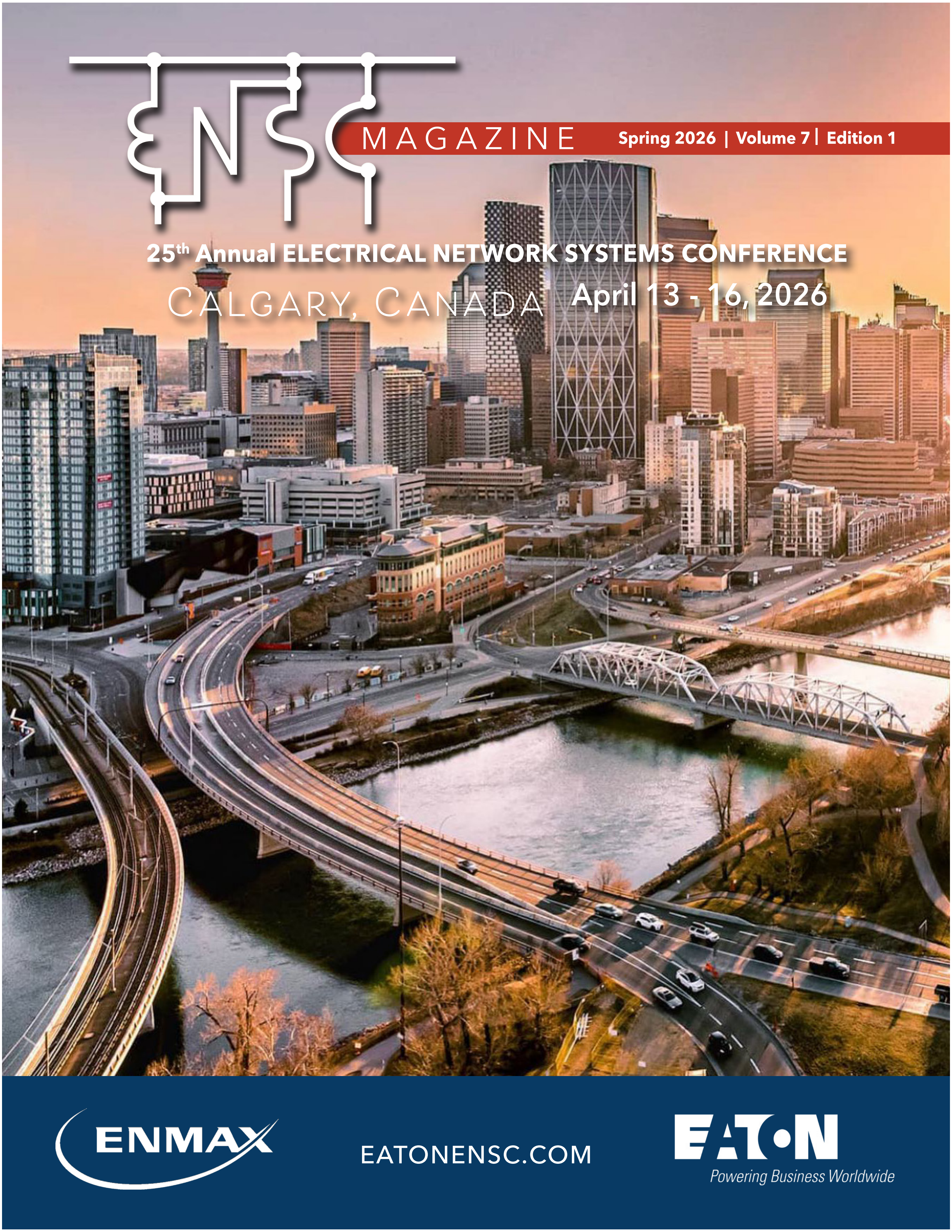

ENSC MAGAZINE

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25th Annual ELECTRICAL NETWORK SYSTEMS CONFERENCE

CALGARY, CANADA April 13 - 16, 2026

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The 25th annual ENSC Conference is a super milestone! This year, we gather in the vibrant city of Calgary, Alberta, hosted by our great partners at ENMAX. Over the past quarter century, ENSC has grown from a small technical gathering into one of the most respected conferences in the underground network distribution community. Its success is a testament to the commitment and passion of all of you who return year after year to learn, collaborate, and share your expertise.

As we celebrate this anniversary, it's worth reflecting on how far our industry has come. Since our beginnings, we have witnessed massive shifts in the expectations placed on underground networks, along with innovations in monitoring, protection, and diagnostics that continue to reshape how we maintain the most reliable distribution systems in the world. Yet even with all these advancements, one principle remains unchanged: we learn best when we learn from each other.

Calgary provides the perfect backdrop for this year's conversations. ENMAX has been an outstanding partner to help coordinate this event, which is never easy. Their commitment to reliability, safety, and innovation mirrors the values that have defined ENSC for 25 years.

This year's agenda emphasizes the accelerating shift toward predictive maintenance, communications-enabled insights, and advanced diagnostic capabilities—tools that continue to transform underground networks to a level of reliability that is expected for our critical loads.

One of this year's most anticipated highlights is the vault tour, giving attendees a rare behind the scenes look at the infrastructure that keeps Calgary's underground network operating at world class reliability levels. This year's tour also includes a visit to ENMAX's new substation—a state of the art facility showcasing modern protection technologies, advanced monitoring, and forward thinking design. This addition provides an unparalleled opportunity to see innovation in action and learn directly from the teams driving these advancements.

To commemorate our 25 year journey, this magazine also features a special "step back in time" section, highlighting every ENSC event and host throughout the years. It's a great way to reflect on how far we've come and the amazing community that has built this conference into what it is today. Be sure to check those out!

And of course, conferences aren't only about work. To celebrate this special anniversary, we're thrilled to include a trip to the breathtaking town of Banff, nestled in the Canadian Rockies. It's a chance to unwind, take in world class scenery, and strengthen the personal connections that make this community so unique.

Lastly, I want to thank each of you for your continued support of ENSC—whether through attending, sharing your knowledge, or spreading the word to new colleagues and suppliers. Together, we've built something truly special over the last 25 years. With your engagement and enthusiasm, I have no doubt we'll continue driving the advancement of underground network systems for decades to come

Sincerely,

Mark Faulkner
Product Line Manager
Eaton

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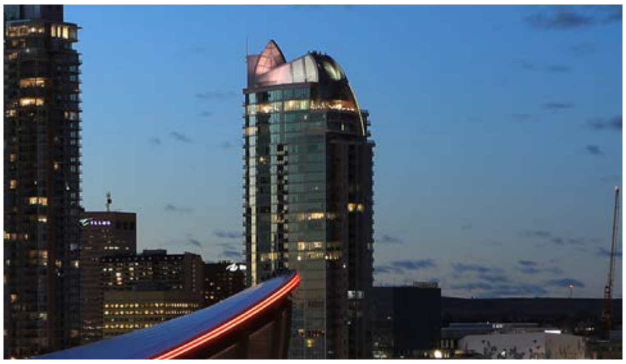

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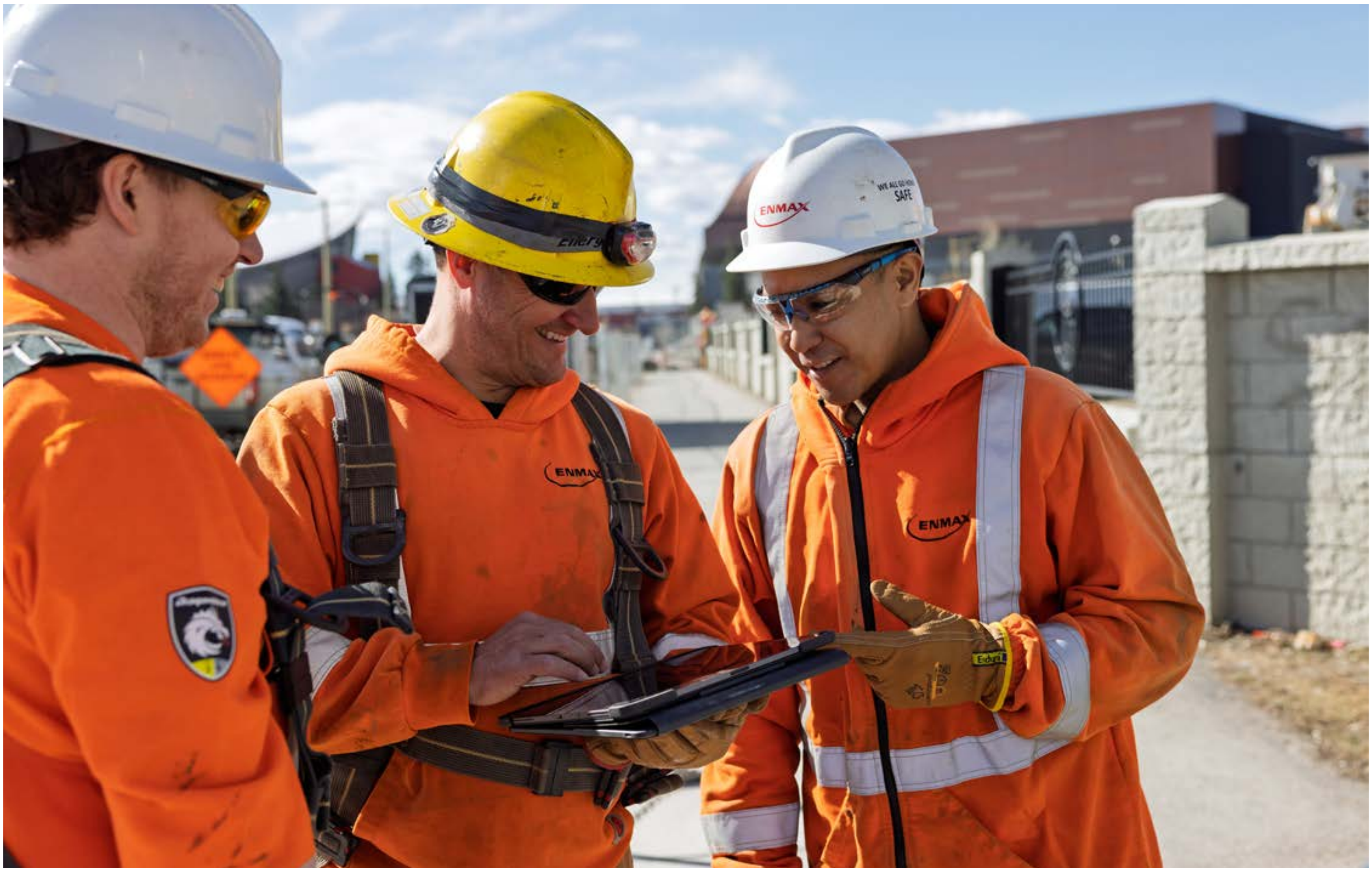
TABLE OF CONTENTS



Calgary’s Growth and the Power Beneath Our Feet

Secondary Networks in a Rapidly Evolving City

Written by: Enmax Team

Calgary is in the midst of a transformation.

