore the value of cable limiters, which can limit the magnitude of current that can flow through an individual wire. Across the industry, cable limiters are not considered a universal solution for fire prevention, however, Springs Utilities is considering a pilot of the equipment to better understand its limitations and potential safety benefits.

Sidebar 2 | Energetic connections

Supporting the community and focusing on the customer are strategic objectives for Colorado Springs

Utilities. This means that they see contributing to the growth, vitality, and quality of life in the Pikes Peak Region as integral to their operation. Springs Utilities' leadership believes that it's their duty to anticipate and exceed customer expectations.

While most downtown electric network teams are comprised of engineers and line specialists, in

Colorado Springs, a key member of the downtown network team, Vicki Schwindt

is a Customer and Enterprise Services Division employee. She's specifically tasked with strategic human connections.

It's her responsibility to be a collaborative partner with business

and residential customers. Her relationships with downtown businesses, other utility providers and government agencies, and employees across the organization helped with smart recovery efforts following the downtown electrical fire in September 2023. Because of her understanding of downtown businesses, the utility was able to:

- effectively coordinate the safe restoration of service.
- respond efficiently to the needs associated with disposal of spoiled food from downtown restaurants.
- improve business access during recovery operations.
- coordinate with telecom providers who used the opportunity to make system repairs and upgrades.

Like the technical trade personnel who had a presence on-site throughout the incident response, the strategic customer manager had support from other utilities employees. Colleagues in the customer service and public affairs departments worked collaboratively to keep the community and affected customers up-to-date with necessary information.





Sidebar 3 | Downtown's changing current

The electric infrastructure in downtown Colorado Springs carries with it essential components of the city's history. Not only is it the location of the electric generating facility that came online the first year of municipal ownership, the electric vaults are named after buildings and proprietors that are long-gone. In their places in the 21st century are new businesses with much different energy needs.

As commerce activities in Colorado Springs accelerated in 1945, the network service to the city's core was proposed. An overhead network was created in the early 1950's and in 1958 the underground conversion began. Another surge in downtown development began at the turn of the century and the efforts for capacity expansion and system improvements began in 2004.

Today, the city is experiencing yet another growth spurt. At least a half-dozen hotels and even more apartment buildings have opened in the past five years. More restaurants are added each month, especially since the COVID-19 pandemic. As the downtown team continuously seeks to provide the safest and most resilient electric service, they're considering the changing needs of the customers.

With more people living and vacationing downtown, the character of the downtown electric load has changed. The hotels in particular are much more sensitive to planned outages. The team carefully adjusts schedules for planned outages, making provision for the customers while balancing system needs. Different equipment has also proved helpful, like adding isolation devices to some downtown vaults.

Fallen Linemen Foundation

Written by: Friends of the Foundation

The story begins long before the foundation was started. Barry Jones and Kevin Dyson met in 1972 when they were four and nine years old, respectively. Their families became best friends and remain so today. As Barry and Kevin matured and settled into their careers, they found themselves in the same industry (electric utility power) and more interestingly, competitors.

In 2004, a twenty-two-year-old line worker suffered a severe electrical burn while working in a substation. This young man had a budding career and a young family with four kids under the age of four. Recognizing the financial burden this could cause the line worker's family, Barry and Kevin immediately called each other to brainstorm ideas to determine how they could help the family. Within 45 days, another injury occurred at a neighboring utility, resulting in the line worker being transported to the NC Jaycee Burn Center in Chapel Hill, NC. Barry and Kevin once again contacted each other and decided to create what is now known as the Fallen Linemen Foundation.

The mission of the Fallen Linemen Foundation is to provide financial support to electric utility linemen injured on the job, scholarships, and assistance for related organizations and institutions.

Much thought was given to the design of the foundation's logo. The shape of the logo is a diamond. The foundation chose this, as a diamond is a precious gem. The foundation considers all those who support the foundation, both financially and with gifts in kind, as precious gems and literally is what keeps the foundation in a position of giving. Embedded within the diamond, there is a mirror image of "FL." This is symbolic of the Fallen Linemen the foundation serves. Also, the logo coloring is light blue (some may refer to this as Carolina blue). This color was chosen to recognize the first dedicated burn center in NC. The NC Jaycee Burn Center at UNC Medical Center plays an important role in the recovery of not just a line worker, but all burn victims. Finally, within the logo, there is a white line that never ends. This represents the dream of the foundation's founders and board that the charity never ends beyond those who are stewards of it now.

