ENSC MAGAZINE

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# 22nd Annual ELECTRICAL NETWORK SYSTEMS CONFERENCE

## Birmingham, Alabama

April 24th - 27th, 2023


Alabama Power

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Finally, I'm pleased to say at the time of this writing, we are out of the COVID cycle, although nothing is for certain, but we are much better prepared to deal with a similar event if another one would occur in the future, and we hope that this does not repeat.

COVID not only disrupted our everyday lives but really caused a wave of downstream effects in every sector. The ENSC for instance is now finally back on the normal April cycle. With Houston being cancelled in 2020 and Alabama cancelled the following year, we were very concerned with getting back to normalcy. This hotel contract shuffling caused a short turn from the Houston October 2022 conference to the current one. However, despite everything, the ENSC 2022 was very successful, and many thanks goes out to CenterPoint for pulling it together. It turns out that the Houston ENSC in 2022 won the all-time attendance record in our historical run of 19 years!

We are pleased to say that in those 19 years the locations were hosted by all different utilities. This location and site diversity allowed the conference members to benchmark the many ways of doing things as it pertains to underground secondary networks. The vault tours are really the lynchpin of the conference, and we thank all the utilities for the hard work and preparation for those events.

A big thanks to Southern Company for hosting us in Birmingham this year! The effort required by all parties is not a small task by any means especially given the short time frame to pull the event together. I'm pleased to announce the upcoming 2024 ENSC that will be hosted by Colorado Springs in Colorado! This one you need to really mark your calendars for, we have contracted with a very special place, the Cheyenne Mountain Resort. This resort is spectacular with wonderful mountain views and its own private golf course! So, bring your clubs and your families as this location is sprawling with multiple tennis courts, pools, and its own private beach area. This conference will be the one where Eaton will unveil some new exciting new products, from a new MPCV relay to a new high amperage Network Protector!

I look forward to seeing all of you at this one!

Respectfully,

Mark Faulkner
*Product Line Manager*
*Eaton*

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**ENSC Magazine**

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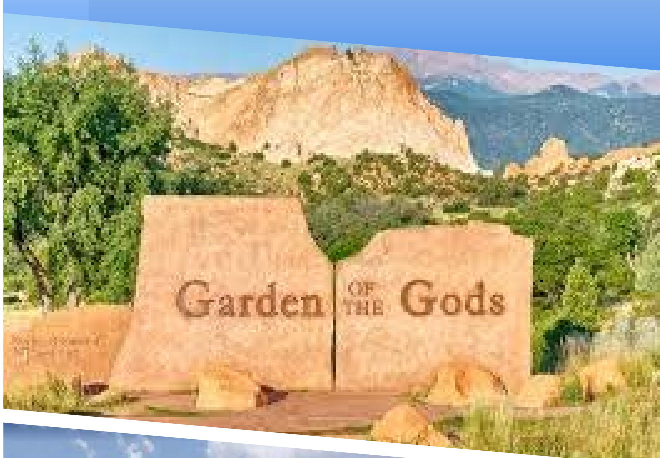
**APRIL 15TH - 18TH, 2024**

**COLORADO SPRINGS, CO**





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*It's how we're all connected*

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# DGA Sensors

Alabama Power


Alabama Power has a long-term financial goal to spend capital money to save on future O&M expenses. One area of large O&M expense for Network UG is associated with Dissolved Gas Analysis (DGA) of network transformers. Network transformers are on a 4-year inspection cycle and the labor to pull oil samples on every network transformer is significant O&M expense. As a result, we have decided to install single gas continuous DGA Monitors on our network transformers. The goal is to only pull an oil sample to be sent off for lab testing, if the online continuous Hydrogen DGA monitor indicates and issue with a transformer.

# Total PILC Cable Replacement Project at Alabama Power Completed in 2022

Alabama Power

In 2017 Alabama Power had 155 miles of 50 year-old PILC cable as part of the network system utilizing 430 network protectors and transformers serving 1,850 commercial customers in the cites of Birmingham, Montgomery and Mobile. All new load additions were being served by EPR cable and any PILC cable failures were replaced with EPR cable. Maintaining lead cable training for the legacy cable was difficult since there were no new installations. Some manufacturers were considering dropping PILC products for purchase. The decision by management moving forward was to cease the lead cable training program and initiate a replacement project over several years.

By December 2022, all 155 miles of PILC cable has been replaced with new 350kCM CU EPR LACT shield 15kV or 25kV cable and 500kCM CU EPR LACT shield 15kV cable. Taps to network transformers were made with H-Bodies to #1/0 CU XLPE 15kV or 25kV cable. Network transformers PILC connections were modified to 600A apparatus bushings to accept 600A T-Bodies. The project involved 82 feeders served by 12 network substations. Also, all secondary lead cables were replaced with 3-500kCM & 1#4/0 600V EPR Low Smoke-Low Halogen secondary cable with insulated bus. The work was performed over a five year period by existing APC network crews plus 52 contract duct bank personnel (several new duct bank routes utilized) and 82 contract network cable splicers.

With the project complete, Alabama Power has the most up to date network system that will provide reliable service and allow safe practices to maintain the system for years to come.

# Network UG Feeder Ties Automatic Transfer

Alabama Power

In order to create a more robust and reliable network underground system, Alabama Power installed express feeder ties between each of its dedicated network substation feeders. Each of these feeder ties has a S&C Vista installed at each substation with SCADA control. In the event of a power transformer failure, for example, all load from any given feeder can be transferred via SCADA to an adjacent substation. Starting in 2013, 27 feeder ties and 54 Vistas were installed among the three networks in Birmingham, Mobile and Montgomery. The cable from Way 1 connects to the substation bus. The cable from Way 2 feeds the network. The cable from Way 3 connects to an adjacent substation. One of the Way 3 switches is Normal Open.

A project is underway with SEL to add logic to these automation controllers that will allow the load to transfer automatically given a loss of potential at either substation. Load will be transferred without operator intervention, but the operator will be able to see via SCADA that the transfer has occurred. Communication between the two controllers will be mirrored bits over fiber. This logic is being deployed at two substations in Montgomery with plans to expand to Birmingham and Mobile.

# Distribution Fiber in the Network Underground

Alabama Power

In 2018, Alabama Power began installing fiber in Network Underground. Fiber is installed in a 6-way innerduct through a spare conduit in the duct bank system. This innerduct provides space for future fiber installation without compromising any additional conduits. Handholes are installed throughout the fiber route to hold storage loops and splice cases. This prevents overcrowding in the manhole for cable splicers and allows telecom electricians to access splices without assistance from network crews.

The company's core need for fiber on the Network system is to improve SCADA communication. Currently LTE is being used, however, there are drawbacks to its use such as limited bandwidth and possible signal interference due to vault locations. Fiber is a faster, more reliable connection and has a greater bandwidth which allows room for more equipment to be connected. These advancement opportunities can assist in improving preventative maintenance and the safety of our employees. With the installation of fiber underway, LTE will stay on the system but will be utilized as a backup connection.