Some reports indicate Calgary has grown by nearly 100,000 people in the last year alone. New communities are rising on the city’s edges. Downtown towers are being converted from office to residential. Major civic investments are reshaping the urban core.

To visitors, the growth is visible in cranes, concrete and skyline silhouettes.

But a more compelling story lies beneath the streets.

It’s the story of one of North America’s largest secondary network systems and one of ENMAX’s largest infrastructure projects to date.

Calgary's Secondary Network

For over a century, ENMAX has operated and maintained Calgary's transmission and distribution systems, ensuring that homes, businesses, schools and other critical infrastructure stay connected to safe, reliable energy.

We serve the population of Calgary and surrounding area with approximately 600,000 metered customers across 1,089 square kilometres and maintain nearly 9,000 kilometers of distribution lines and over 355 kilometres of transmission lines.

In Calgary, we have one of the largest secondary networks in North America and the largest in Canada, covering eight square kilometers. More than 90 per cent of the infrastructure is located underground. These systems allow us to minimize disruptions for our customers, which is critical for businesses, hospitals, and residents alike.

In addition to more people calling Calgary home, we know customers needs are evolving and how they will use the grid in the future is changing. In 2022, ENMAX completed the first successful pilot in Canada to export power from a secondary network back to the grid.

Findings from the pilot and the technology used remove technical and financial barriers, enabling customers within secondary networks to adopt renewable energy options.

This kind of innovation will could give urban customers, both in Calgary and potentially across North America, more choice in how they generate and use electricity while maintaining a safe, reliable grid.

At ENMAX Power, we are committed to supporting this growth by investing in infrastructure, integrating new technologies, and preparing the grid for a more dynamic energy future. Annually we invest million in system growth and maintenance to ensure we can reliably meet our customers' energy needs now and in the future.

A century at the centre of the grid

In 1912, Calgary built its first substation to power streetlights and a growing streetcar system. It was named simply: Substation No. 1.

More than a century later, Substation No. 1 still supplies electricity to nearly half of downtown Calgary, approximately 19,500 customers, including office towers, residential high-rises, data centres and health-care facilities.

Around it, the city has evolved dramatically. The population has surged. Buildings have grown taller. Loads have become more complex. Electrification is accelerating.

The original substation adapted for decades, but as Calgary entered a new period of rapid growth, the time came to modernize the backbone of the downtown secondary network.

"Substation No. 1 has adapted to serve Calgary for more than 100 years," says Adam Delong, Manager, Substations at ENMAX. "Replacing it wasn't about capacity alone – it was about ensuring the reliability standards of a modern secondary network are sustained for the next century."

The replacement of Substation No. 1 is now complete, a 35,000-square-foot facility built across the street from its predecessor. It is ENMAX Power's largest infrastructure project to date.

The quiet complexity of a cutover

Replacing a downtown substation is not like swapping equipment in an open yard.

Calgary's core is served by an interconnected secondary network, designed for high reliability in dense urban environments. Multiple primary feeders supply network transformers, interconnected at the secondary level to share load and maintain service during contingencies.

That reliability is by design. It is also what makes replacement work so complex.

Over the coming weeks, ENMAX crews will complete a carefully staged cutover, transferring:

- Six high-voltage transmission lines
- Twenty-four distribution feeder lines

"From a technical perspective, the cutover is the most critical phase," says Delong. "We're transferring feeders one at a time while preserving redundancy across the network. Every move is sequenced to ensure we maintain contingency capacity and system stability throughout."

The process involves excavating downtown streets, accessing aging duct banks, pulling new cables, splicing conductors inside manholes and commissioning new protection systems, all while maintaining uninterrupted service to customers.

Feeder transfers are sequenced to preserve redundancy. Load is redistributed in real time. Network integrity is maintained at every stage.

From the sidewalk, it may look like standard construction. From an engineering standpoint, it is a carefully choreographed reconfiguration of a live urban network.

When complete, later this summer, downtown Calgary will be served by a modernized backbone capable of supporting decades of future load growth.

Growth above ground, pressure below

In 2025 alone, ENMAX connected more than 22,000 new homes and businesses – the busiest year in more than 15 years. Development permits rose 28 per cent over previous years.

Some of that growth is happening in established neighbourhoods.

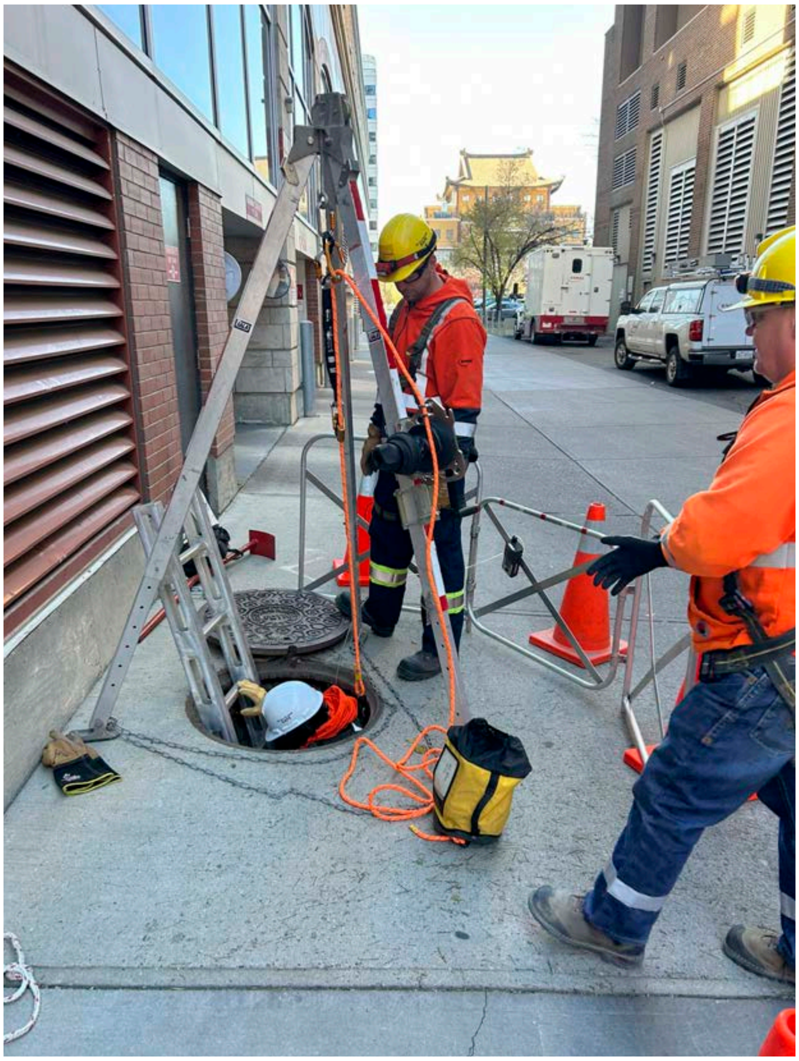
Office-to-residential conversions are reshaping the downtown load profile. High-density infill development is increasing coincident demand. Electric vehicle charging infrastructure is expanding rapidly. Building electrification is no longer theoretical, it is material.

Despite this, Calgary maintains one of the highest reliability rates in Canada. Customers experience an average of just 38 minutes of outage time per year. Significantly below the national average of over two hours.

"Maintaining high reliability during rapid growth requires replacing infrastructure before it becomes constrained," says Juval Bothe, Senior Lead Engineer, Network, High Density and Distributed Energy Resources. "Secondary networks are inherently resilient, but they require disciplined planning and investment to keep them that way."

Maintaining that performance while densification accelerates requires forward-looking investment in secondary network infrastructure.

Substation No. 1 is the most visible example of that strategy.



Powering a new civic district

A few blocks from Substation No. 1, another major project is taking shape: Scotia Place.

The new events centre will anchor Calgary's evolving Culture + Entertainment District and serve as home to the city's NHL franchise, the Calgary Flames. Supporting it requires more than arena lighting, it demands careful integration into an already dense underground utility environment.

ENMAX has installed new underground duct work in the area to support both Scotia Place and future surrounding development. Much of the route builds on existing system capacity, leveraging the strength of the downtown secondary network.

The work requires close coordination with:

- Calgary Municipal Land Corporation
- Calgary Sports and Entertainment Corporation
- Calgary Stampede
- City of Calgary

Layered beneath Victoria Park's streets are decades of water, sewer, telecommunications and gas infrastructure. Secondary network design, with its redundancy and interconnected feeders, provides the resilience needed to support high-density civic facilities and large event loads without compromising surrounding customers.

Extending Network Thinking Beyond Downtown

Calgary's growth story is not confined to the core.

Mixed-use developments such as University District and West District are creating new high-density nodes elsewhere in the city.

"We're seeing density emerge outside the traditional downtown footprint," says Juval Bothe, Senior Lead Engineer, Network, High Density and Distributed Energy Resources. "That prompts important planning questions, where do secondary network principles provide long-term reliability value, and how do we design for electrification trends that are still accelerating?"

These communities feature mid- and high-rise residential buildings, commercial space and transit integration – with load characteristics that increasingly resemble urban core environments.

While not all such areas require full secondary network configuration, ENMAX is applying network-informed planning principles:

- Enhanced underground duct capacity
- Built-in feeder redundancy
- Capacity planning for EV adoption and electrified heating
- Scalable infrastructure for phased development

As Calgary continues to densify, the traditional boundary of the "downtown network" is becoming less rigid. Growth is prompting a broader conversation about where and how secondary network architecture can best support evolving urban form.

Infrastructure that enables opportunity

Calgary offers a live example of what it means to steward a mature secondary network through a period of extraordinary change:

- Replacing critical assets before constraint becomes crisis
- Sequencing complex cutovers without compromising reliability
- Integrating network planning into major urban redevelopment
- Anticipating electrification-driven demand in both core and emerging districts

Above ground, Calgary's skyline is evolving.

Below ground, its secondary network is being strengthened to ensure that growth is supported by infrastructure built to last another century.

Eliminating Manual Transport Risk in Electric Utility Networks

Written by: Movex Innovation

In the electric utility network sector—transmission, distribution, substations, and dense urban secondary networks—manual transportation of heavy equipment remains one of the highest-risk routine activities crews perform.

For decades, moving transformers, switchgear, cable reels, and battery banks by hand was considered "part of the job." Today, that mindset is changing. Across North America, electric companies increasingly view excessive manual handling not as a worker issue—but as a design failure.

This shift is driving growing interest in compact mechanized solutions specifically designed for confined utility environments, such as the electric and remote-controlled material-handling equipment developed by Movex Innovation.