It is important to note that as the foundation has strengthened, it has been able to make donations to each of the burn care facilities in the areas that fund raising events are held.

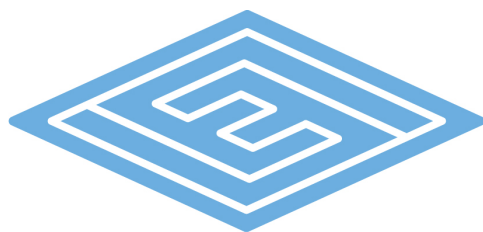
As Barry and Kevin began to brainstorm how to raise money, the idea of having an annual golf tournament was born. The foundation's first golf tournament was held in 2004 near the hometowns of the two injured line workers previously mentioned. The tournament was very well supported by competing electric utilities, consultants, contractors, vendors and friends. This day very quickly became referred to as "a common day for a common cause."

Since the initial event, the foundation has expanded its footprint into South Carolina, Virginia, Maryland, Delaware, Pennsylvania, and New Jersey. Each state has a supporting committee that organizes their event, while maintaining a consistent format with the original North Carolina tournament. It is important to note the net funds realized in each state are used only to financially assist line workers in that state.

As awareness of the foundation grows, charitable contributions are received from other areas of the country.

In 2014, the board voted to establish a scholarship program to benefit children of line workers to recognize the foundation's 10-year anniversary. Currently, this program is active only in North Carolina and is funded solely through the generosity of ElectricCities/NCAMES. The program consists of five \$2,000 scholarships awarded annually to qualifying children of active line workers. Since its inception, the foundation has awarded scholarships totaling \$71,350. The foundation is actively seeking to secure annual renewable donation sources in all fundraising areas, so the program can be expanded to allow the foundation to contribute to more children achieving a higher level of education.

To keep the decisions of award in a non-bias space, the foundation appointed a chairperson unrelated to the electric power world to review all applications. This ensures the selection of recipients are not swayed by any preexisting relationships.



FALLEN LINEMEN
F O U N D A T I O N

Applications can be found on the foundation's website
www.fallenlinemenfoundation.com.

Staying true to the foundation's mission statement, \$191,000 has been donated to line workers and their families. In addition, donations made to the designated burn care facilities total \$106,000. To date the foundation has made donations to families, care facilities and children of active line workers, by way of the scholarship program, in the amount of \$368,350.

There are many "feel good" moments the founding members and board have experienced over the years. For example, in 2016, the foundation awarded a scholarship to a young lady accepted into East Carolina University. Upon award, the foundation learned the recipient was the daughter of one of the line workers assisted in the first year of the foundation's existence.

Additionally, at an industry related show regularly attended by the foundation, the show organizers, coordinated with the Golden Knights parachuting team out of Fort Liberty (formerly named Fort Bragg), to kick off the Linemen Rodeo to honor the United States, the state of North Carolina and the Fallen Linemen Foundation. The respective flags were delivered to the ground by the outstanding Golden Knights parachuting team. To have the Fallen Linemen Foundation flag delivered in this way and in the company of the United States and North Carolina flags was an honor that will rest in the hearts of the foundation members forever. The foundation appreciates the Golden Knights jumpers and all the men and women serving the United States protecting the freedom all Americans are privileged to experience.

Barry and Kevin deem themselves to simply be stewards of the foundation and dream it never ends. The foundation would not have been able to provide the support it has and hopefully what is to come without the generosity and trust of those who have, without condition, given to the foundation with their money and gifts in kind. It goes without saying, the humbleness Barry and Kevin feel is immeasurable.

It is also important to note, there are many beyond Barry and Kevin that have given endless hours of their time to help a couple of good ol' boys pull this off!! To them Barry and Kevin give their heartfelt thanks. They know who they are!!

The future of the foundation is bottomless. This story line is not yet complete, and surely there is more to come!!

Should others wish to support the foundation, please visit www.fallenlinemenfoundation.com. The Fallen Linemen Foundation maintains a 501-3C status.

The Primary Network Switch Evolving Location

Written by: Larry Dix

One thing about this industry - nothing seems to move fast. It is more of an evolution. It is often like kicking back and watching the grass grow. In the secondary network transformer section of the industry, things do not look too much different than they were 60, 80, or 100 years ago.