Additional fiber capacity is being installed with a purpose of utilizing those excess strands for new opportunities such as fiber leases and partnerships. By having existing fiber infrastructure in place, customers can use our fiber for connectivity solutions.

# Gas-Insulated Switchgear

Alabama Power

Gas Insulated Switchgear is a compact metal encapsulated switchgear consisting of high voltage components such as breakers & disconnects, which can be safely operated in confined spaces. GIS is compact, up to 75 percent smaller than traditional switchgear., making it ideal for limited space sites and urban areas.

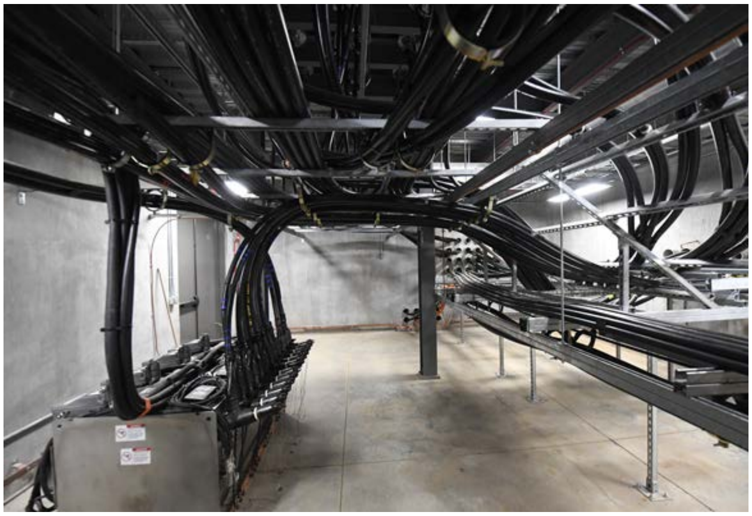
GIS contrary to the traditional Metal Clad Switchgear doesn't requires the racking in and out of breakers/grounding devices to take a clearance and ground. Significantly reducing the required personal protective equipment (PPE) that is typically needed to perform switching on the later.

With GIS, each phase is encapsulated and SF6 is used as an insulator. This single-phase design eliminates phase-to-phase faults within the switchgear. All the switching can be done from the front panels by using an operating handle, computer, and a camera.

Another feature of the GIS switchgear is that it has both mechanical and electrical interlocks.  These interlocks help to prevent the switching errors and improper sequence (mis-operation) of switches.  Meaning there is a specific order that must be followed to operate a switch.

The maintenance schedule of the GIS is minimal because all the live parts are enclosed in SF6 which protected from the environment such as animals, dust, moisture etc. Because of the GIS design, a fire suppression system is not needed like metal clad switchgear.

Reliability & dependability continue to be a focus in our footprint. As we continue to modernize and network our infrastructure, GIS has been one of the technologies used to accomplish those goals.

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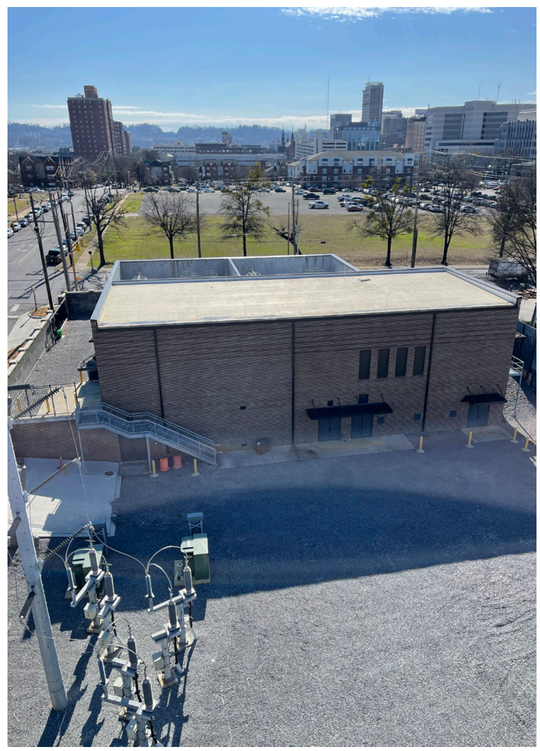


# Network Training Facility

Alabama Power

At Alabama Power we believe hands-on knowledge and practice is the best training and the key to safe work. We have training switchgear and equipment set up as in the field. With our G.I.S. (Gas Insulated Switchgear) we are able to train on switching scenarios just as in the field. We also have other switching equipment set up in our high bay and in our OJT training field. We also train on the cold shrink and heat shrink splices and terminations that we use.

We have a spot network set up in our training building. This makes training on network equipment possible. Tasks like taking oil samples on the transformers takes on a real world feel. We can also train on switching and troubleshooting equipment including transformer switches and network protectors. We can practice energized secondary work and troubleshooting as well.


FOR 277V INPUT WIRE #1
MUST BE ON TAP A
FOR 125V INPUT WIRE #1
MUST BE ON TAP B
ETI

# High Side Fault Interrupters for Network Transformers at Alabama Power

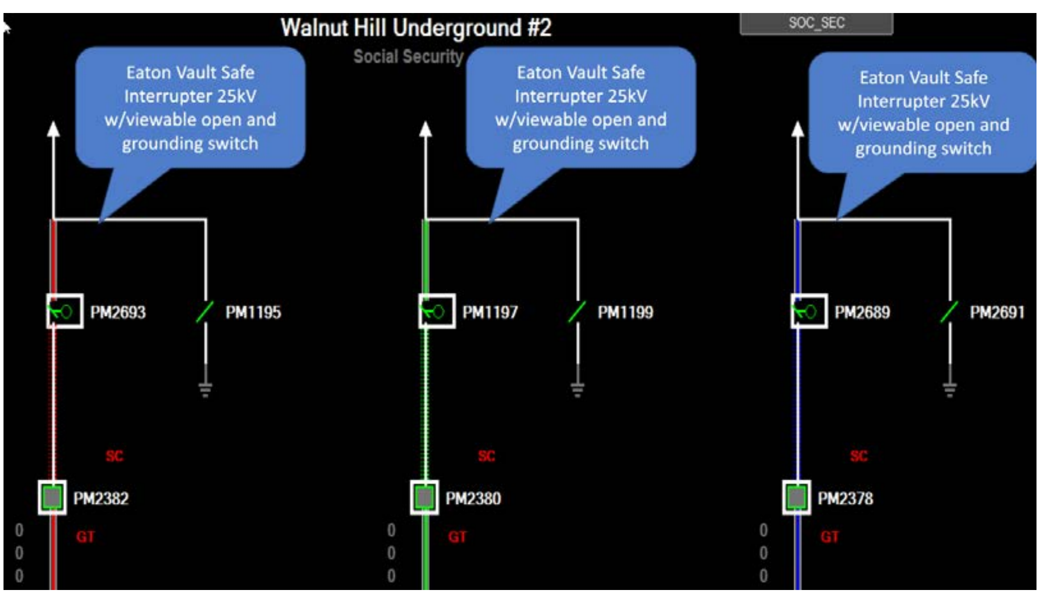
Alabama Power

For a three-spot network vault, the three network transformers are fed by three different feeders to maintain reliability and uninterrupted network service. Transformer maintenance or replacements can be performed by de-energizing one feeder while still maintaining the customer's service. However, this will also de-energize one transformer in all other connected three-spot vaults serving other customers from the same feeder. Reliability is reduced and there may be a need to notify the other customers.