The Core Problem: Manual Handling Drives Injury

Musculoskeletal disorders (MSDs) are consistently the leading cause of lost-time injuries in physically intensive industries. In utility operations, risk is amplified by:

- Lifting and positioning pad-mounted transformers
- Carrying cable reels across gravel, mud, snow, and slopes
- Working in trenches, vaults, and substations
- Repetitive handling during installations and storm restoration

Recent utility safety analyses show that back injuries, shoulder damage, knee strain, and chronic pain remain the most frequent day-to-day injuries. These injuries lead to long recovery times, high workers' compensation costs, reduced crew availability, and early career attrition.

In response, utilities are increasingly evaluating equipment that removes lifting and carrying tasks altogether. Electric tracked carriers and compact lifting equipment—like those designed by Movex Innovation—allow heavy loads to be transported without direct physical exertion from crews.

Manual Transport Multiplies Other Hazards

Manual handling increases the severity of other risks already present in the network environment.

Slips, Trips & Falls

Carrying heavy or bulky items reduces balance and reaction time. Falls while loaded are more severe and often result in secondary injuries such as fractures or spinal compression.

Crush & Pinch Injuries

Manual positioning of transformers, battery racks, and cabinets exposes hands and feet to shifting loads—especially in tight spaces or during team lifts.

Electrical Hazard Amplification

Physical strain reduces situational awareness. Near energized equipment, fatigue increases the likelihood of mistakes and reduces reaction speed.

Confined Space Exposure

Vaults and trenches restrict movement and escape routes. Awkward posture combined with heavy loads significantly raise injury severity.

Compact mechanized carriers and stair-climbing transport systems—such as those used by many utility contractors today—allow crews to control loads remotely while maintaining a safer distance from hazards.

> *This shift has opened the door for compact mechanized solutions designed for constrained utility environments. Manufacturers such as Movex Innovation focus specifically on ultra-compact, electric, remote-controlled equipment for confined and hard-to-reach areas.*

Where Risk Concentrates

Underground Distribution & Urban Network Systems

Underground and secondary network systems present a concentrated risk profile:

- Tight vault access
- Energized bus structures nearby
- High fault energy at low voltage
- Wet or uneven footing

Manual handling persists largely due to the "last 5–20 meters" problem—where trucks or forklifts cannot reach final placement locations. The combination of confined space and heavy load transport makes this one of the highest ergonomic exposure zones in the electric utility industry.

Ultra-compact tracked carriers, such as Movex Innovation's utility-focused electric transport equipment, are designed specifically for these situations, allowing crews to move transformers or heavy cabinets safely into confined spaces without manual lifting.

Substations

Substations contain extremely high available fault current. While electrical severity dominates, heavy equipment installation—transformers, breakers, control cabinets, battery banks—drives crush injuries and severe overexertion cases during construction and retrofit work.

Compact electric carriers—like those offered by Movex Innovation—allow crews to transport these components safely across substation yards while reducing the risk of overexertion or crush injuries during installation and retrofit projects.

Overhead & Right-of-Way Work

Off-road terrain introduces mud, slopes, snow, and unstable footing. Carry distances increase fatigue, particularly during storm restoration. Overexertion injuries are frequent, and fatigue elevates electrical mistake probability.

All-terrain electric carriers, like the Mini-Crawler Crane developed by Movex, allow heavy equipment to be transported safely over uneven ground, backyards, and hard-to-reach areas while reducing physical strain on crews.

Regulatory & Strategic Pressure

Modern safety frameworks prioritize engineering controls over administrative controls or PPE. Utilities are increasingly expected to eliminate foreseeable manual handling hazards where practical alternatives exist.

Training alone is no longer considered sufficient if mechanized solutions are available.

Beyond compliance, workforce sustainability is driving change. Utilities face:

- Aging technicians and linemen
- Skilled labor shortages
- Increasing storm intensity
- Rising compensation costs

Reducing physical strain extends career longevity, improves retention, and preserve crew readiness.

Engineering the Risk Out

This shift has opened the door for compact mechanized solutions designed for constrained utility environments. Manufacturers such as Movex Innovation focus specifically on ultra-compact, electric, remote-controlled equipment for confined and hard-to-reach areas.

Typical Applications

Remote-Controlled Tracked Carriers

Move transformers, cabinets, and reels over uneven terrain without manual carrying.

Electric Mini Loaders

Operate inside vaults and substations with zero emissions.

Compact Lifting Equipment

Lift and position heavy components without direct physical strain.

These solutions directly reduce lift weight, carry distance, fatigue, and exposure in uneven terrain—addressing the primary injury drivers identified in utility safety reviews.

The Business Case

Utilities increasingly justify mechanization through:

Injury Cost Avoidance

A single serious MSD claim can exceed six figures when medical, lost time, and insurance impacts are included.

Productivity Gains

Mechanized transport reduces crew size for heavy moves and preserve energy for technical work.

Storm Response Readiness

Less fatigue means sharper decision-making around energized systems.

Regulatory Risk Mitigation

Engineering controls demonstrate proactive duty of care.

The Direction of the Industry

Manual heavy transport is steadily being replaced by short-distance mechanized movement—especially in underground distribution systems and urban network environments.

Equipment manufacturers such as Movex Innovation are helping utilities address this challenge by designing ultra-compact, electric and remote-controlled machines capable of operating where traditional equipment cannot.

For utilities facing increasing infrastructure demands and workforce pressures, reducing manual handling is becoming more than a safety improvement—it is a strategic necessity.

The future of network safety will not depend on stronger workers.

It will depend on smarter equipment and safer ways to move heavy loads.

Fault Location Techniques for Underground Medium Voltage Cable Systems

Written by: Megger

Abstract - Accurate cable fault location reduces outage time, excavation, and repair cost in MV/HV cable systems. This abstract summarizes a practical workflow combining route verification and electrical fault prelocation. Tracing is the first critical step to confirm the cable path, depth, and correct circuit before any high-voltage testing or excavation. A controlled hipot (withstand) test is then used to verify the insulation defect, assess whether the fault is stable or intermittent, and in many cases condition the fault so it becomes measurable with reflection-based methods. For prelocation, the arc reflection method is highlighted as a key technique that uses a temporary arc at the fault to create a clear reflection for distance-to-fault estimation. When reflections are weak or unreliable, impulse current decay provides an alternative distance estimate based on discharge/current behavior. For high-resistance or unstable faults that cannot be prelocated, burning may be applied to lower fault resistance and stabilize the defect, enabling subsequent surge/reflection measurements. If uncertainty remains, sectionalizing narrows the faulted segment to restore service faster and reduce the search area. Finally, the abstract emphasizes that these methods typically provide an estimated distance, not an exact spot. A pinpointing device is therefore essential to locate the precise fault position on the ground, minimizing unnecessary digging and ensuring safe, fast, and accurate repairs.

Cable construction

Underground medium-voltage cables are typically installed in one of three configurations: (1) separate insulated single conductors, (2) a twisted bundle of the insulated single conductors known as a triplex assembly, or (3) a covered three-conductor cable. In all cases, the insulated conductors share the same basic construction, as shown in Figure 1.

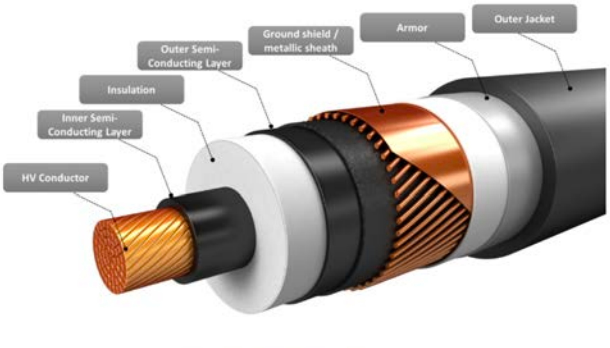


Figure 1. Cable Construction.

A medium-voltage cable has several layers with specific jobs. The conductor is usually stranded copper or aluminum, carrying load current with low resistance while staying flexible for pulling, bending, vibration, and thermal expansion. Semi-conducting conductor and insulation shields control the electric field by smoothing interfaces, removing air gaps, and keeping voltage stress uniform, which reduces partial discharge and insulation aging. The insulation is typically XLPE or EPR, providing the main dielectric barrier and withstanding operating voltage, overvoltage, and heat. A metallic tape shield offers a grounded low-impedance path for charging and fault currents. The outer jacket protects from abrasion, impact, moisture, and chemicals

Equivalent electrical circuit of good cable

Figure 2 illustrates the electrical equivalent circuit of a healthy length of cable. In an ideal case with perfect insulation, the parallel resistance (R_p) would be infinite (effectively absent) and the insulation would behave as a pure capacitance (C). In reality, all insulation has some leakage, so a finite insulation resistance R_p is present. This is the resistance measured with a when performed insulation resistance testing, and the associated leakage current is what is monitored during a DC hipot test (as shown in Figure 1). Together, the cable's series resistance (R_s), inductance (L), capacitance (C), and parallel resistance (R_p) form the cable's transmission-line behavior, commonly expressed in terms of its characteristic impedance (Z_0).

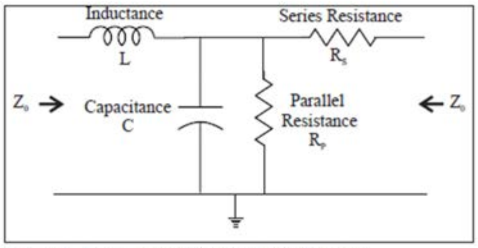


Figure 2. Equivalent circuit of good cable.

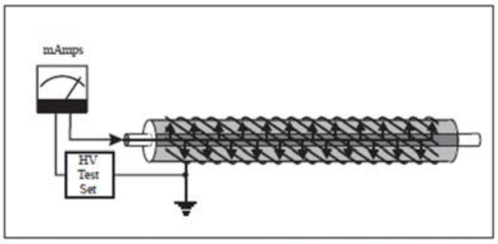


Figure 3. Equal distribution of electrical fields in good cable

TYPES OF FAULTS

Cable faults are commonly grouped into insulation (shunt) faults and open-circuit (series) faults. A shunt fault can be a short circuit when mechanical damage forces the conductor and metallic shield into contact, or when a low-resistance carbon/metal bridge forms between them (typically R < 100 Ω). Many shunt faults are nonlinear (voltage-dependent), especially in extruded-insulation cables: at low voltage (V < 500 V) the cable may appear unfaulted, but above about 500 V the fault can flash over or behave like a voltage-dependent resistance. In submerged faults, the shunt resistance may also change with applied voltage.

Series faults include open circuits caused by mechanical damage (severed conductor or sheath, separated splice) or electrical damage where cables, joints, or terminations are blown apart—often linked to sectionalizing practices like reclosing or re-fusing. Other series faults can be nonlinear (current-dependent) due to shield corrosion, deteriorating splices/terminations, burnt conductors, or water-soaked blown-out faults. Finally, flashing/intermittent faults may hold a DC voltage higher than peak phase-to-ground voltage and are often associated with mechanical damage, open terminations, separated splices, or conductors blown apart by reclosing, leaving an electrically isolated end; in some cases, a non-carbonized insulation hole creates a high-resistance or insulating path between conductor and shield.