Figure 1 shows a picture of a network transformer. Note the primary network switch compartment - a two chamber area which included a High Voltage terminal chamber and a High Voltage Switch chamber. Very similar to most of the units today and reflecting the early specifications even through almost 70 years of evolution. Figure 2 shows the C57.12.40 - 1982 ANSI standard page identifying the switch chamber and its key features.

When the standard was written, the features of the switch compartment were important enough to be identified and defined in relative detail. Notice the 1982 standard illustrations and the 1950s picture.

Primary network switches have been around since the early days of underground secondary networks. There are basically two types, a three-position and a two-position switch. The two-position switch is primarily used at Con Ed in New York.

Figure 1 - Network Transformer Before 1950

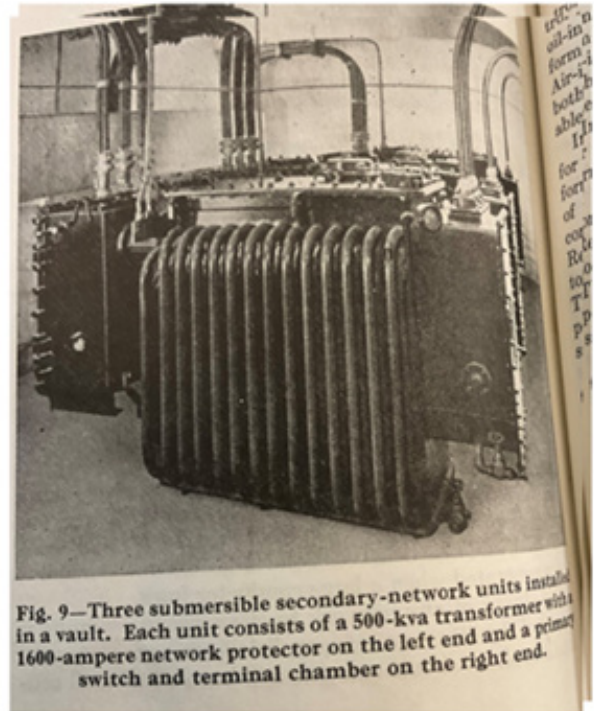
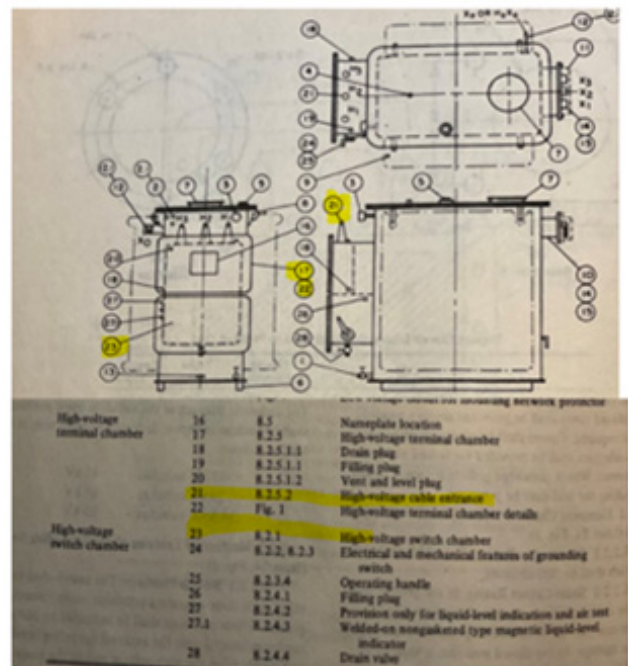
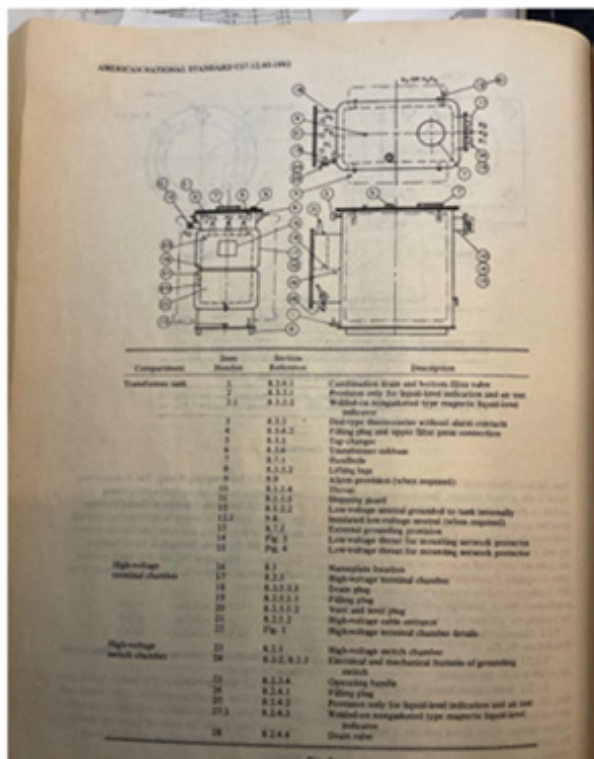


