# Metal Enclosed Electrical Bus – The Lifeline to the Transformer: What You Should Know and Why It's Important to Your Bottom Line

by **Mohsen Tarassoly**

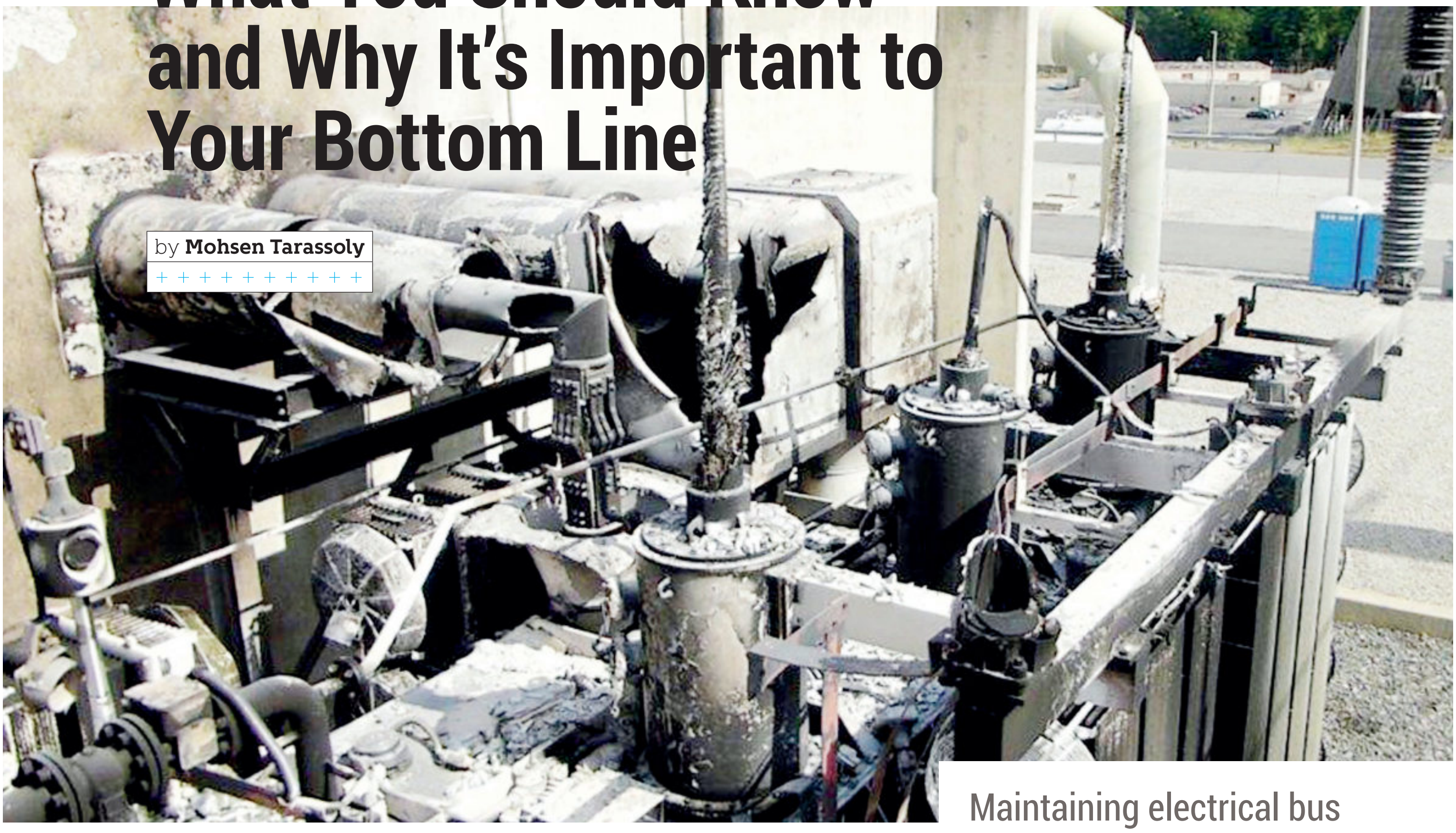

Photo: Electrical Builders

Most of us know what happens when a catastrophic event occurs at a transformer; power distribution comes to a grinding halt and plant personnel scramble into action to assess the damage and try to piece together the root cause in order to bring the system back to full operation as quickly as possible. However, what is almost always unexpected, is the logistics of replacing damaged electrical bus duct, an often-overlooked system critical component spanning from the generator to the main transformer, carrying the system's full current. When a failure occurs, and the electrical bus duct is impacted, the entire energy producing system shuts down until the components and its appendices are repaired or replaced. The unplanned downtime often results in the revenue loss of hundreds of thousands of dollars while the plant isn't generating power.

