Risk Control Bulletin:
Low Voltage Busway Systems

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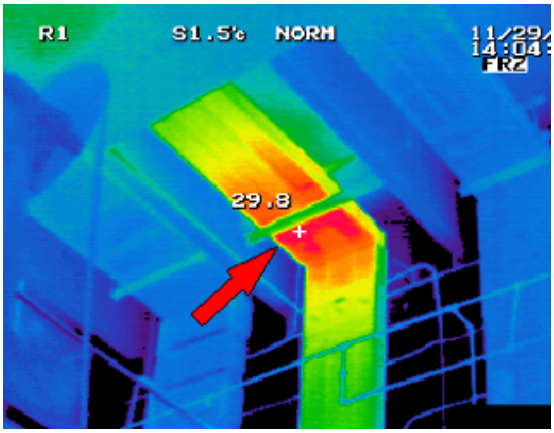
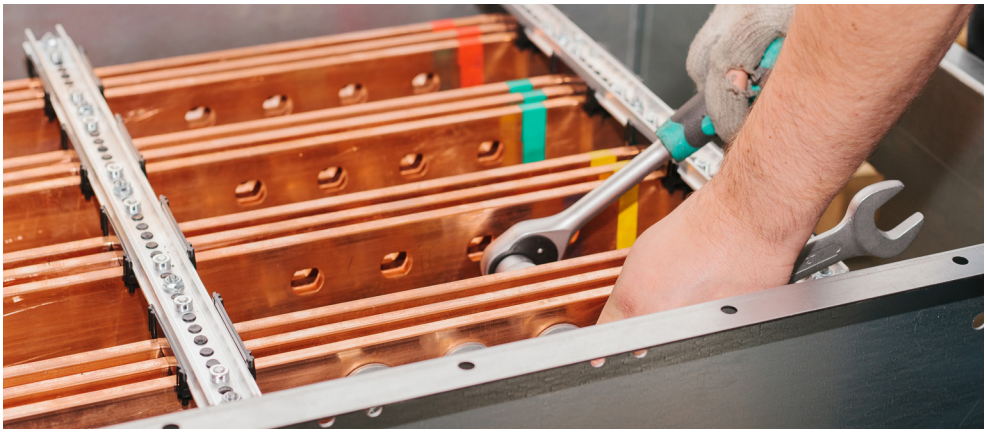




Reducing Operations and Management Costs While Verifying the Integrity of Your Distribution Busway

Busway Purpose and Definition

Three-phase electrical distribution systems used in commercial and industrial systems use various designs to conduct electrical energy. These methods often include heavy, individually insulated cable conductors that are run in trays or conduit.

Cable and conduit assemblies are expensive and time consuming to install and, once installed, are difficult to modify. To eliminate those shortcomings, power is often distributed using prefabricated, fully enclosed bus bars. This conductor design is referred to as "busway."

Many building power distribution systems employ a combination of cable and busway.

The focus of this bulletin is the discussion/identification of failure mechanisms common to busway and the periodic maintenance and testing that will either prevent or minimize the possibility of electrical faulting of electrical busway.

NEMA Definition

Busway is defined by the National Electrical Manufacturers Association (NEMA) as a *prefabricated electrical distribution system consisting of bus bars in a protective enclosure, including straight lengths, fittings, devices and accessories.* Busway includes bus bars, an insulating and/or support material and housing.

In electrical distribution installations, a busway is a sheet metal duct prefabricated in sections. Sections come in standard lengths of 5, 10, and 20 feet and contain either copper or aluminum bus conductors. As the bus conducts a substantial amount of electrical current, they are fully enclosed for safety. Busway can be used in lieu of power cables or cable bus.

Low voltage busway (rated up to 600 volts) is often used to deliver large amounts of power from the main switchgear line-up. If the busway fails, it typically can take down all or large portions of a facility. This can be very costly and time consuming to repair. With proper preventive maintenance, busway can be fully reliable as a means of electrical distribution. A major advantage of busway is the ease with which busway sections are connected. Electrical power can be supplied to any portion of a building by connecting standard lengths of busway.

The busway assemblies are constructed and tested in accordance with the following codes and standards:

Underwriters Laboratories, Inc. (UL)

National Electrical Manufacturers Association (NEMA)

International Electrotechnical Commission (IEC)

National Fire Protection Association (NFPA)

All equipment will be subjected to standard production testing per ANSI/IEEE C37.23 Standard for Metal-Enclosed Bus.

Busway carries NEMA 1 rating for indoor use.

Electrical Busway Vulnerabilities and Risk Exposures

- Destruction from arcing fault
- Fire, smoke and water damage
- Arc flash
- Overhead water sprinkler activation due to arc flash
- Personnel injury
- Immediate loss of business as a result of electrical outage
- Cascading physical damage to other electrical system components
- Prolonged outage
- Potential spoilage of goods in production or storage

Common Use and Applications of Busway (Power Distribution)

- Transformer to switchboard
- Switchboard to switchboard
- Switchboard vertical and or horizontal runs

Busway is used in a wide variety of applications including industrial plants, data centers, offices, high-rise buildings and just about any other type of commercial facility.