Fig. 9—Three submersible secondary-network units installed in a vault. Each unit consists of a 500-kva transformer with a 1600-ampere network protector on the left end and a primary switch and terminal chamber on the right end.

From Westinghouse Transmission and Distribution 1950

Figure 2 - American National Standard C57.12.40-1982



In 1966 the RTE corporation (now part of Eaton) received a patent on an electrical connector, the "Safe Break Terminator". It was what eventually became known as the loadbreak elbow design and would change the underground distribution system method of connecting to transformers in general. Over time, this elbow connector migrated into applications beyond the original intent of padmounted distribution transformers including Network Transformers.

As this design moved into the arena of Network Transformers, the potheads and wiping sleeves evolved into the elbow termination, though not always loadbreak. In ANSI C57.12.40-2000 it was recognized that connection to the transformer could be made by elbows requiring "... adapters or separable insulated connectors, or both." This put the High-Voltage terminal chamber (the upper chamber) on a path of evolutionary elimination of an unnecessary and space hogging cube.

In a large number of vaults, space is at a premium. It began to occur to people that if this space was not needed, maybe they could eliminate it. Several utilities began to ask manufacturers to eliminate the upper chamber. At first, this space was just filled with oil. Some transformer OEMs began to shrink this space. However, it took until 2017 for the IEEE standard to recognize it as part of the standards. IEEE C57.12.40-2017 (formerly the ANSI standard) showed the transformer with only a single chamber housing the Primary Switch. The High Voltage Terminal Chamber was removed.