To improve reliability and improve operational efficiency, Alabama Power is adding a high-side switch (fault interrupter) that can be opened to de-energize only one of the three-spot vault network transformers while the feeder remains energized from the substation. The network protector for that transformer will automatically open, isolating the transformer. In addition, each high-side switch has been added to ADMS so control center operators can operate and verify status of each switch. Below is an example of the Eaton 600A 25kV VSI (vault safety interrupter). An example SCADA display is shown providing status information and access to operate (open or close) the switch from the control center. For maintenance work on the transformer, the transformer load can be dropped energized with the 600A interrupter and the feeder cables isolated with the viewable contacts. This allows work to be performed at the transformer location with the feeder energized. If there is a need to de-energize the feeder and perform feeder work, the de-energized feeder cables can be grounded on the source side of the interrupter using the grounding switch.

Alabama Power is participating in a pilot evaluation of the Eaton Vault Safe Interrupter (VSI) as a high side Network transformer switch. The Eaton VSI is a submersible, non-gas, non-oil filled device. So no issues wih reporting SF6 or other

maintenance issues. Alabama Power has installations in place communicating to the SCADA system allowing monitoring and control points. Transfomer loading can be monitored and the switch can be controlled via the included electronic relay communicating DNP3 to the SCADA front end. The transformer load can be dropped energized remotely via the SCADA controlled Eaton VSI before crew personnel enter the vault. So work can be efficiently and safely completed.

# Transformer Gauge Monitoring

Alabama Power

Another area of potential O&M savings is transformer gauge monitoring. We already have SCADA communication to the network protectors. We have added Smart gauges for temperature, pressure, and liquid level. With these sensors on SCADA, we now have continuous monitoring of everything that used to require a manual trip to the site to check. In addition to the added safety for employees and public, this will result in additional O&M savings as well.


MAX
25°C
MIN
80
120
160
Liquid
Temperature


MAX
25°C
MIN

# Paper Insulated Lead Covered (PILC) Replacement Cable

Marmon Utility

Most large North American urban centers still contain some form of paper insulated, lead covered (PILC) cables in their underground network power system. The introduction of these types of cables goes back to the early 1900s, making some of the first cables installed over 90 years old. The EPA has been encouraging utilities to get PILC cable out of the ground as soon as possible.

There are many problems to face when deciding to remove PILC type cables. Often the original ducts have shifted, or been crushed or misaligned, and the cable is jammed inside. The cable may have bends within the ducting, which will not easily straighten out when pulled. Most often, the PILC cable diameter is such that even with removal from the duct, many replacement cables are too large to be installed in the old duct. This is because most of the PILC cable is compact, three-conductor sectored cable where a three-conductor round cable, even of the same size, is larger in diameter.

However, because of the high cost of duct replacement in urban areas and the disruption to everyday life, most utilities try to use an existing duct in good condition after removal of the PILC cable. In order to get the maximum-current cable in the minimum diameter, custom cable designs are required.

### Preparing for PILC upgrades

PILC cables have performed well over the years, but as these systems approach the end of their design life, utilities have to prepare for the inevitable concerns regarding the oils used to impregnate the papers, the difficult, labor-intensive lead wipe process, and related toxicity issues.

Because PILC cables represent some of the oldest cable installations and sectored conductor designs, they cannot always be replaced by today's standard designs. In order to get replacement cable in the existing ducts, it is frequently necessary that cable cross-sectional dimensions be reduced.

Kerite's PILC replacement product is specifically designed with reduced diameters in mind for compatibility with the 3, 3.5, 4 and 5-inch duct systems installed in the early 1900s. Because of Kerite's Permashield stress control layer - in conjunction with Kerite EP discharge-resistant insulation - we are able to reduce insulation thickness and still maintain cable performance. This system was introduced 60 years ago, and it has achieved the highest level of dependability and the lowest total cost of ownership in the industry.

### Terminations & splicing

Kerite cable terminates and splices faster than other solid dielectric cables due to our free-stripping insulation shield and will provide at least 50 percent additional cost savings compared to PILC lead wipe splices and terminations. Our cable is 30 percent lighter than equivalent PILC cable and has a diameter that is 15 to 20 percent smaller than other PILC cable replacement manufacturers. This allows for longer and easier pulls.

### Paper Insulated Lead Cable (PILC)

- Lead, oil used in manufacture
- Labor intensive
- Declining pool of experienced lead wipers
- Toxic material: lead wipe, lead pot
- Difficult Installation: heavy limit pulls
- Environmental Issues

### Compact Replacement Power Cables

- No Lead, no oil
- Labor Savings
- Standard line person skills required
- No toxic materials: no lead sleeve required
- Ease of Installation: smallest cable diameter in the industry with 30% lighter per foot (longer, easier pulls)

### Single conductor power cable

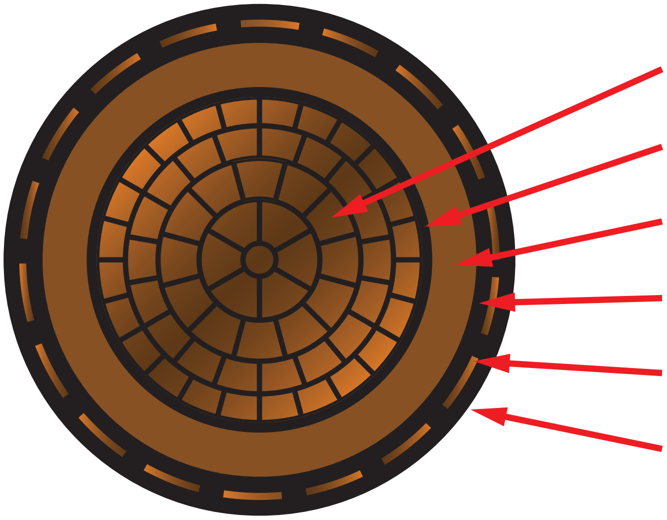
Single conductor power cables allow for ease of splices and terminations. In addition to Kerite's Permashield® and DR-EPR insulation system, our single conductor PILC replacement design consists of a compact strand that provides up to a 10 percent reduction in conductor diameter over full round conductors, flat strap concentric neutrals providing a smaller profile and a polypropylene jacket for additional abrasion resistance. Cables can also be paralleled or twisted on a single reel to aid the installation process.