VERIFICATION OF FAULTED CABLE

Tracing cable - It is an optional but strongly recommended step before fault location. A tracer transmits a signal onto the cable using direct connection clips or an induction clamp. A handheld receiver then sweeps along the expected route, providing audible and visual indication of the cable path. Most importantly, tracing verifies the correct circuit and route before applying surges, hipot, or percolation tests, improving safety, accuracy, and dig efficiency.

Figure 6. Cable tracing

Performing breakdown test (Hi-Pot test) – A hi-pot (withstand) test is typically the first step to confirm that a fault is present. The test voltage is applied phase-to-ground up to the cable's specified withstand level and held for a defined duration. If the cable successfully holds the voltage without breakdown and leakage current remains stable, the insulation is considered acceptable and further fault-location work may not be required. If the cable cannot sustain the applied voltage, an insulation breakdown will occur, indicating a fault. In that case, the voltage will collapse and the faulty section will prevent the test voltage from being maintained beyond the defect location.

PRE-LOCATION METHODS

1. Arc-reflection Method

Surge arc reflection enables power-cable fault prelocation using the lowest practical high-voltage levels, reducing stress and risk to otherwise serviceable cable. A surge generator applies an impulse that can momentarily convert high-resistance or intermittent faults into a low-resistance arc—often well below the cable's characteristic impedance—so the fault produces a clear reflection.

In the first stage, the TDR is operated alone. Because a high-resistance or intermittent fault does not create a strong reflection, the trace typically shows only normal cable features such as the cable start, joints/splices, transformers or other discontinuities, and the cable end.

In the second stage, the surge generator is enabled. Its impulse voltage is set only high enough to cause the fault to break down and arc at the defect point. When the arc forms, it temporarily turns the fault into a low-resistance condition, producing a clear TDR reflection that appears as a negative deflection on the screen and marks the fault location. After the arc extinguishes, the fault returns to its original high-resistance state.

By comparing traces with the surge generator charging (no arcing) versus firing (arcing), the technician sees the normal "landmark" cable signature during charge mode and the additional negative deflection superimposed during arcing, which identifies the fault distance.

Figure 8. Real-life Arc-reflection trace.

2. Impulse current method.

The impulse current method is used to percolate high-resistance and intermittent cable faults. A surge generator injects a high-voltage impulse into the faulted cable, causing an arc to form at the defect point. A portion of the impulse energy is reflected back toward the cable end at the test point, where the low impedance of the surge capacitor reflects it back into the cable again. The resulting waveform travels back and forth repeatedly until the energy is fully dissipated. This "ringing" behavior can be captured by coupling a synchronized monitoring device—such as a digital oscilloscope or a TDR—at the cable end. The time spacing between successive reflections shown on the display is used to calculate the distance to the fault.

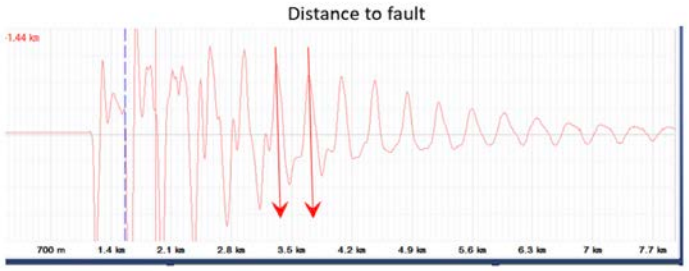


Figure 10. Real-life trace of ICE method.

3. Burning Method

By applying an AC source (power frequency or VLF) or a DC source (such as a burn-down set or a thumper) with adequate voltage and current, a high-resistance or intermittent fault can be changed into a low-resistance fault—either temporarily or permanently. The process begins by initiating arcing at the defect. The current is then sustained so that carbonization (charring) or molten metal fusion forms a stable, low-resistance conductive path at the fault location. If the burning process is prolonged, the damage can escalate and may ultimately cause the cable to burn open (sever).

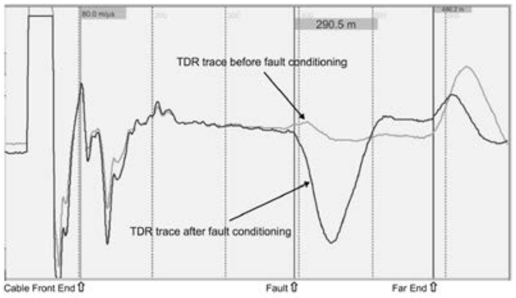


Figure 11. Real-life trace of before and after performing burning function.

PIN-POINTING FAULTS

A surge capacitor—often called a thumper—is discharged into the faulted cable, creating a flashover (arc) at the defect. An electromagnetic (EM) pickup traces the traveling surge current along the route, while an acoustic sensor listens for the audible "thump" produced at the fault location. Near the fault, the EM arrival is used to start a timer, and the acoustic "thump" is used to stop it. The smaller the time difference, the closer you are to the fault; the operator is directly above the fault when this delay reaches a minimum. Because it uses both EM and sound, it provides accurate pinpointing and can also be applied to cables installed in conduit (with appropriate sensing and access points). Lightning-and-thunder example: This works like estimating how far away a lightning strike is. You see the lightning almost instantly (fast EM signal), then hear the thunder later (slower sound). As you move closer to the strike point, the delay between "flash" and "boom" gets shorter. Similarly, the cable fault produces an immediate EM event and a delayed acoustic thump—measuring that delay helps you home in on the exact fault spot.

Figure 12. Pinpointing faulted cable.

CONCLUSION

Effective underground MV cable fault location requires a structured approach that balances accuracy, safety, and minimizing damage to serviceable cable. As outlined in this article, the workflow starts with route tracing and fault verification (hi-pot/withstand) to confirm the correct circuit and validate that a fault condition truly exists. Once confirmed, prelocation techniques—such as arc reflection and the current impulse method provide a practical distance-to-fault estimate by temporarily converting high-resistance or intermittent defects into measurable events. When faults remain unstable or highly resistive, controlled fault conditioning (e.g., burning) and operational strategies like sectionalizing can further narrow the search area and support faster restoration. However, prelocation results represent an estimated distance and can be influenced by cable landmarks, attenuation, and installation variables. Therefore, final repair efficiency depends on pinpointing, where electromagnetic and acoustic coincidence methods identify the exact fault spot, reducing unnecessary excavation, limiting collateral damage, and enabling a safe, precise repair.

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Understanding 480V Faults—and the Case for the NPL Fuse

Why 480V spot networks demand more from protection than "normal" 216V grid systems

Written by: Mark Faulkner, Product Line Manager, Eaton

By the time a network engineer reviews a 480V one-line diagram, they usually recognize a fundamental reality: 480V systems can deliver exceptionally high fault energy. But there is a specific class of 480V distribution that demands even greater respect—the network configuration, where multiple transformers operate in parallel on a common isolated low-voltage bus. At the 480Y/277V level, as opposed to 216Y/125V systems, several characteristics change significantly, including the volatile re-striking behavior of 480V arcs, which elevates both the complexity and the risk of protection.

In these systems, the available fault current isn't just high—**it is multiplicative**. This characteristic is exactly why the Network Protector Limiting (NPL) fuse emerged as one of the most critical, yet often misunderstood, elements in network protection.

Originally, network protectors used internal fuses designed primarily for overload protection, since early systems were limited to 216V mesh networks. These grids often included dozens of protectors feeding a common load area, which meant higher circulating currents and a greater likelihood of a protector remaining inadvertently closed. In this environment, fast acting internal fuses served as effective backup protection, quickly isolating a "hung closed" protector or a unit back feeding into the grid. Their speed was essential in preventing one malfunctioning device from impacting the many interconnected protectors within the mesh network.

After World War II, network systems began serving isolated load areas at higher distribution voltages, most commonly 480Y/277V or 600Y/347V. These voltages were well suited for spot network topologies, which could deliver more power at lower current levels, reduce copper requirements, allow smaller equipment, and improve overall system efficiency. They also aligned naturally with the growing use of 480V building equipment such as chillers, air handling units, pumps, elevators, and large UPS systems.

However, the move to 480V introduced new protection challenges—most notably the highly destructive and re striking behavior of 480V arc faults. Because of this, internal network fuses could not be used; their interruption ratings were not adequate for the higher energy levels. As a result, Westinghouse had to develop a new form of external fault protection capable of safely interrupting these severe events.

The NPL fuse was developed in 1975 by Westinghouse—later acquired by Eaton in 1994—to provide a dedicated high fault energy protection device for Network Protectors. As its name implies, the Network Protector Limiter (NPL) was specifically engineered for spot network applications, where severe 480V fault currents and re striking arc behavior demand robust, high interrupting capacity protection.

Earlier fuse types—such as Y and Z copper links and alloy links—were well suited for 216V mesh networks, where sensitive overload characteristics were more important than high fault interrupting capability. In those large mesh grids, dozens of protectors operated together, making quick isolation of overloads and back feed conditions essential.

Spot networks, by contrast, serve a single concentrated load and involve only a few protectors in parallel. In these systems, back feed likelihood is much lower, but the fault characteristics at 480V is significantly different. As a result, a slower acting overload characteristic is acceptable, while the ability to interrupt extremely high, re striking 480V faults becomes the top priority—the exact condition the NPL fuse was designed to address.

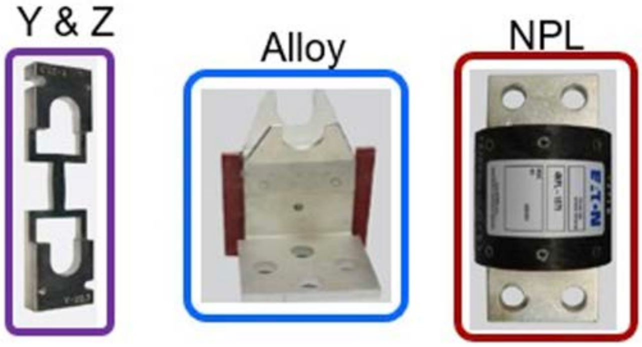


Photo 1: Typical Network Protector Fuse Choices

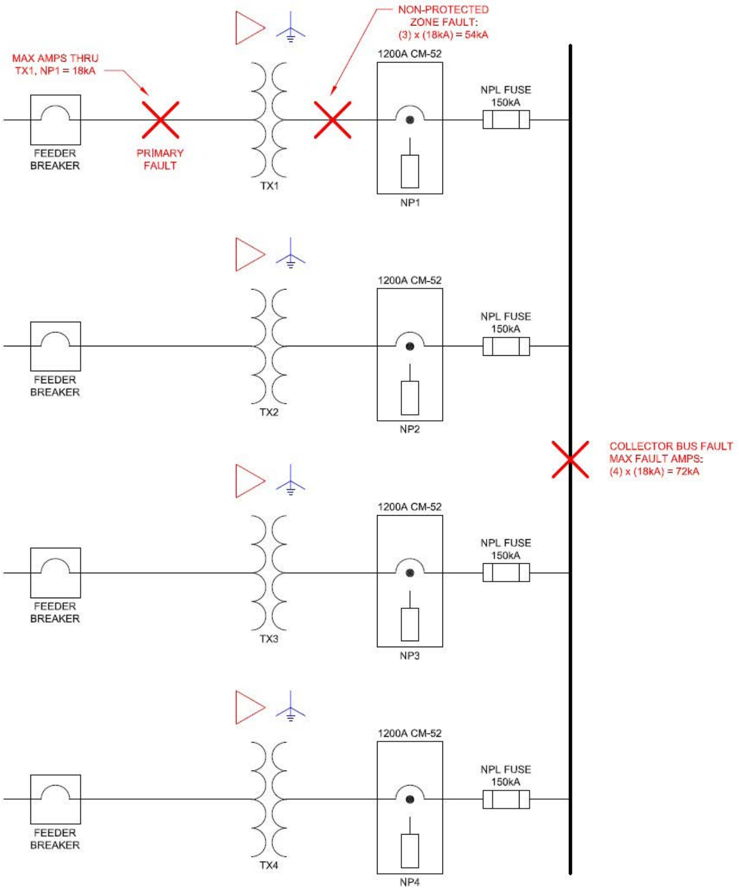
This example breaks down the fault behavior of a 480V spot network and explains why the NPL fuse is often specified at 150 kA interrupting rating, even when simplified calculations show fault currents far below that number.