Figure 3 - Elbow Connector from Eaton's website

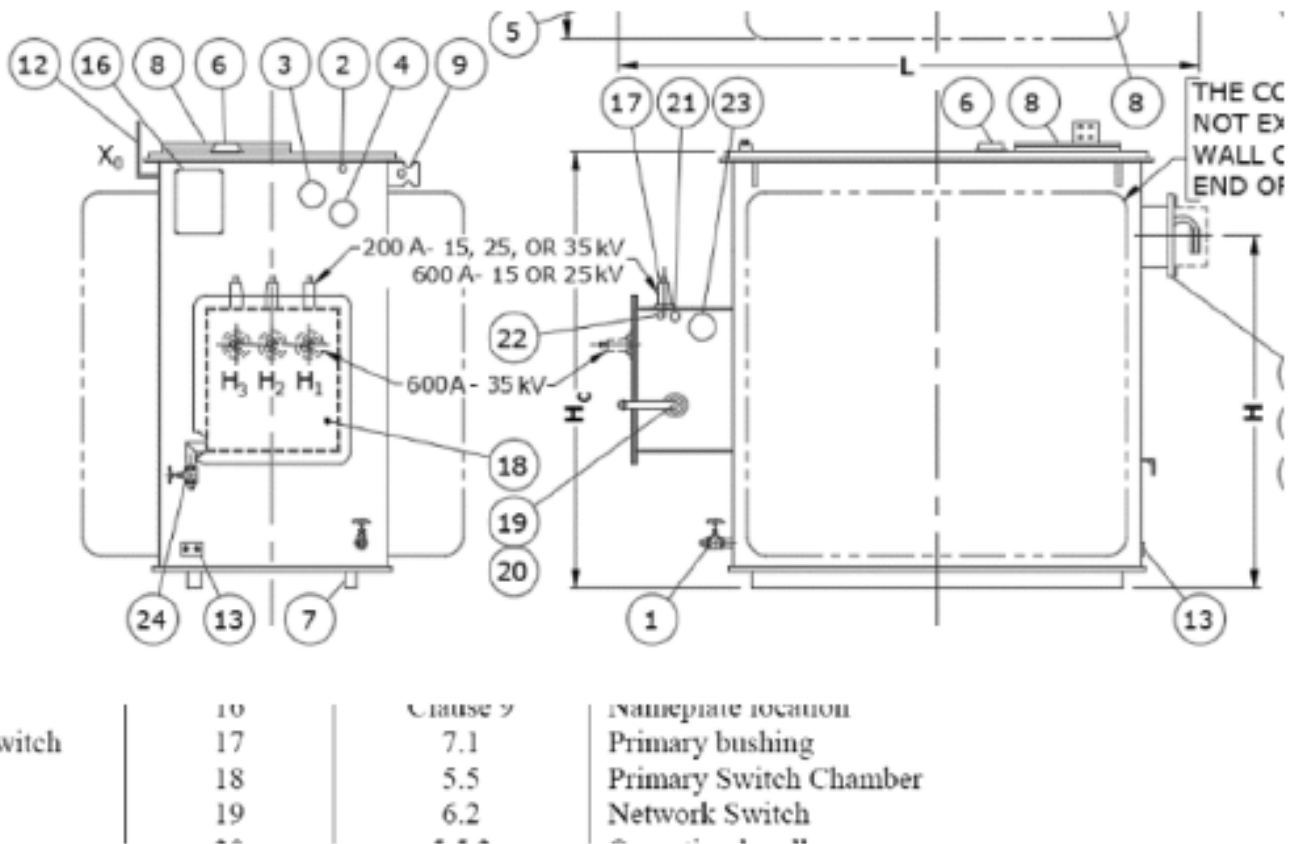


Figure 4 - C57.12.40-2017 recognizing single primary chamber

*Figure 5 - Typical Primary Termination Chamber
And Primary Switch Chamber Prior to Elbow Terminations*

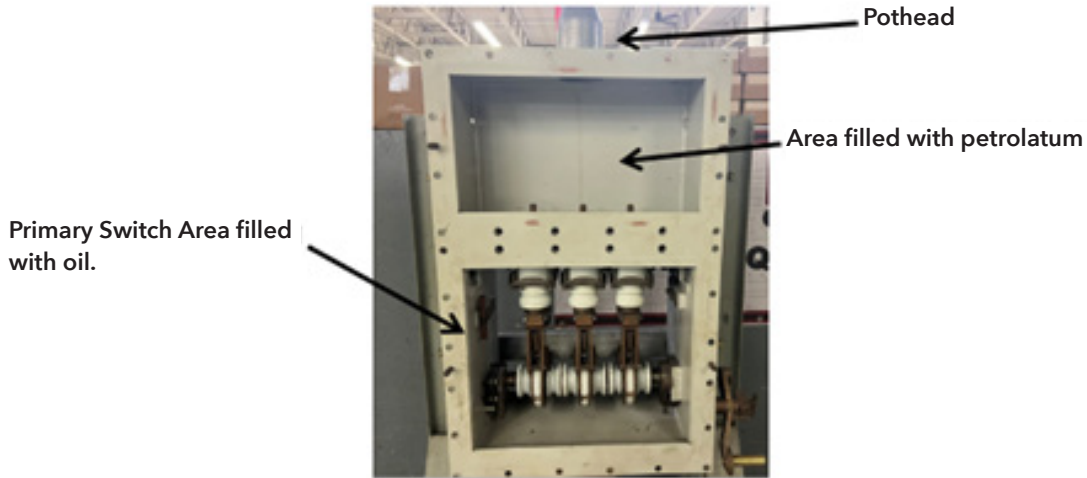


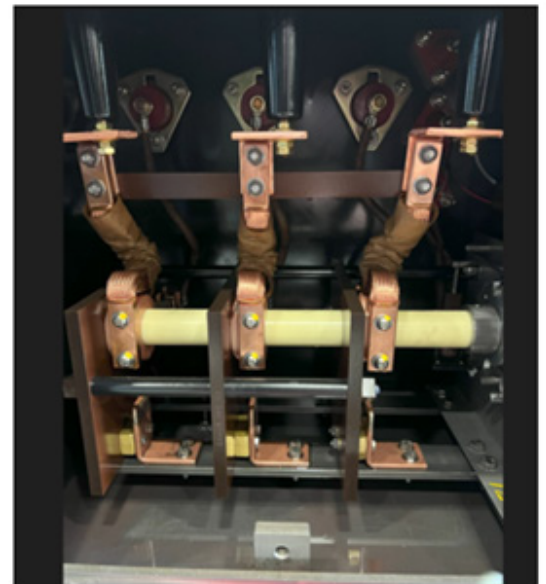
Figure 6 - Single Chamber Designs

Early combining Primary Termination Chamber and Primary Switch Chamber into one oil filled chamber.