### A large utility with 75-year old PILC

The nation's largest municipally owned energy, located in the South Central U.S., provides electric service to close to 900,000 customers. The issues with their Paper Insulated Lead Cable (PILC) began when the damaged cable jacket caused oil to leak out in their downtown network, which has 85 miles of PILC cable in clay ductwork that is over 75 years old.

In order to contain capital spending, this utility opted for a new cable design to replace their old PILC cable using the existing clay ducts. This measure would set the table for all their PILC cable to be replaced during the next four years.

Marmon Utility Power Cable sales and engineering met with the customer's engineering group and presented Kerite's solution for PILC replacement cables. The selection criteria centered on water impenetrability, immunity to partial discharge, and light weight and flexibility. However, the single most important criterion: Kerite's cable diameter size, which is approximately 20% smaller than the other cable brands.




**Sometimes the easiest solution is also the best**

Marmon Utility designed a reduced diameter Kerite DR-EPR cable with the following characteristics: 15kv, 3-1/C triplexed 500 kcmil (35-37 strands) compact filled copper conductor. This cable design has the closest diameter to their currently installed PILC cable.

The customer's main concern was the condition of their existing clay ducts. It was imperative to find the smaller cable diameter so it could be used in existing clay ducts, thus saving millions of dollars that would otherwise be required for new ducts, new road construction, and management of outages and traffic disruption in the downtown area.

The customer decided to specify the smallest cable diameter available in the market in their cable tender. This put Kerite in the lead since it is the only company in the industry with the smallest cable diameter meeting the electrical ratings established by the ICEA cable standards.

Marmon Utility was the successful bidder and was awarded the 4-year contract. This customer has begun installation of the planned 85 miles without any issues using the existing clay ducts. The line crews who have direct experience with this product have reported that "Kerite is the easiest cable we have ever installed."

# History of AC secondary networks

Mark A. Faulkner

The AC secondary network system found today in many North American cities and in limited places internationally, provides the highest level of reliability and provides great flexibility in serving our ever-increasing loads. The evolutionarily path to get to the current state of the AC network distribution is an interesting one. So, foremost, lets explain what the current system is and then we can go backward to the beginning of the age of power distribution.

### Basics of the AC network grid

In a secondary network system, the secondary mains surrounding city blocks in densely populated areas are connected to form a network (mesh) where service loads are taken. The secondary voltage of this system is typically 216Y/125. The secondary cables are tied together at every convenient point to form a solid network electrical mesh. Typically, most very early systems have no protection of any kind that is installed for faults on the secondary cables, the concept was that the nature of a secondary fault would burn clear and limit damage propagation. This is still true today at the 216-voltage level, even though in many applications, limiters are applied.

This grid is supplied over multiple medium voltage feeders through network transformers. In this system, the loss of one or more feeders (depending on design contingency) does not cause service disruption to customers connected to the grid because the load is supplied over the remaining feeders. When such a fault occurs on one of the medium voltage feeders, the protective relaying in the substation will open first, then an interruption device is necessity to prevent a back feed of power from the network grid to the fault. This interruption device isolates all the network transformers on the effected feeder, therefore protecting the upstream system. This protective interrupting device is called a Network Protector. This Network Protector is usually mated to the Network Transformer and is a low voltage device with high current carrying capability.

### Early History of AC Network Grids

Grid distribution systems originated from the Edison DC network system prior to 1922, where 110 VDC was used for home lighting in New York City. In this first system, the conductors (which were solid copper rods) were insulated with Jute wrapping. Jute is a derivative of the fiber of an East Indian plant that was also used for twine and burlap wrappings. These early systems consisted of converter and battery stations , where the battery was the backup for the convertor. However, they were expensive to maintain, and the low voltage output of the generators could not sustain heavy power loads over long distances.

The first low voltage network system is reported to have been in Memphis around 1907. Transformer banks were supplied by primary feeders though primary cutouts, no limiters or fuses were used. Network Protectors did not appear to much later in the evolution.

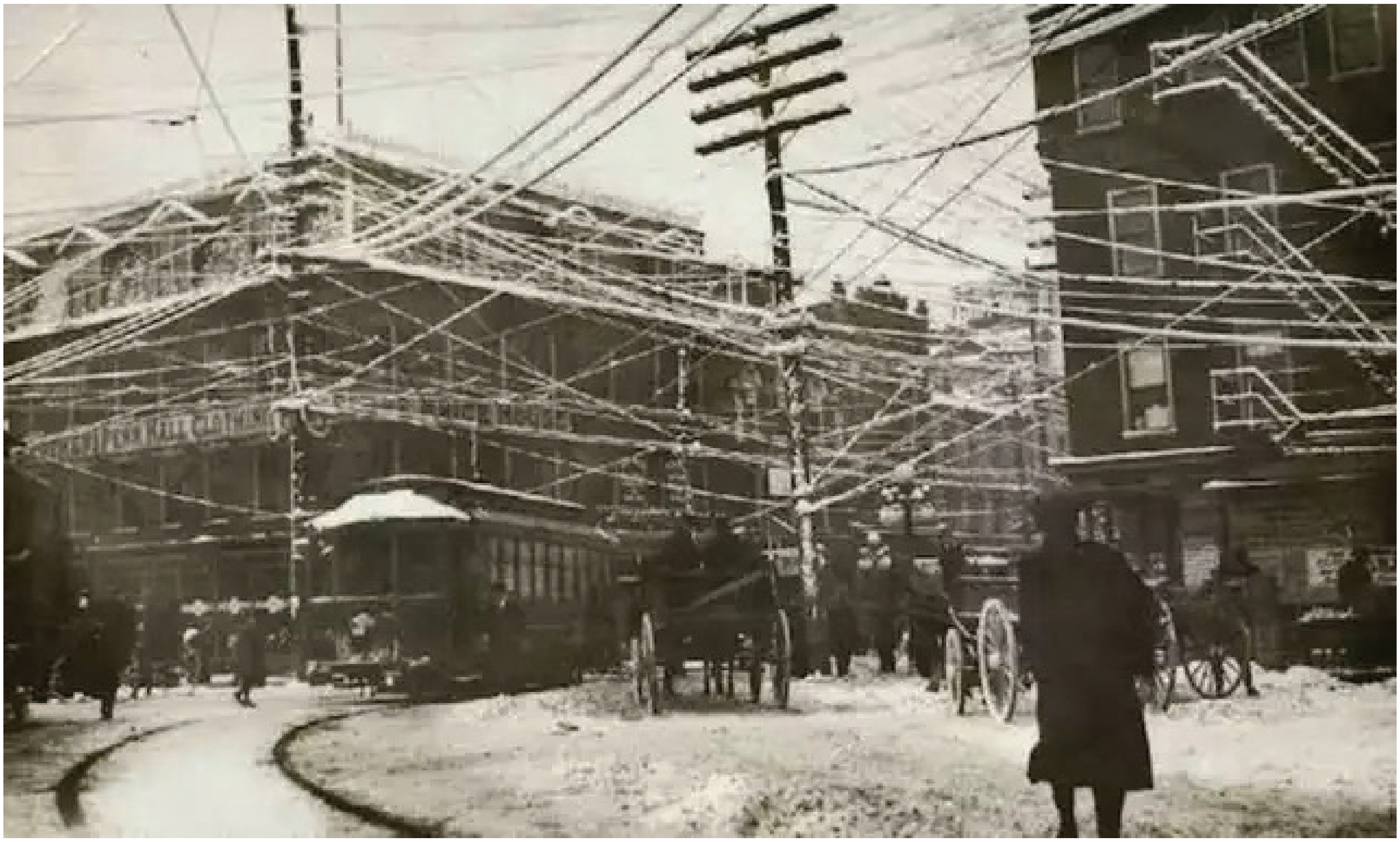
Perhaps, the most interesting part of early AC networks was the battle of the currents, which pitted Edison against Westinghouse. Edison was intent on keeping his DC system in place, despite the shortcomings. The cons of the DC system were the inability to provide a robust system over longer ranges and the dependence on highly maintenance burdened batteries and generators. The latter devices dotted the downtown landscape along with the mesh of overhead wires in the DC era. The system was quite cumbersome before the move to underground.