The Spot Network: One Bus, Many Sources

A typical 480V spot network might consist of several identical transformers feeding a common 480V collector bus.

Example Data:

- Each transformer: 750 kVA
- Primary: 13.8 kV
- Secondary: 480V
- Transformer impedance: 5%
- Each transformer connected to the collector bus through a Network Protector (NP)



Immediately, it looks straightforward: four sources share the load and provide redundancy. But electrically, it creates a unique challenge:

Any fault on the 480V system may be fed by multiple transformers at the same time.

That fact changes everything about protection and interrupting duty.

Transformer Impedance: The Starting Point

Transformer impedance (often expressed as %Z) is a primary driver of available fault current. For short circuit estimates on the secondary, a commonly used approximation is:

I_sc ≈ I_FL / Z_pu

Where:

- **I_sc** = transformer secondary short circuit contribution (A)
- **I_FL** = transformer secondary full load current (A)
- **Z_pu** = transformer impedance in per unit

For a 5% impedance transformer:

Z_pu = 0.04 → I_sc ≈ 25 × I_FL

Calculating Full-Load Current at 480V

For a three phase 750 kVA, 480V transformer:

I_FL = 750,000 / (√3 × 480) ≈ 902 A
I_sc ≈ 902 / 0.05 ≈ 18 kA

This **18 kA** represents the maximum fault contribution from a single transformer.

The Additive Reality of a Parallel Network

A bus fault in a spot network is fed by **every transformer** in parallel.

Thus:

I_bus_fault ≈ N × I_sc

For four transformers:

I_bus_fault ≈ 4 × 18 kA = 72 kA

This alone is enough to determine network protector ratings, bus bracing, and arc flash mitigation requirements.

But **this is not the most severe scenario**.

The Hidden Worst Case: Back feed Faults Through a Single Device

The more dangerous condition occurs during a **transformer fault**, not a bus fault.

If one transformer faults, the **other transformers back feed** into that fault through the collector bus. The current through the affected network protector and its fuse becomes:

I_through_NP/Fuse ≈ (N − 1) × I_sc

For four transformers:

I_through_NP/Fuse ≈ 3 × 18 kA = 54 kA

This means a single NP and fuse assembly may see almost 54 kA during a transformer fault.

Traditional internal fuse types (Y, Z, alloy, or "S" fuses) are only **30 kA interrupting**, and—because they are mounted *inside* the protector enclosure—any arc event could spread into unprotected areas. These internal fuse types were acceptable for 216V grid networks but are not suitable for 480V systems.

In contrast, the NPL fuse is mounted **externally** and rated at **150 kA interrupting**.

Why the NPL Fuse Is Rated So High

Even though the calculated duty in this example is ~54 kA, a 150 kA interrupting rating is required because interrupting rating is a **survivability threshold**, not an operating current. The fuse must withstand the **maximum possible** fault energy at its terminals.

Interrupting rating must account for:

- worst case utility source strength
- possible future system upgrades
- initial asymmetrical (DC-offset) currents
- modeling uncertainty and equipment tolerances

High ratings such as 150 kA are typical for current-limiting silver-sand fuses used in network applications.

→

What Happens If the Fuse Interrupting Rating Is Too Low

If an NPL fuse were applied with only a 30 kA interrupting rating (Rating of internal fuses) where 50–90 kA is available, it may fail catastrophically. Instead of clearing the fault, the fuse could:

- rupture or explode, ejecting molten metal
- fail to interrupt and sustain an arcing fault
- damage Network Protector internal components
- escalate into a collector-bus failure
- cause a severe arc flash event

A fuse with insufficient interrupting capability can turn a clearing event into a destructive—and potentially life-threatening—incident.

When the NPL Fuse Should Operate

Under normal conditions, the NPL fuse should never operate. It is intended only for major, abnormal events such as:

- internal transformer faults
- faults in secondary leads or terminations
- Network Protector failure to interrupt
- extremely high-energy faults that require instantaneous current limitation

When an NPL fuse does operate, its external housings contain the event away from NP internals.

There are a few important caveats when using the NPL fuse—or any silver sand fuse:

1. **NPL fuses cannot be located inside the Network Protector enclosure** due to the heat generated during operation.
2. **They should not be mounted horizontally.** In a horizontal position, the sand filling can settle unevenly, potentially creating voids that may lead to premature fuse rupture.
3. **They must be protected from moisture.** The fuse tube contains sand and internal contacts that can be compromised if exposed to water.
4. **It can be difficult to determine whether an NPL is blown.** A continuity meter may still read conductive because silver particles create a tracking path through the melted silica, which solidifies into a glass-like structure. The most reliable field method is to place a small gauge indicator wire taut across the fuse and verify its presence through the viewing window. If the wire is missing—often accompanied by a black mark on the fuse barrel—the fuse has operated.

In summary, the NPL fuse is not intended for routine overload protection. Its purpose is to isolate catastrophic, high energy faults and protect the integrity of the 480V spot network. For 480V service, the NPL should be the preferred fuse type. Traditional internal fuses remain suitable for 216V grid applications, where reduced height and more sensitive overload characteristics are advantageous. 🅔

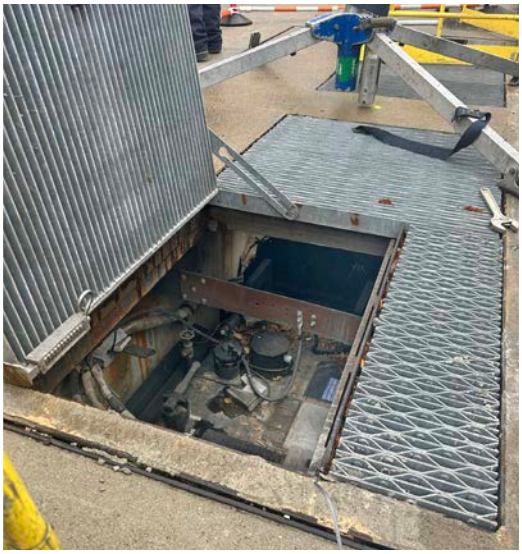
Advancing Underground Network Transformer Monitoring

Written by: Joe Rusin, Vice President, Transformer System Sales at H2scan

When asked about the current condition of their underground network transformer fleet, most utility operations managers must admit that they don't know. Across major metropolitan areas, thousands of network transformers deliver power to critical services, businesses, and residents while housed as part of an underground infrastructure. Condition monitoring of these vault transformers through periodic transformer oil sampling remains operationally impractical, logistically challenging, and prohibitively expensive.

The consequences are measurable. Transformer failures that could be detected months in advance through continuous monitoring instead occur without warning. These transformer failures can escalate into fires, compromise multiple transformers, disrupt service to thousands of customers, and create hazardous conditions for emergency response crews. Industry data shows the timeline from start of gassing to transformer failure averages six months, yet manual oil sampling occurs annually at best and in many cases, not at all.

The monitoring gap stems from fundamental operational challenges. Network transformers operate in hostile vault environments: confined spaces subject to heavy loading, elevated temperatures (exceeding 100°C), water infiltration, and debris accumulation. Accessing these confined vault spaces requires coordinated outages, vault preparation, confined space protocols and subsequent laboratory analysis of the oil sample. This entire process stretches maintenance budgets, and as fleet sizes grow and vault access becomes more difficult, monitoring stresses overworked maintenance crews.



Vault transformers are often in a hostile location, making maintenance and testing difficult.

The underground network monitoring challenge

Network transformers are subject to operational stresses that distinguish them from standard substation equipment. Heavy loading in confined vault spaces can raise transformer oil temperatures. These conditions accelerate the thermal degradation of insulating materials, producing hydrogen gas as the primary indicator of developing faults.

Unlike above-ground transformers, for which periodic dissolved gas analysis can be performed cost-effectively, accessing underground network transformers for manual sampling poses significant logistical and safety challenges.

Traditional monitoring solutions designed for substation transformers cannot withstand the extreme conditions found in network vaults. The combination of high ambient temperatures, elevated hydrogen concentrations during fault conditions and exposure to moisture creates an environment that damages standard monitoring sensors. Additionally, the economics of network transformer monitoring have historically been prohibitive—with hundreds of network transformers in a typical urban grid, the cost per unit must remain reasonable while providing reliable data.

Hydrogen is the first and most reliable fault gas, appearing before other gases during incipient fault development. However, monitoring hydrogen in network transformers requires sensors capable of measuring both absolute hydrogen levels, which can reach concentrations that would damage conventional sensors, and the rate of hydrogen generation, which provides critical early warning of developing abnormalities.

Purpose-built monitoring system

H2scan Corporation's HY-VAULT™ Underground Transformer Monitoring system addresses these challenges through an integrated solution combining the GRIDSCAN® 5015 hydrogen sensor with the AVO-1 interface device. The GRIDSCAN 5015 was engineered specifically for the extreme conditions encountered in network transformers, with a measurement range extending from 250 PPM to 50,000 PPM and continuous operation capability at temperatures up to 80°C. This extended range proves essential in network applications where hydrogen concentrations during fault conditions far exceed levels found in typical substation transformers.

The system employs patented self-calibration technology that eliminates sensor drift and the need for periodic calibration. The sensor's proprietary integrated circuit, paired with field-proven solid-state sensing elements, provides reliable hydrogen detection in environments where conventional electrochemical sensors would fail or require frequent replacement.