True Single Chamber Design



No space savings



Saved Space and Busings

The primary termination chamber was essentially non-oil filled originally. Potting jelly was used in there but oil was reserved for the transformer and the primary network switch. So now we have an oil filled chamber with a switch in it and an oil filled chamber with a transformer in it. And space is usually at a premium in an underground vault. So the next step is to put the switch into the same compartment as the transformer. In theory, one can position the switch in a space that is not filled with active material and the active material (core and coil) could be expanded into the space now blocked by the primary

Figure 7 - Primary Switch in main tank - no external switch chamber

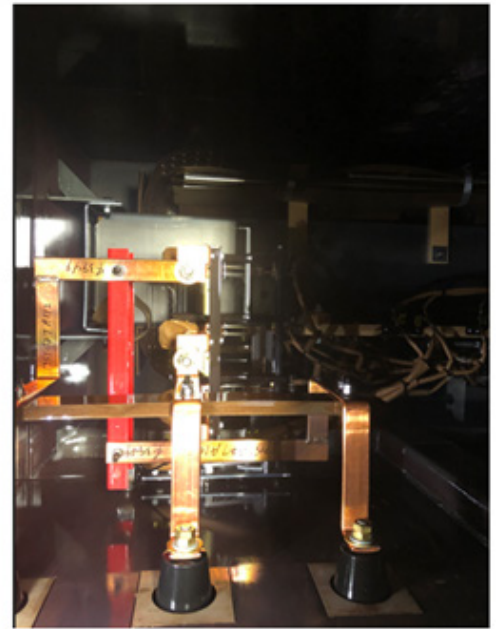
Handle on End



Handle on Side



View inside tank



switch chamber. More KVA in the same footprint. Some utilities have already started this evolutionary process. The OEMs have started modifying designs to do this. There are advantages for all involved. Many utilities will not try it until it is accepted and documented into the C57.12.40 standard. Evolution.

But it gets interesting. Remember I mentioned the 1982 ANSI standard earlier? Couple that with the fact that Con-Ed had used a two position switch in their units. In the 1982 standard there was a separate part of the standard called "Part II: Transformers with Two-Position Grounding Switch". This was in the standard for Con-Ed. However, there was a period of time that Con-Ed was not actively involved in the standard writing process and the folks involved felt somewhat unqualified to verify the parts of the standard without involvement of the Con-Ed folks. The result? That part of the standard disappeared and is not found in C57.12.40-2000 and subsequent standards. Essentially the present standard states that the Network Transformer with a switch must have a separate compartment. Con-Ed still uses the switch in the tank. Some utilities have started putting the switch into the tank. I believe it is where we are headed and designs will be adapted and improved to better fit the switch into the tank. However, until that is in the standards, it will be a while before all utilities accept it as a standard practice.

Evolution, in this case, is going back in time but it will take a while.

1968 Blast From the Past

Large Denver Shopping Center Uses Spot Networks and Pad-Mounted Transformers

Written by: H. J. Miller, Jr.
Public Service Co. of Colorado

The largest shopping center on the electrical system of the Public Service Co. of Colorado (PSCo) has been completed at Englewood, Colo., a suburb on the south edge of Denver. The big complex, known as the New Englewood Shopping Center, has some 1,200,000 sq ft of retail selling area, plus enclosed malls, and draws an estimated electrical load of 900 kw.

To provide a quality of service comparable to that of the downtown Denver network area, it was decided to feed the center with thirteen two-feeder spot networks, eight at 120/208 v and five at 265/460 v.

The spot networks are fed from two separate 13-kv overhead feeders from Englewood Substation. Each feeder originates from different 115/13-kv transformers fed from different 115-kv transmission lines. One feeder dips underground into the center on the east side and the other on the west. Each terminal pole has lightning arresters, a 600-amp load-break switch and a mechanically interlocked grounding switch for grounding one shopping center feed while working on it. Before closing the grounding switch, voltage tests will be made to insure that all of the network protectors on that feed are open and the cables are de-energized.