In 1886, Edison had competition from Westinghouse, who acquired a hot shot engineer, named Nikola Tesla, who advocated alternating current as the future.

Edison fought vehemently against this new system and most likely knew a paradigm shift was on the horizon. The catalyst for the movement against AC electrically was sparked from several accidents early on. The most famous was the death of a Western Union lineman named John Feeks. Feeks was working overhead on low voltage communication lines in the busy downtown area of Manhattan, we he was electrocuted due to a suspected unknown short of an AC line that was many blocks away, although to my knowledge, never proven.

Here are a sample of the anti AC posters of the era displayed

Photo 1: Anti AC Posters



1880s overhead conductor view of New York City

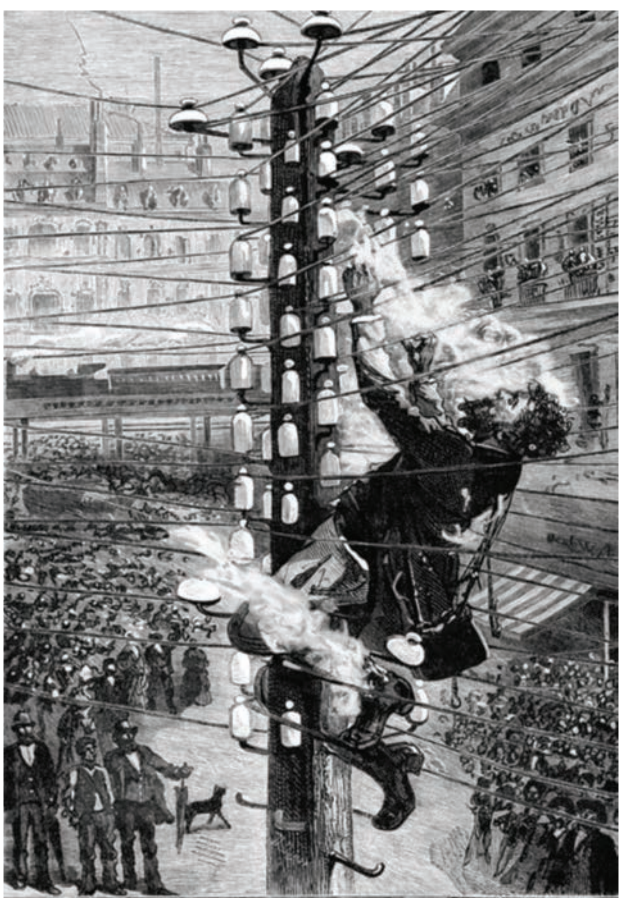


Photo 3: A poster based on the death of John Feeks.

to harbor public sympathy

The feud was so contested, other pressures joined in concert. One such person was an electrical engineer named Harold Brown. Brown argued to legislature that AC was too dangerous and "damnable". He went as far as rounding up stray dogs and held public events where the animals were electrocuted using AC generators. This leads up to even more horrendous events such as the public execution of a horse at Edison's west orange laboratory. There were many rebuttals to Edison and Brown that pointed out that DC had cause many fires and accidents in of itself.

All of this led to new laws that required the movement of overhead AC to the underground. Edison still resisted, stating that "moving AC underground would just move death underground."

In the end, despite all the ingenuity and good Edison gave the world, AC prevailed as the dominant system. Edison himself divested his interests in his founding company and dropping the Edison name, GE went on to become a behemoth in the power world, producing AC equipment quickly after the departure of Edison. Edison was later quoted as confessing to being wrong about AC and here we are today.

Fused networks soon evolved as early as 1915, where power was bought into network area at a primary voltage level and then stepped down accordingly through transformers. However, a multitude of problems existed for fused networks, including difficult coordination for faults, and single phasing creating a maintenance nightmare in underground vaults.

Small improvements were made in the concept of a power

Photo 4: The lowering of an early Network Transformer

mesh distribution grid and in 1921, Seattle connected the transformer secondaries to the solid grid though the use of early Network Protectors. These devices could protect and open in response to reverse current but had to be manually re-closed.

In the early 1920s, the biggest improvements were made to secondary networks with the invention of the automatic Network Protector. The term "automatic" is key to Network Protectors and many older versions of product literature still have automatic in the title. The term automatic implies that the protector can both open for reverse current and re-close upon system normalcy. This was key because ideally the system should work without user intervention and open not only on faults on the primary but open in the absence of faults when the associated feeder substation breaker is open. The reason for the latter, is that the primary circuits should be isolated to perform any required maintenance. This meant that the equipment must respond and trip upon the flow of magnetizing current from the transformer when the substation breaker is opened and in order to do this, the protective relay devices must be able to respond to very low-level reverse currents, for example in the 3 to 6 ampere range.

In 1921, The Palmer Electric Manufacturing Company perfected this piece of equipment complete with the compliment of single-phase protective relays for automatic operation and was a key to the success of evolving grids to come. For the first time, all the network protectors on a single feeder can be opened by simply opening the feeder breaker back at the station. This automatic feature including closing which was revolutionary at the time. The labor required to maintain the grids was greatly reduced with the invention of automatic re-closing upon feeder breaker closure. A new design emphasis was placed on closing and the "Closing Mechanism" evolved over time to what we have today. This legacy is carried out in the product names from Westinghouse and now Eaton, with the "CM" precursor in the product name.