Metal enclosed electrical bus duct is custom designed and built specific to each plant's specific electrical parameters. It has no moving parts. It also has no redundancy, despite it being a critical component in the overall generation system. Understanding the bus type connected to your transformer and the standard by which the bus is designed, is important. While there are many standards that cover different aspects of electrical bus duct, the current standard followed by all U.S. bus manufacturers is IEEE C37.23-2015. This standard supports four types of bus designs: Isolated Phase Bus (IPB), Segregated Phase Bus (Seg), Non-Segregated Phase Bus (Non-Seg), and Cable Bus. Most generators delivering current in the voltage range of 15 kV to 38 kV will have IPB installed. This doesn't mean you won't see systems connected with Cable Bus or Non-Seg Bus; it simply means IPB is the preferred bus to use. The main difference between IPB and the other bus types, is how the bus functions. Made primarily from

> Maintaining electrical bus is just as important as maintaining your generator and transformer.

aluminum, each phase conductor of IPB is housed inside its own enclosure with air space separating each phase. Assembled enclosure and conductor sections are welded together in the field except at termination to the major equipment where bolted flexible connectors are used. IPB design is also referred to as zero flux design since once energized, induced current from the conductor, flows through the housing, in the opposite direction from the phase current producing a magnetic field in the enclosure opposite to the conductor's canceling each other out. Additionally, the forces created between conductors during a short circuit event will be significantly reduced. All other bus types produce very little induced current by the conductors, resulting in minimal magnetic fields in the enclosure. In short, the advantages of using continuously welded IPB are minimizing phase-to-phase faults, eliminating proximity effect for extra forces and heating, personnel protection (safe to the touch), and pliability. These factors make IPB the preferred bus design of choice for power generation.

Regardless of type, each bus electrical bus system is unique, and custom designed for each plant. While all bus manufactures must comply with the same IEEE design standards, each manufacture has their own specific method of constructing bus, which is unique to their company. However, what makes the bus a highly customized product, aside from meeting the plant's specific electrical profile, is the bus layout from the generator to the main step-up transformer. The electrical bus system must weave through the plant and accommodate the changing elevations, twists, turns, connections to various cubicles, etc., all while maintaining the appropriate clearances and navigating through possible space constraints. When the bus meets at the transformer, the bus to transformer termination arrangement is housed in a customized aluminum compartment, also referred to as the "doghouse". The doghouse contains the connections to the transformer bushings, all terminations typically using copper flexible connectors, rigid Copper adapter bars, and is bolted to the transformer face or top depending on the bushing orientation and in consideration of the required clearance to the high voltage side. As such, it is subsequently critical that the transformer termination configurations are designed appropriately to accommodate the fit up to both IPB and low voltage bushings of the transformer. For these reasons, when a failure occurs or transformer change-out is required, rarely is "like-for-like" replacement equipment readily available. Even when a "like-for-like" is planned, history and experience demonstrate that existing equipment conditions and environmental factors nearly always result in necessary bus modifications, fabrication of replacement components, transformer termination re-configuration, and proper assessment, planning and installation by an experienced bus duct service provider. All of these aspects are critical to minimize downtime and ensure safe and efficient return to service.