Each spot network is made up to two pad-mounted network transformers with primary fuses, special network protectors and network balancing transformers. A cable tap box ties the secondaries to bus duct feeding the load, without secondary ties between spot networks. Essentially there is duplicate electrical facilities to the secondary load busses.

Because of the load characteristics and electrical parameters of the two supply feeders and their sources, a vector voltage difference of as much as 12% between the primaries of the two transformers of a spot network is expected under ordinary conditions. This vector voltage difference tends to force power and var's from one feeder to the other in the form of a circulating current through the secondary. The result can be heavy load unbalances between two transformers of a spot network or tripping of a protector during light shopping center loads. By offering a high impedance to circulating current and negligible impedance to load currents, balancing transformers will prevent these undesirable efforts for all but extreme cases. Any feeder voltage difference that is too great for the balancing to handle will trip one protector of a pair.

Is applying network balancing transformers to spot networks fed from overhead feeders with widely varying characteristics, PSCo is relying on some 10 years of successful operating experience with two trial installations at Stapleton International Airport. Balancers have been redesigned by the manufactures to take advantage of modern core steels and preliminary tests at a new installation at the North Valley Shopping Center, Denver, indicate that they are operating well within expectations.

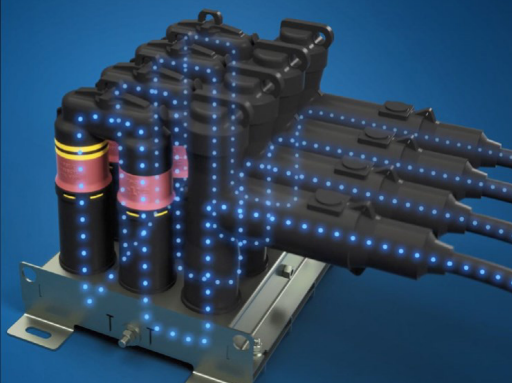
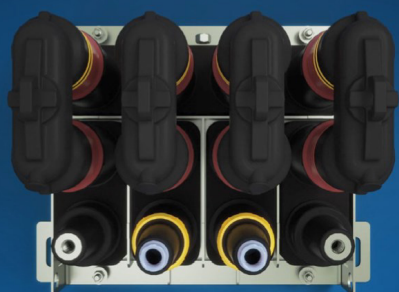
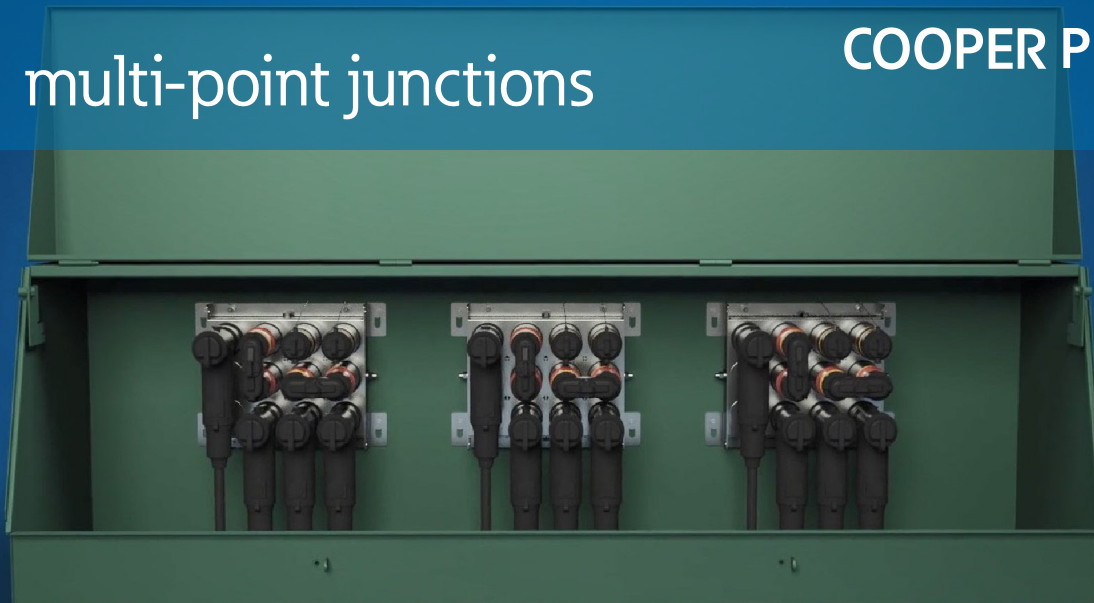
The installation was completed last fall, while the New Englewood Shopping Center opened in March of 1968.