The AVO-1 interface device extends monitoring capability to previously inaccessible vault locations. Network transformer vaults often lack the communications infrastructure available in substations, requiring monitoring solutions that can operate with limited connectivity while still providing actionable data to system operators. The AVO-1 addresses this gap, enabling data collection and transmission from remote underground locations while maintaining the IP rating necessary for reliable operation in humid vault environments.

HY-VAULT offers operators marine-grade corrosion resistance for reliable operation in the harshest vault conditions. Rapid deployment allows installation and commissioning in hours rather than weeks, while connectivity options, including Modbus and analog outputs, enable seamless integration with existing utility infrastructure.

Technical implementation and benefits

The HY-VAULT system provides continuous monitoring that has the capability to alert network operations teams to incipient faults as they develop, rather than after catastrophic failure occurs. By tracking both absolute hydrogen levels and rate of change, the system enables operators to distinguish between normal thermal hydrogen generation, which increases gradually under load, and accelerating fault conditions that require immediate attention. This dual-measurement approach reduces false alarms while ensuring genuine fault conditions trigger an appropriate response.

Installation of the HY-VAULT system integrates with existing network transformer infrastructure without requiring extensive modifications. The sensor mounts directly to the transformer, eliminating the need for complex sampling systems or additional vault penetrations. This straightforward installation reduces deployment costs and minimizes service interruptions during system commissioning.

The system's data enables utilities to transition from reactive maintenance—responding to failures after they occur—to predictive maintenance strategies based on actual equipment condition. Operations teams can prioritize field interventions based on real data rather than age-based replacement schedules, optimizing resource allocation while improving system reliability. When hydrogen trends indicate developing problems, transformers can be de-energized and removed during planned outages rather than emergency response situations.

Addressing industry-wide infrastructure challenges

The timing of viable network transformer monitoring solutions coincides with mounting pressures on utility operations. Workforce shortages across the electric utility industry compound the challenges of maintaining aging infrastructure through labor-intensive manual processes. Supply chain constraints have created unprecedented lead times for transformer procurement, with reports indicating delivery times of 30 to 100 weeks for new units. Multiple factors contribute to these delays:

- surging demand driven by renewable energy integration
- data center expansion
- increasing electrification
- raw material constraints
- manufacturing capacity limitations

In this environment, the traditional "run to failure" operational approach becomes untenable. Every transformer failure not only triggers immediate emergency response costs but also potentially initiates a two-year wait for replacement equipment. Network transformer failures often affect multiple adjacent units and associated infrastructure. Vault fires can damage cables, switchgear, and nearby transformers, multiplying repair costs and extending restoration timelines.

Early detection of transformer faults significantly improves personnel safety by reducing exposure to hazardous conditions. Field crews responding to transformer failures face risks from electrical arcs, hot gases, and fire. Continuous monitoring enables proactive intervention before conditions escalate to catastrophic failure, allowing maintenance work to proceed under controlled conditions rather than in emergency situations.

System operators gain visibility into transformer fleet condition that previously required periodic manual testing—a process that is both labor-intensive and potentially hazardous due to vault access requirements. Continuous data collection provides trend information that manual snapshots cannot capture, revealing gradual degradation patterns that might otherwise go unnoticed until failure.

Modern solutions for an age-old problem

For the first time, an underground monitoring system offers a solution to the unique challenges of vault environments through purposefully designed and manufactured technology. The HY-VAULT system provides utilities with a cost-effective means of protecting critical infrastructure, improving operational safety, and transitioning to predictive maintenance strategies. As urban networks continue supporting increasing load density and reliability requirements, continuous transformer monitoring establishes a foundation for more resilient power delivery systems.

For utilities operating network systems, the question has shifted from whether to monitor network transformers to how quickly monitoring can be deployed across the fleet. The combination of proven solid-state sensing technology, maintenance-free operation and integration capabilities positions continuous transformer monitoring as a standard practice for modern network operations—one that enhances both safety and reliability while reducing total cost of ownership through avoided failures and optimized maintenance strategies. Ⓔ

About H2scan

H2scan, a pioneer in the development of hydrogen sensor technology, has been at the forefront of innovation for more than two decades. Building on a strong foundation of research and development, including proprietary solid-state technology pioneered at Sandia National Laboratory and the U.S. Department of Energy, H2scan has established itself as the preferred provider of leading hydrogen sensors, analyzers, and systems. The operating life of its sensors surpasses that of other commercially available systems, and the company's new Gen.5 solutions with self-calibration offer unparalleled accuracy, maintenance-free operation and cost-effectiveness.

Trusted by industry giants, like ABB, ExxonMobil, NASA and others its products are integral in shaping the new Hydrogen Economy for a clean, secure, and affordable energy future. With sensors deployed across all six continents in 190 countries, H2scan products protect more than $3.2 billion in transformer assets. Our comprehensive monitoring solutions are used by power utilities for transformer fleet monitoring, by the petroleum and chemical industries to optimize hydrogen-based processes, and for safety monitoring in enclosed areas susceptible to hydrogen leaks.

H2scan's proprietary self-calibration technology delivers the clean, reliable data that AI and predictive maintenance initiatives demand—eliminating costly data cleanup while protecting current operations. Tomorrow's winners are collecting accurate data today. H2scan holds 40 patents covering its core technology, software, and product innovations.

For more information, visit www.h2scan.com.

Impact of Non-Linear Loads on Network Transformers

Written by: Nabi Almeida, Product Development Manager, Prolec

Electric distribution systems across the United States are experiencing a major shift in the types of grid-connected loads. The distribution grid—residential, commercial and light industrial—commonly sees the following:

- LED lighting
- Variable frequency drives (VFDs)
- Computer servers and data centers
- EV chargers
- Solar photovoltaics (PV) and battery energy storage (BESS)

These technologies bring energy savings and better control, but they also introduce new electrical behaviors. Many of these devices do not draw current in a smooth, sinusoidal waveform. Instead, they draw "non linear" current which contains harmonics (currents and voltages at higher frequencies than the normal 60 Hz waveform).

Harmonics and inverter based technologies affect transformers in the following ways:

- Increasing heat inside the core and windings
- Raising hot spot temperatures
- Stressing insulation
- Increasing the chance of gas generation in transformer oil
- Changing the direction of power flow (reverse power flow)

For network transformers, especially those installed in underground vaults, these impacts can be more severe because the transformers operate in confined spaces with limited cooling. As non linear loads continue to grow, understanding these effects becomes more important, not only for engineers but for system operators, field crews, and maintenance teams.

The impact on network transformers

Network transformers serve dense urban areas and often sit inside underground vaults. Several characteristics make them more sensitive to today's load environment:

Limited Space and Cooling
Vaults typically have the following characteristics:

- Fixed dimensions
- Restricted airflow
- Limited heat dissipation

Transformers installed in vaults rely on carefully designed thermal margins. When load characteristics change (especially with harmonics), this thermal balance can be disrupted.

Designs Based on Older Load Assumptions
Most network transformer designs were standardized decades ago when conditions were as follows:

- Residential loads were mostly resistive
- Harmonics were low
- Reverse power flow did not exist
- Load variability and fast changing loads were rare

Today's load shapes look different.

Reverse Power Flow from Distributed Energy Resources (DERs)
Solar units and home batteries can push power back onto the grid. For the transformer, this means:

- The magnetic core goes through a re magnetization process
- Additional excitation current flows
- Core losses increase
- Hot spots can shift compared to normal forward flow

This adds new stresses not considered in older transformer designs.

How non linear loads change transformer behavior

Transformer losses can be grouped into three categories:

1. Core (no load) losses – from energizing the steel core
2. Load losses – from current flowing in the windings
3. Stray losses – heating in clamps, tank walls, leads, and nearby metal

Harmonics increase items 2 and 3, while reverse power flow affects item 1.

Core Loss Distribution: Why Losses Concentrate in Specific Areas

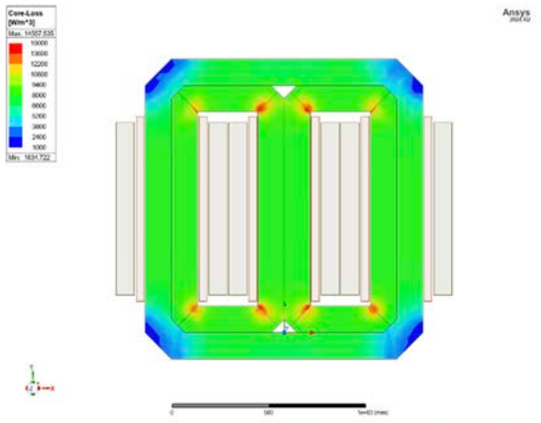


Figure 1 - Core loss distribution (wound core)

The image shows the areas of the core where losses tend to concentrate, in corners and yoke to leg transitions. These regions already have higher flux density, and harmonics push them even harder.

But why should field crews and system operators care? Higher losses mean extra heat, which makes oil run hotter and reduces overload capability. In vaults with poor ventilation, this can cause temperature alarms, oil degradation, or repeated over temperature trips.

Winding Temperature Distribution: How Hot Spots Develop

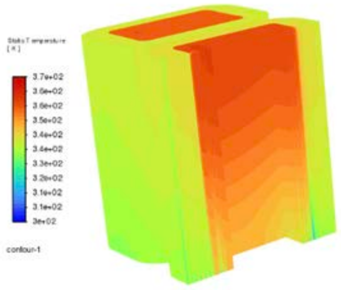


Figure 2 - Winding temperature distribution

Figure 2 thermal model shows how temperatures rise in transformer windings:

- The top of the winding is the hottest because heated oil rises
- Harmonics increase eddy losses (which grow with frequency squared)
- Stray flux heats leads, clamps, and structural parts
- Hot spots form where current density is highest

These conditions can lead to accelerated insulation aging which reduces transformer life and increases fire risk. Hot spots can cause faster gas generation showing up in DGA tests, and persistent high temperatures can trip network protectors or alarms.

Harmonic Waveforms: What Non Linear Load Current Looks Like

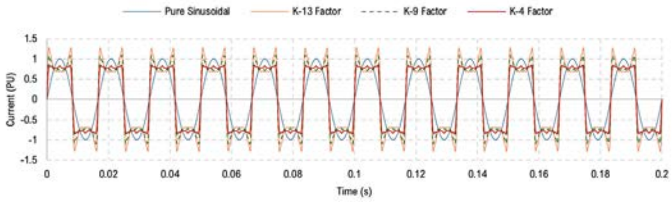


Figure 3 - Example of different K-factor waveshapes

Figure 3 shows four waveforms:

- Pure sinusoidal current (no harmonics)
- K 4 load
- K 9 load
- K 13 load (very harmonic rich)

As harmonics increase, the waveform gets more "peaky," and the RMS current increases even if the average load does not. Heating inside the transformer increases, and voltage distortion can spread to nearby equipment.

This all matters in real-life operations. A transformer may look lightly loaded on SCADA but run unusually hot. Harmonic currents reduce the effective capacity of the transformer, and K factor rating (or de rating) helps determine safe load levels.