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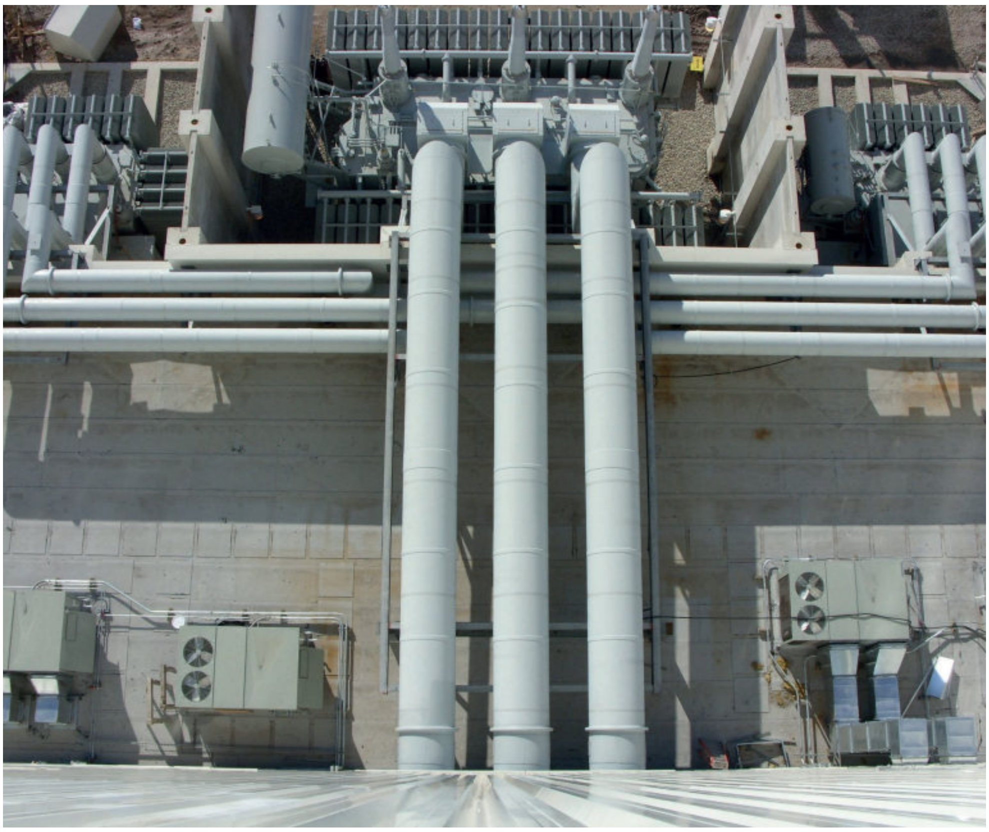

Even though the metal enclosed bus system is an integral component of the generation system, many engineers and plant maintenance personnel have limited awareness and experience of bus duct design, required maintenance procedures and frequencies, and best practices for transformer change-outs. This type of knowledge and expertise is unique and typically not covered in college curriculums, including engineering. This is one of the many reasons why the electrical bus system is often neglected and an afterthought when developing most contingency plans. When the unexpected occurs and the bus system is impacted, often, plant personnel don't know who to call for repairs or where to find replacement parts. This causes further delays and ultimately, impacts the bottom line. Some plants are so unprepared they mistakenly hire contractors who are unqualified to handle bus duct maintenance and repairs, putting the entire system and those around it at further risk. Partnering with a proven and experienced bus duct contractor to develop a proactive emergency service and repair plan is critical to extend the life of the plant's critical assets and is highly recommended as a best practice approach for leading power generation utilities.

Unfortunately, the pandemic has introduced further challenges. Several experienced personnel close to retirement have opted to leave their long-standing positions, oftentimes without sufficient onboard training for those taking over their roles. This has resulted in knowledge and data transfer loss. Incoming replacement personnel often must go to great extent to find and collect system critical component data and history. Even when this information is located, often, crucial information is missing, illegible, or inaccurate. Further complicating the issue, the need to identify the right parts, and dealing with lead-times on replacement parts and materials that have been significantly extended due to decreased production and availability as a result from the pandemic. These pitfalls result in inaccurate RFQs, unforeseen change orders and major project delays. Worse yet, if the plant encounters an unplanned outage or failure, these pitfalls will impact how quickly the plant can get back online.