In early 1922, this equipment was installed as a trial using both single- and two-phase network protectors produced by Palmer Electric Manufacturing Company. During the same month, Westinghouse Electric Corporation purchased

Palmers Intellectual property rights to this type of system and equipment and undertook future developments as we will discuss shortly.

In April 1922, the first true automatic AC network system was placed in service in New York City by United Electric Light and Power Company, now known as Consolidated Edison. This system consisted of multiple primary feeders supplying a solid grid of low voltage cables though transformers and network protectors. The grid was 3 phase four-wire and operated at a nominal voltage of 208Y/120. The use of Network Transformers in the 4% to 6% impedance range had the best results for improved voltage regulation and provided higher fault currents to effectively clear the cables during faults. The use of 5% impedance transformers seemed to be the sweet spot in early grid deployments.

By 1925, This system became the benchmark for supplying both power and lighting load in major cities.

By 1936, limiters were installed in most grids at the end of each phase conductor of the secondary mains. This was done to ensure that the faults would burn in the clear, due to any insufficient currents and to "limit" the extent of damage to the cables when the faults took a longer time to burn clear. Hence the name "Limiter" for those who had always been curious. The current time characteristics of the limiters are such they will isolate well before the insulation of the cables are damaged due to the thermal exposure of the fault. When a fault on the secondary mains clears quickly, then the limiters will stay intact, this is the case for most of the time in the grid systems. However, As stated earlier as the purpose of the limiter, if the fault hangs in longer or the current is not enough to clear, the limiters at the two ends of the cable will blow preventing insulation damage and possibly avoiding manhole fires or explosions if cable insulation is heated to extreme levels and outgassing occurs building up pressure in tight manhole spaces.

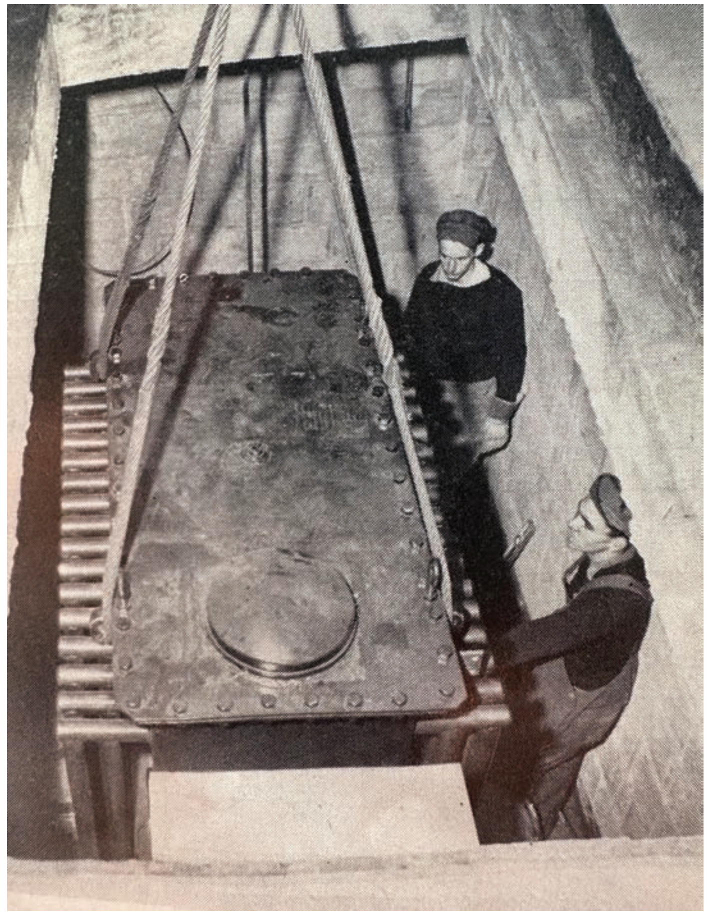


Photo 5: Early Network Install, notice the bolted top on the transformer. I'm not sure if those hard hats would pass OSHA standards today!