Combined Thermal and Electrical Stress

Harmonics do more than just add heat. They change how the insulation behaves electrically.

Electrical Stress

Distorted waveforms have higher peak voltage, faster rise times, and a greater chance of initiating partial discharge (PD). All of these can damage weak points in a transformer's insulation.

Thermal Stress

Higher temperatures:

- Accelerate paper aging
- Promote oil oxidation
- Reduce dielectric strength
- Increase risk of thermal faults (seen as ethylene/acetylene in DGA)

How These Two Stresses Reinforce Each Other

High temperature → weaker insulation → more electrical stress →more damage→ higher temperature.

This cycle shortens transformer life significantly if not addressed.

How to Manage the Impact of Non Linear Loads

For new transformers

If harmonic loads or DERs are expected:

- Specify harmonic rated (K factor) transformers
- Request enhanced cooling or improved thermal design
- Use materials tolerant of high frequency heating
- Ensure adequate thermal margins for vault environments

For transformers already in service

De rating

Using IEEE Std C57.110, utilities can calculate allowable transformer loading under harmonic conditions and determine whether derating is required.

Install Harmonic Filters

When de rating is not acceptable, filters can reduce harmonic currents. These include passive filters (fixed tuning), active filters (dynamic cancellation), and hybrid systems.

Increase Monitoring

- Track hot spot temperatures
- Use or install DGA sensors
- Record harmonic levels (THD, individual orders)
- Compare current conditions with historical trends

Increased monitoring of the above conditions allows for early detection of stress and informed maintenance planning.

Conclusion

Modern load behavior, especially non linear loads and inverter based technologies, has introduced new challenges for network transformers. These units were not originally designed for harmonic currents, high frequency effects, or reverse power flow, making it essential to understand and manage these impacts.

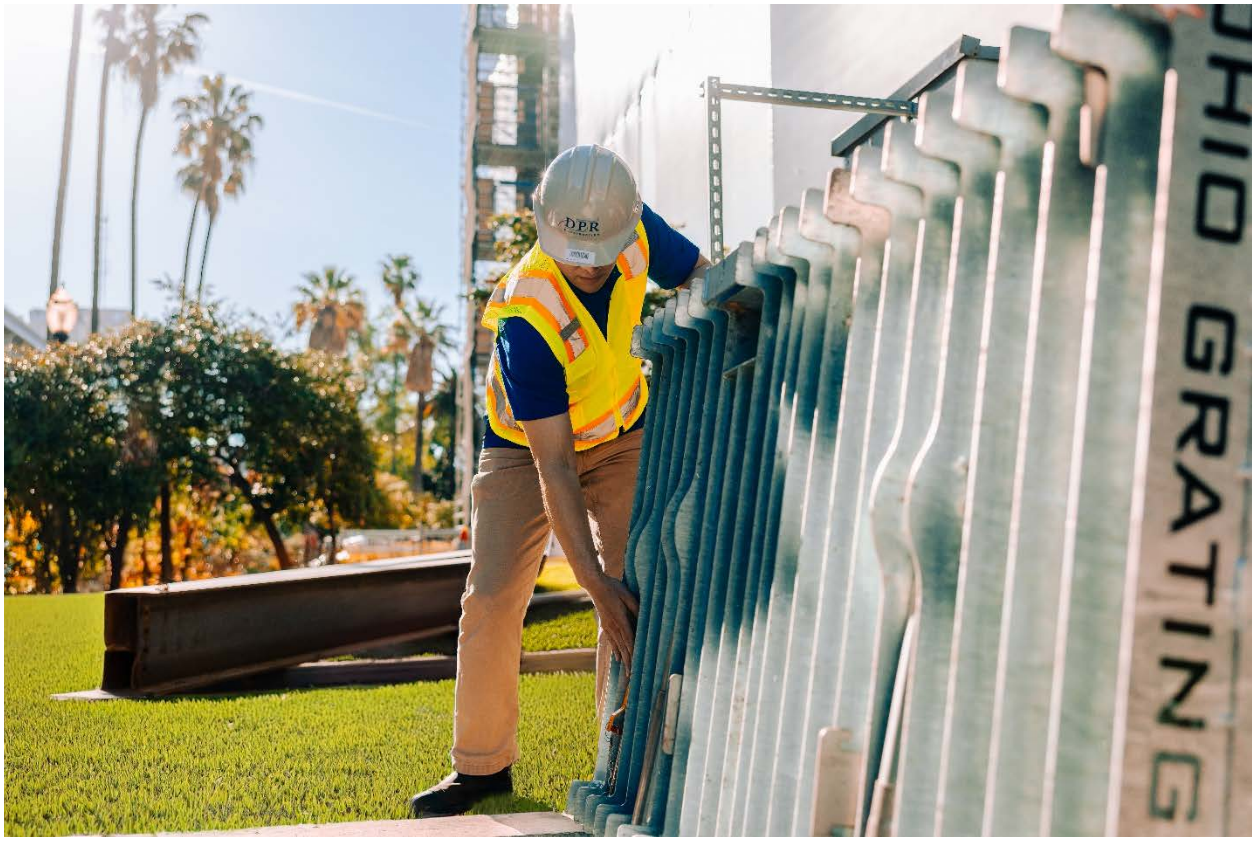
For engineers, field personnel, and system operators alike, this means:

- Being aware of how harmonics influence heating and transformer life
- Monitoring load characteristics beyond simple kVA
- Updating specifications and operational practices
- Using de rating, filtering, or improved monitoring where needed

By taking these steps, utilities can improve asset reliability, reduce unplanned outages, and extend the life of critical network transformers.

Grater Balance® Delivers Stronger Vault Access—With Just One Hand!

Written by: Ohio Gratings, Inc.



Grater Balance ergonomic access systems provide a safe, easy and secure method for individual workers to quickly access underground structures without cranes and other costly mechanical equipment.

Why Vault Access Is Becoming a Safety Priority

CANTON, OHIO – For underground network crews, a job often does not begin with the transformer or the relay… It begins with the cover.

In many cities, accessing underground electrical equipment still requires cranes, rigging, traffic control and multiple workers to remove heavy concrete or steel panels. What should be routine maintenance can quickly become a coordinated operation. Each step adds time. Each lift introduces exposure to risk for workers in the field and potential damage to equipment. As service territories expand and crews remain lean, those inefficiencies matter.

"The access piece was slowing everything down," said Aristotle Zournas, specialty products manager at Ohio Gratings, Inc.

"We kept hearing the same thing from utilities. The equipment underground was modern. The cover above it was not. This increased the risks for everyone involved, including utility workers."

According to the Bureau of Labor Statistics, one in every 100 utility workers missed work due to injury in 2023. The National Safety Council reports that back injuries cost employers an average of $40,000 per incident. Many of those injuries are linked to lifting and overexertion.

For utilities measured on both reliability and safety performance, access is no longer a minor detail.

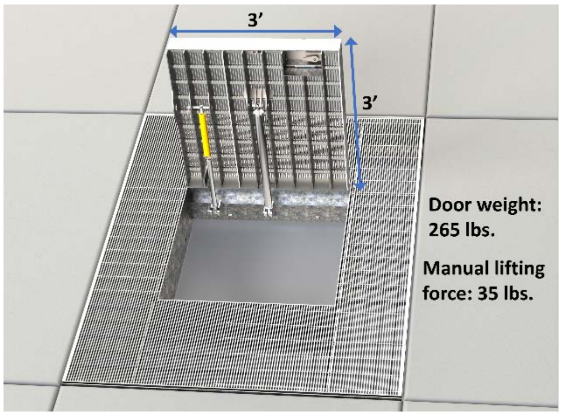
Designing Access Around the Worker

Traditional vault entry often requires installing lifting lugs, coordinating mechanical equipment and reversing the entire sequence once service is complete. The physical demand placed on crews can be significant.

In response to repeated customer feedback, Ohio Gratings developed Grater Balance®, an access system that incorporates a counterbalance mechanism to offset door weight. Field demonstrations show that doors weighing several hundred pounds can now be raised with substantially reduced lifting force, allowing a single worker to open the hatch while maintaining a controlled, proper lifting posture.

"The magic is in the design," Zournas said. "We engineered the lift so crews are not fighting the weight. It can now be opened with just one hand."

Doors are designed to descend in a controlled motion and balance at an approximate midpoint, reducing the risk of pinch and impingement injuries associated with the uncontrolled closing of panels. Mechanical components are housed within the assembly to promote consistent performance in both hot and cold environments.



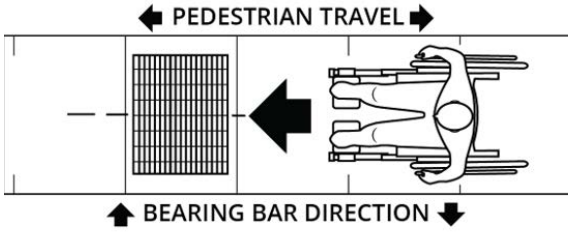
Access hatch doors are counterbalanced for safe, easy and ergonomic manual lifting.

The intent, Zournas said, was to make vault entry routine rather than demanding.

"When you remove strain and complexity, crews can focus on the actual electrical work instead of the logistics of getting into the vault," he said.

Preparing for the Unexpected Load

Worker safety is only one side of the equation. Vault covers installed in sidewalks must comply with Americans with Disabilities Act guidelines for pedestrian safety, including bar spacing and slip resistance.



ADA: Surface bars must span perpendicular to the predominant flow of pedestrian traffic.

However, not all sidewalk covers are engineered for heavy vehicular loading.

Fire trucks, sanitation vehicles and delivery trucks can mount sidewalks unexpectedly. Covers not designed for that load can warp or fail, creating hazards that may not be immediately visible.

Ohio Gratings engineers its vault covers to meet American Association of State Highway and Transportation Officials H-20 loading requirements, which account for axle loads up to 32,000 pounds.

Hazardous Conditions: Damaged Vault Covers

That rating is intended to prepare the surface for the unexpected vehicle, not just routine foot traffic.

“In busy downtown environments, you have to assume a heavy vehicle could end up on that surface,” Zournas said. “If the cover is not designed for it, you are creating a long-term risk."

From Custom Installs to Consistent Standards

As utilities modernize underground systems, some are also reevaluating variability in their vault cover specifications.

Recently, Ohio Gratings worked with a major metropolitan utility to replace existing vault tops that were neither ADA compliant nor properly rated for vehicular loading. The upgrade included new galvanized frames, properly rated grating and integrated ergonomic access doors.

Once installed, the utility chose to standardize their frame depths and panel sizes for future projects. Maintaining consistent opening dimensions simplified replacement planning and reduced the need for custom fabrication on each installation.

“We are seeing more utilities reviewing and updating their specifications,” Zournas said. “When opening sizes and access systems are consistent, future projects become much more manageable.”

Modular designs enable faster lead times.

Grater Balance systems accommodate clear spans up to nine feet without center support and can be configured in solid plate, bar grating or combination designs. Standard systems provide open areas ranging from 52 percent to 76 percent, typically satisfying airflow requirements for heat-emitting equipment such as transformers while maintaining structural performance.