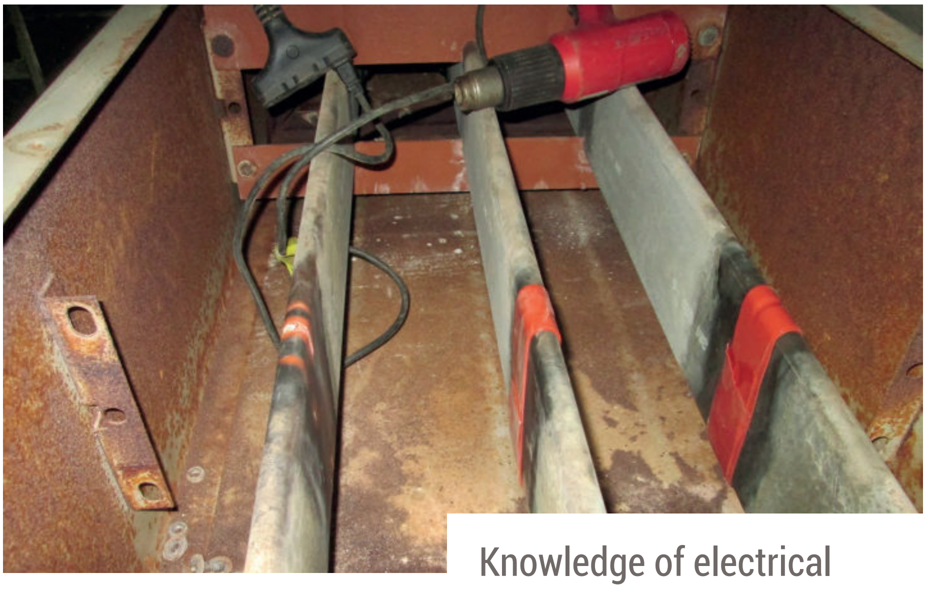

Photo: Electrical Builders

Unfortunately, a growing number of plants have adapted a "run-to-failure" or "reactive" maintenance and repair approach. Compared to a "proactive" maintenance strategy, the reactive strategy appears to be less costly on the surface but waiting until something fails is a big gamble, and a safety risk. A risk that can significantly lower efficiency and further aggravate what could be a smaller, preventable issue, complicating an already critical situation. Opting for a proactive maintenance strategy can contribute significantly to the company's profit and losses (P&L) and certainly the opposite is true if an unplanned outage or catastrophic failure occurs. In fact, statistics have shown that a run-to-failure (reactive) maintenance strategy can cost 2-5 times as much as implementing a routine proactive, preventative maintenance schedule. In some cases, these numbers can be significantly higher (up to 10-15 times) with a much larger impact to the bottom if the failure occurs during peak power production schedules, when the generation system is being pushed to the limit and indirect costs are introduced into the mix. As such, the need for having an iron clad contingency and proactive, preventative maintenance plan has never been more prevalent.

Industry best practice recommends that "offline" bus duct inspection and maintenance to be performed annually at every scheduled plant outage, or at a minimum of every 18-24 months. However, over the past few years, there has been a strong movement in the power generation industry for digitalization and the ability to be able to monitor the systems' critical assets online as an early warning tool. Different technologies such as Electromagnetic, Infrared, Acoustic, Ultrasonic, etc., have been utilized initially for transformers and generators and extended more recently for bus systems. In most cases, this has caused a misconception that offline bus duct inspection and maintenance can be postponed or ignored. The monitoring systems today primarily monitor for detection of partial discharge, corona, arcing, etc., but fall short of monitoring for presence of temperature elevation, moisture and humidity, degradation of components such as insulators, gaskets etc. The outcome of the monitoring system usually represents some non-definitive "value" requiring further interpretation. A well-planned

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Over the past few years, there has been a strong movement in the power generation for utilization of online monitoring options, adding to the misconception that offline inspection maintenance can be post-poned, which can be a costly decision.

and comprehensive offline visual inspection can eliminate these uncertainties and can identify the source of issues as well as offer a permanent fix. Employing online monitoring system also cause plants to divide their budgets across two activities with partial results, versus one that provides certain results (offline inspection).

It is important for leading utilities to partner with a proven and experienced bus duct contractor they can rely on to proactively manage these critical electrical assets on their behalf. This approach results in less down time, increased operational efficiency and safety, and is the key in preventing a bus duct failure.

A thorough offline inspection can identify, with certainty, many things; including but not limited to poor installation or system design, cracked insulators, localized overheating, corona/arcing, condensation/water intrusion, loose connections, loose/missing/inappropriate hardware, dust/dirt build up, debris/foreign material, improper grounding, cracked weld joints, poor or inadequate insulation, lack of proper silver plating, etc. Once these abnormalities are discovered, proper repairs and/or upgrades can be performed to ensure the system is running at optimal condition.

If your plant is currently planning an outage, or transformer change-out, don't overlook including your electrical bus duct system in your plant's fleet maintenance plan. Maintaining electrical bus is just as important as maintaining your generator and transformer. Routine preventative maintenance is not only a cost-effective way to extend the life of your electrical assets, but also a critical task in minimizing the risk of a forced outage and avoiding bodily harm to onsite personnel. Identifying the right partner to proactively maintain, service, and repair your electrical bus duct equipment, in addition to being your turnkey solutions provider, is critical to operational success and the key to plant sustainability.