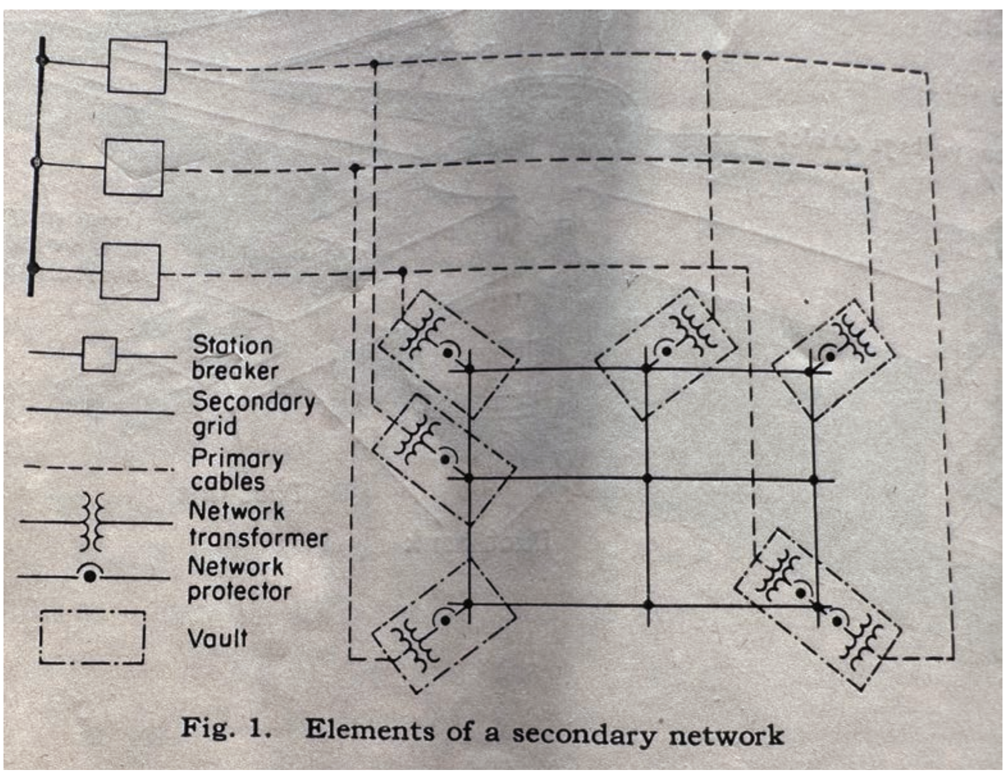



Photo 6: Early network grid for a four-block area with 3 feeders

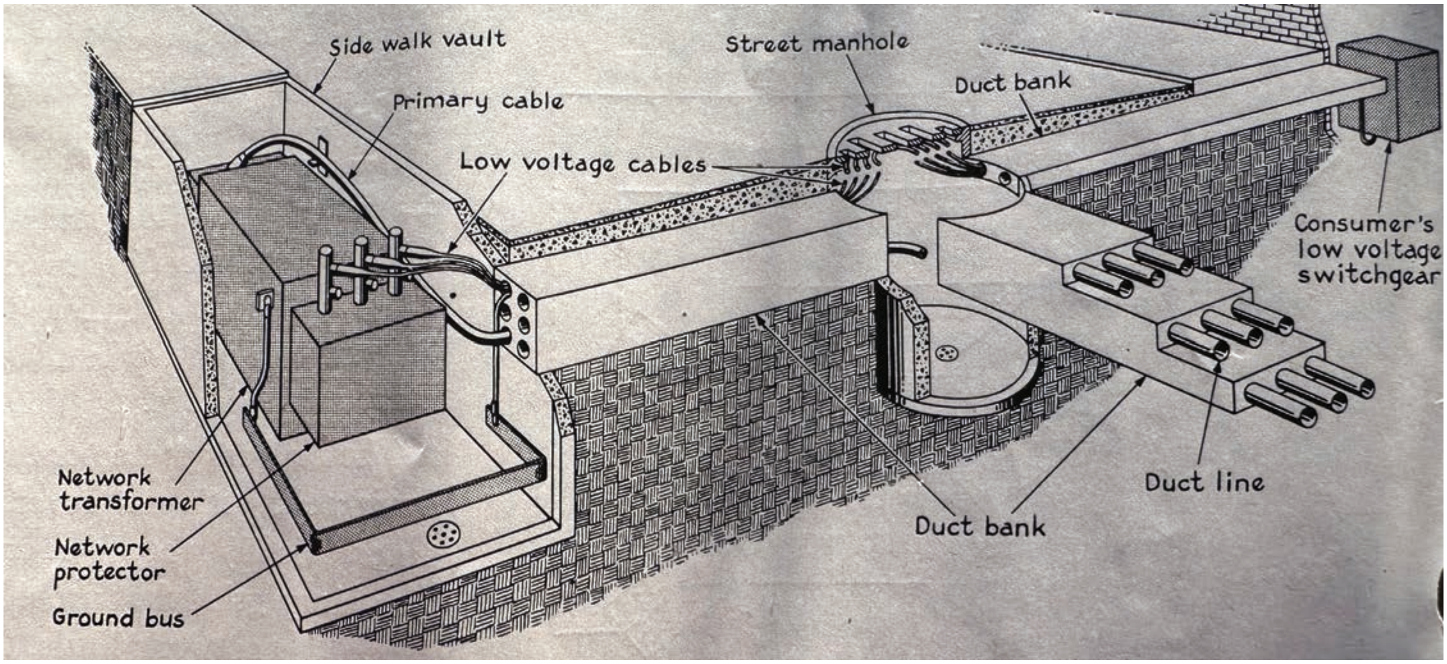


Photo 7: Cutaway view of an early underground system

## Evolution and Advancement of Equipment

**The section below is not all inclusive for Westinghouse but displays the most common models. General Electric produced their own version of a Network Protector called the MG series. They had to use a different control scheme to work around a Westinghouse patent and created their own version of protective electro-mechanical relays.**

**1922- Type CM Network Protector**- This network protector was an adaptation of the Palmer model under the Westinghouse brand. It used two solenoids for both opening and closing. It had early electromechanical phasing relays. The other advancement was the use of Network Protector Fuses, which were basically necked down pieces of copper whose cross-section element would not carry beyond the rating of the Network Protector. Since secondary network grids were the most reliable form of power distribution, these fuses were added as a backup to the protector, in the case that either the relays did not operate, or something was wrong with the opening mechanism. These fuses were not intended to protect the secondary side of the grids. These first fuses were called "Y" and "Z" and coordinated with the thermal damage curve of the network transformer.

**1925- 1927 Type CM1/CM2 Network Protector**- improvement was made to replace the closing solenoid with a motor and thereby adding more reliability. These air interrupters used a spinner arc chute to elongate and extinguish the arc.

**1934- Type CM-22 Network Protector**- The mechanism design was changed to a modified 4 bar mechanism and provided more advanced thermal insulation. This protector came with improvement in the electro-mechanical system of protective relays. The CM-22 used 3 relays to compensate for grid anomalies and baked in the lessons learned in earlier grid deployments, such as time delay and phasing. These relays were called Master (3 phase relay), Phasing (single phase) and BN Desensitizing Time Delay relay. The prior relays were single phase and this protective relay set performed similar automatic trip and close functions, but the advent of the BN allowed compensation for system anomalies by providing both overcurrent protection and time delay using a bi-metal element to time out residual regenerative back feeds such as caused by elevators of that era. The CM-22 is still produced today albeit with some insulation improvements on control wiring and components. However, the electro mechanicals have been replaced with one microprocessor relay to give even more fine tuning to the grid system than previously available. Additionally, a new fuse style was developed called the "Alloy" fuse or low loss fuse. This fuse ran much cooler thermally than the Y or Z and did not blow copper out to contaminate the breaker upon interruption like the solid copper fuses.

**1968- The CMR-6 Network Protector**- This was the first spring closed Network Protector, available only up to 2250 Amps and made for the New York Grid system. This protector is still manufactured and used by Con Edison today. This was the first protector with a fault close rating to have the robustness required to close in on secondary faults to aid in cable clearing.

**1975- The CMD Network Protector**- The first dead front, draw-out Network Protector and leveraging the spring closed similar design as the CMR-6 Network Protector. This unit was designed with safety in mind in response to the unfortunate accidents that occurred with live front equipment centering around the advent of 480V/277 spot networks, which occurred in the 1940s, to increase power to service single concentrated loads. The self-distinguishing arc of the 216V grid was not the same behavior when it came to 480V arcs, which are re-striking, highly destructive and unforgiving. This arc nature led to concerns with the unprotective zone and the invention of the NPL "Network Protector Limiter" Network sand fuse. This was the fuse of choice for the CMD, given the fuses 200kA rating and the barrel containment of any arcs.

**2000- The CM-52 Network Protector**- This protector leverages all the lessons learned and includes for the first time, a true power breaker for the interrupter. The "Magnum". Breaker was used for its high interruption and withstand ability. Additional, arc mitigation devices were incorporated into the design to make a much safer choice in today's modern electrical grid, especially for 480V spot networks.

**2000-today.**

The evolved advanced network protector today (CM-52)

## Historical Westinghouse Development Timelines

**1922-1923.** Built the first 3 phase, automatic reclosing network protector.

**1926.** Applied the first grounding switch to Network Transformers

**1927.** Built the first 3 phase, network master relay

**1929.** Developed the first non-sensitive, reverse current trip scheme for network protectors, to reduce un-necessary protector operations, which functions under full sensitivity under fault conditions.

**1933.** Introduced the use of "De-ion" arc chambers on network protectors to reduce protector size and increase contact life. These are the arc chutes we use on all protectors today.