Covers can be installed in new construction or retrofit into existing frames, providing flexibility without requiring full vault replacement. Replacing vault tops is significantly more cost effective than rebuilding the entire structure and allows utilities to address safety and compliance concerns proactively.

Vault covers are available in both metal bar grating & solid plate to meet the requirements of any application.

Access That Supports Reliability

As underground systems age and network demands increase, utilities continue evaluating how design decisions affect daily operations.

Vault access may not draw the same attention as advanced relays or communications equipment, but it directly impacts worker safety, service speed and public protection.

"Our mission is to offer solutions that make a tangible difference in everyday operations," Zournas said. "When access is safer and more efficient, crews can focus on the work that keeps networks reliable."

For utilities reviewing vault standards, considering ergonomic access systems and properly rated covers can represent a practical step toward improving both safety metrics and operational efficiency.

Utilities interested in learning more about vault cover standards, ergonomic access systems or specification updates can connect with the Ohio Gratings Specialty Products team to continue the conversation. Simply call Ohio Gratings at 1.800.321.9800 or visit their website at www.OhioGratings.com.

Aristotle Zournas (azournas@ohiogratings.com) serves as the specialty products manager for Ohio Gratings, Inc. He holds a bachelor's degree in electrical engineering from The University of Kavala in Greece and studied civil engineering at The University of Akron. He brings a wealth of expertise to the industry with over 20 years of experience in structural analysis, product design and development, manufacturing and sales. Aristotle provides innovative design solutions to help engineers meet their unique product needs, applying more than 18 years of metal bar grating industry knowledge with a focus on city sidewalk vault applications.

About Ohio Gratings: Since 1970, Ohio Gratings, Inc. has been a leader in metal bar grating design, manufacturing and custom fabrication services. Their products are used in industrial, commercial and architectural applications for walkways, catwalks, trenches, stairs, bridge decks, screens, grilles, fencing, mezzanines and shelving. Ohio Gratings is headquartered in Canton, Ohio. For more information, visit www.ohiogratings.com

JSHP
Transformer

NETWORK TRANSFORMER

ANSI/IEEE C57.12.40, CSA C199
EXPLOSION PROOF DESIGN

JSHP Design

The design strictly follows ANSI/IEEE C57.12.40 2024 and also comply with DOE 2016 and DOE 2029 efficiency standards.

The tank can withstand 22 MJ explosion without rupture.

Key Feature

Best operational and public Safety with the field tested explosion-proof tank design and controlled rupture at extreme situation.

Best Lead Time

With JSHP capacity , JSHP has best lead time in the world for mass production of network transformer.

JSHP Transformer has 59+ years of history and supplies the transformers up to 850kV 1500MVA and also supplies explosion-proof off-shore wind application cell transformers up to 66kV 16MVA.

The Network Transformer product line includes capacities from 300 kVA to 2,500 kVA, with high-voltage ratings from 2.4 kV to 34.5 kV, and low-voltage ratings from 600 Volts, comply with DOE 2016 or DOE 2029 efficiency standards.

Per ANSI/IEEE C57.12.40, JSHP's network transformers are for vault-type or subway-type applications. Vault-type network transformers are designed for installation in above-ground dry vaults, where occasional submersion may occur. Subway-type network transformers are designed for installation in subsurface vaults, where frequent or continuous submerged operation is likely. Subway designs can also be used in vault-type applications.

- **All transformer tanks are designed in accordance with ANSI C57.12.40 and constructed with copper-bearing steel with a minimum content of 0.20% of copper.**
- **The JSHP tanks can withstand 50 PSIG pressure and withstand at least 22 MJ internal arcing explosion without rupture.**
- **Even with extra pressure/energy, The JSHP tanks/enclosure design will make sure it only rupture from the bottom.**
- **All tank surface is grid-blasted and then painted with a rich zinc primer, followed by an epoxy-polyamide coating to provide a minimum total dry-film.**
- **The primary three-pole, three position disconnecting and grounding switch is located in the HV switch chamber and complies with ANSI. It is available as a two or three position switch. The switch can be of the "Mag-Break" type for fast interruption of the exciting current. All interlock features comply with ANSI C57.12.40.**
- **JSHP also works with the network transformer protector vendors closely so JSHP can provide an integrated network transformer with protector as one package.**

See Arc Withstand Test
No Rupture

8KA/1s Arcing
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25KA/1s Arcing
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Contact Us: *Info@jshp.com* *WWW.JSHP.COM*

Cleer™ multi-point junctions

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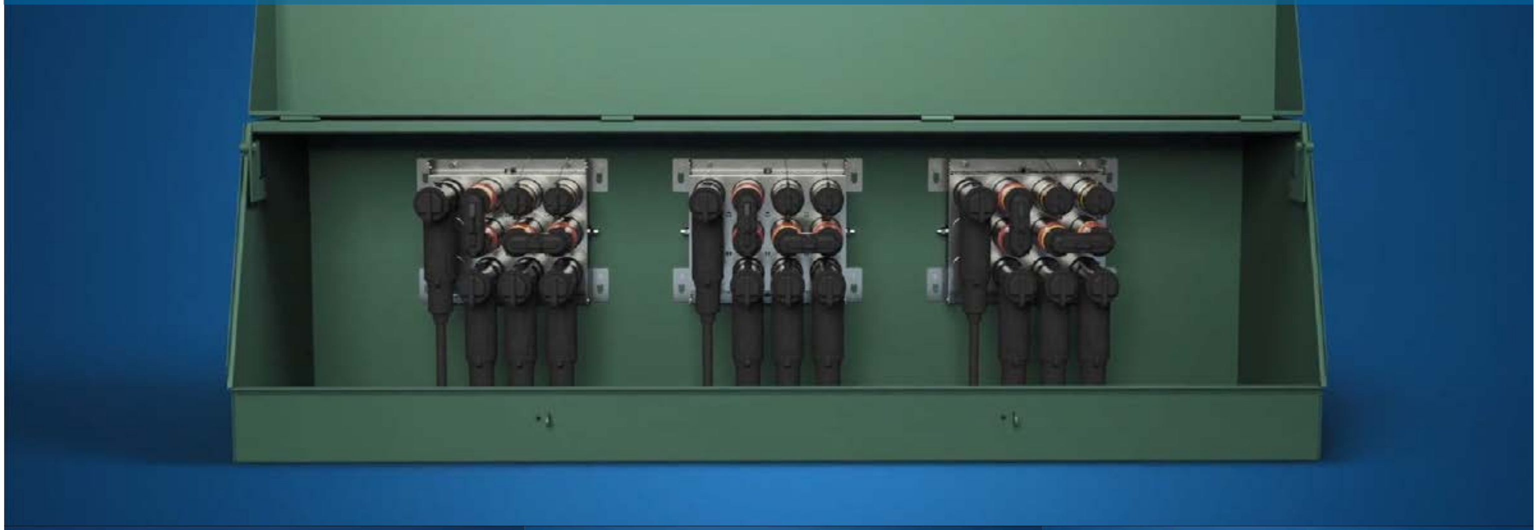

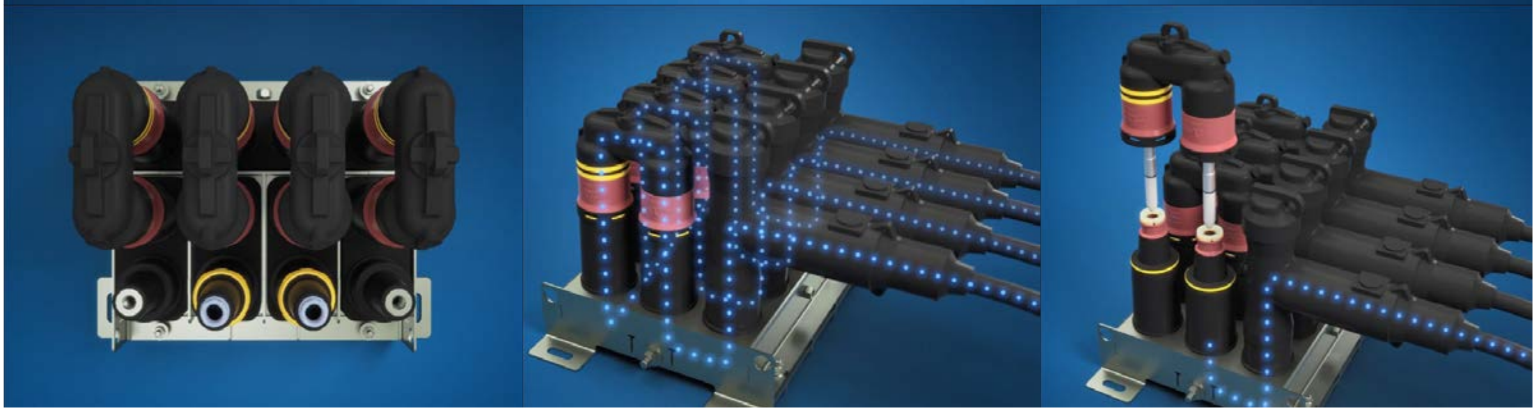

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- ✓ Eaton Vaultgard optimization, network relay support and system performance analysis.

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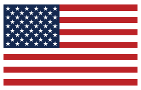
MPCV-NXG
Network protector relay

The intelligent investment for tomorrow's grid



Made in America

Powering Business Worldwide

The MPCV-NXG network protector relay represents the next generation in network protector relay technology while continuing to offer the most popular features from previous Eaton MPCV series network protector relays. The MPCV-NXG relay is designed to deliver state-of-the-art intelligence, best-in-class embedded cybersecurity and unparalleled scalability to future-proof your investment. Smarter, faster and more flexible than any predecessor network protector relay, the MPCV-NXG relay helps utilities enhance reliability and efficiency, reduce operational and maintenance costs, and protect systems against mounting threats—today and well into the future.

Intelligence

This exceptionally powerful and intuitive relay utilizes internal algorithms to identify DER backfeeds.

Note: Requires an additional module for network protector.

Embedded security

Integrated security tools guard against cyber threats and unauthorized access.

Expandable

Modular, scalable platform allows interconnection of multiple relays for the evolving grid.

Compatible

Configuration retrofit option allows for pairing with Eaton's state-of-the-art CM52 network protector or any legacy network protectors.

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2007 Columbia, South Carolina

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2009 Clearwater, Florida

2010 Cincinnati, Ohio

2011 Fort Worth, Texas

2012 Savannah, Georgia

2013 Albuquerque, New Mexico

2014 Indianapolis, Indiana

2015 Tempe, Arizona

2016 Portland, Maine

2017 Saint Louis, Missouri

2018 Madison, Wisconsin

2019 San Fransico, California

2022 Houston, Texas

2023 Birmingham, Alabama

2024 Colorado Springs, Colorado

2025 Sacramento, California

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26th Annual

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