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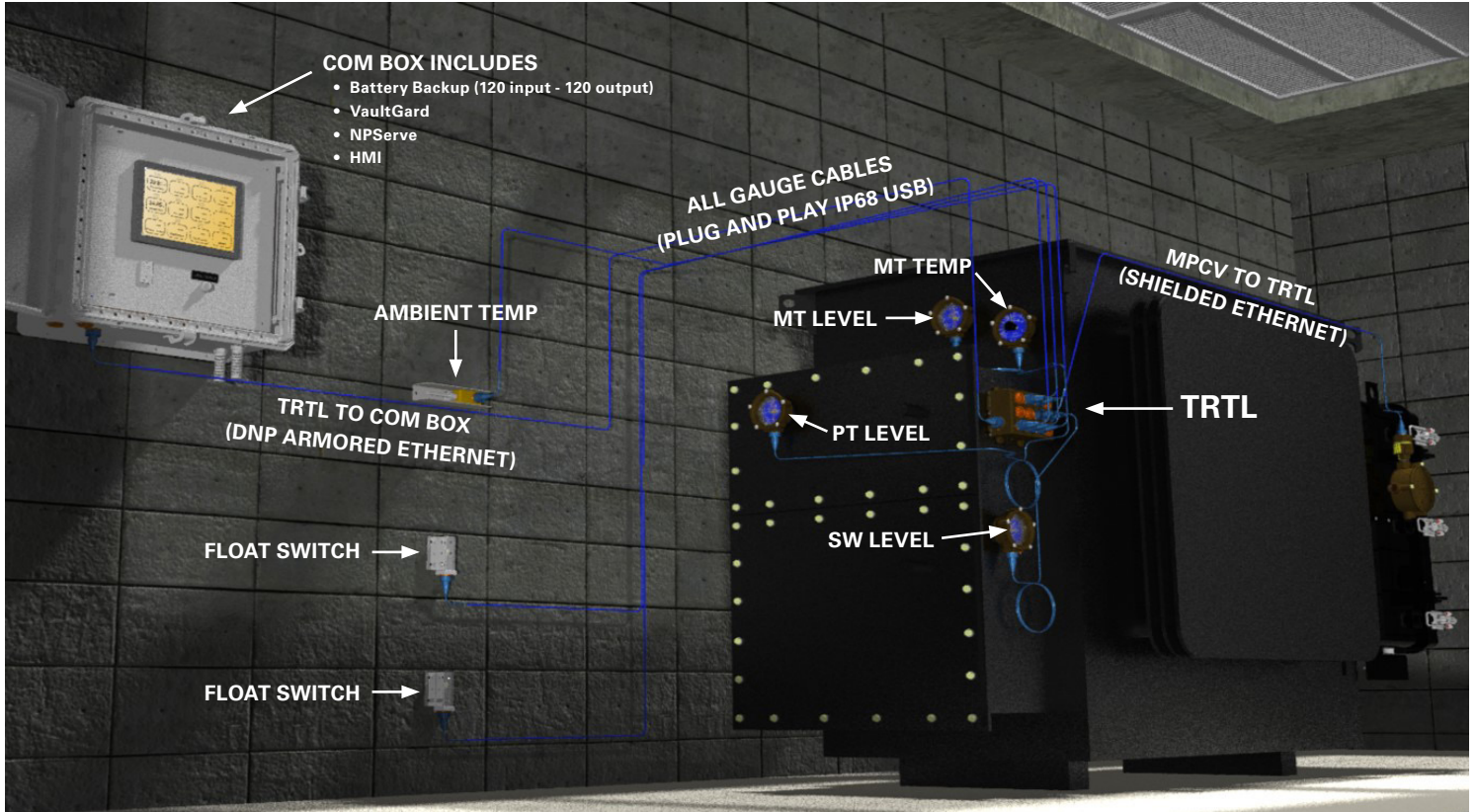


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