**1934.** Built the first three-phase, low-loss, oil insulated network transformer

**1936.** Introduced a simple gear motor closing mechanism for network protectors

**1938.** Built the first welded on cover network transformer

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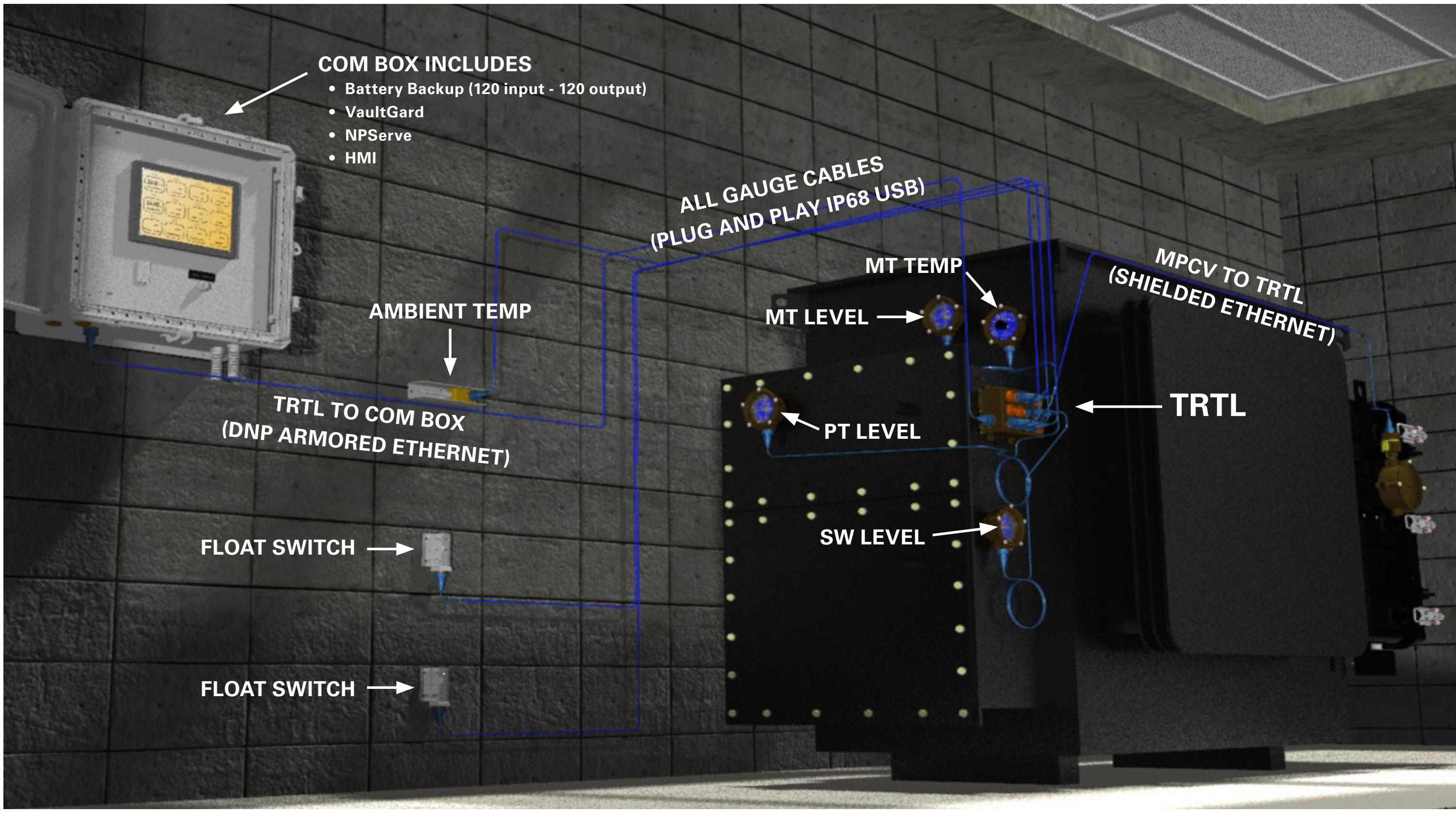


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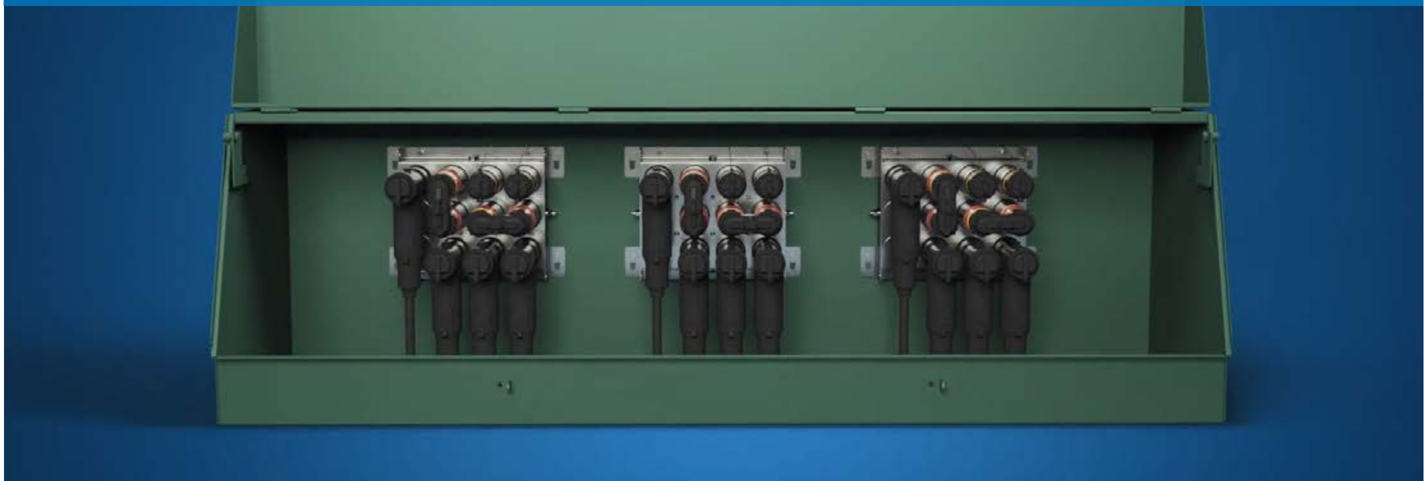

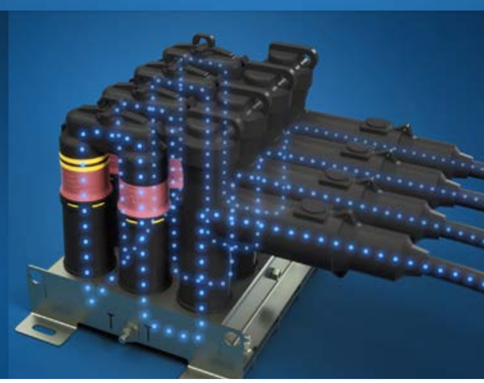

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