Generally, there are two types of busway installations: horizontal and vertical. Horizontal busway is often used in industrial locations to supply power to heavy equipment, lighting and air conditioning. Vertical busway, also known as *busway risers*, can be installed economically in high-rise buildings where it is used to distribute lighting and air conditioning loads. Manufacturers deliver them assembled in sections for installation by qualified electrical contractors.

Electrical Failure Prevention = Proper System Design & Engineering + Component Maintenance

There are many factors to consider when evaluating exposure to loss, primarily hazards or exposures that, at first glance, are not initially thought of as loss producing conditions.

Electrical equipment failures account for millions of dollars in damage and lost business opportunities every year. As electrical infrastructure continues to age, this problem is going to worsen. More than two-thirds of electrical system failures can be prevented by a structured preventive maintenance program.

From 2010-2014, an estimated 16,070 non-home structure fires reported per year to U.S. fire departments involved some type of electrical failure or malfunction as a factor contributing to ignition. These fires resulted in $614 million in direct property damage.[1]

Since electrical distribution busway has no moving parts, it quickly becomes part of the background and falls into the category of "out of sight-out of mind." Why address preventive maintenance when problems previously did not exist? Busway failures can cause complete electrical outages for extended periods of time. Other issues include fire, heavy smoke and the need for immediate evacuation.

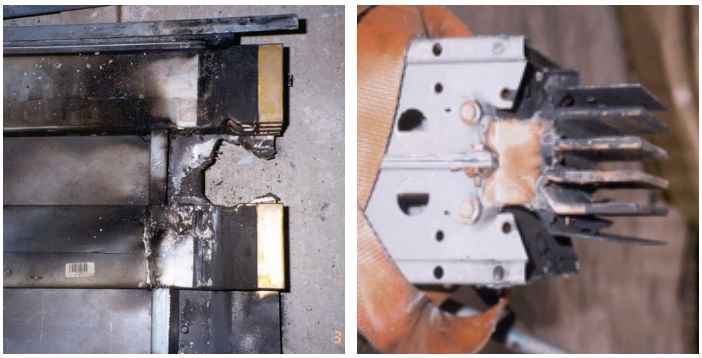
Causes of Busway Failures

There are numerous causes associated with busway failure with excess heat being a primary culprit. Electrical current flowing through a conductor generates heat due to the resistance of the material. Excess current generates excessive heat that damages the conductor's electrical insulation. For that reason, conductors have a rated maximum current carrying capacity or *ampacity*.

As current flow increases, the conductor size must be increased. Checking circuit amp loads is vital for safe and uninterrupted operation.

The following list identifies various causes that contribute to failure of electrical busway:

- Lack of a formal Electrical Preventive Maintenance (EPM) program.
- Excessive ambient temperature accelerates the rate of insulation degradation. High temperatures can be avoided by providing adequate ventilation.
- Excessive internal temperatures due to high resistance at loose connections. Aluminum softens at lower temperature than copper. Aluminum bus connections have been known to loosen over time due to heat and clamping pressure causing the aluminum to 'creep'.
- Contamination by water or condensation causing corrosion and high resistance at connection points ultimately damaging insulation.
- Dirt and/or dust leading to arc flashover.
- Improper or inadequately supported busway (equipment such as switchgear, switchboards, or transformers should not bear the weight of busway).
- Misalignment; improper installation, such as loosening of bolts; improper vertical support, creating permanent deformation of the busway due to bowing.
- Uneven pressure or expansion forces cause the busway to bend at "weak points."
- Thermal expansion can exert excessive mechanical forces potentially causing permanent deformation.
- Increased loads from original design.
- Accidental impact must be avoided at all costs (overhead bus runs must be avoided by fork lift drivers).



Evidence of electrical arcing at busway section connection points

1. NFPA "Electrical Fires Report" March 2017 http://www.nfpa.org/news-and-research/fire-statistics-and-reports/fire-statistics/fire-causes/electrical-and-consumer-electronics/electrical

To avoid costly physical damage to electrical busway and subsequent business interruption, an EPM program that addresses busway and switchgear must be established. In addition to an EPM program, installation of electrical surge protection as required by NEC Article 368.17 is highly recommended. The installation of electrical surge protection at key points in the distribution system has proven effective in preventing damage to electrical equipment and sensitive electronic components.

Recommended Maintenance Practices

Facilities that cannot Isolate Power for Electrical Testing

Often the isolation of busway for electrical testing is not practical, for instance in a hospital or condominium. In such instances:

- Every three years, engage either a qualified electrical contractor or the original equipment manufacturer (OEM) to conduct a physical inspection of the busway for problems such as alignment issues, bowing or bracing, or required vertical spring hanger adjustments. Adjustment is normally required over time, especially in new buildings. NETA (International Electrical Testing Association) recommends an annual visual inspection.[2]
- Each year, perform Infrared thermal (IR) scan (NFPA 70B, 20.4.2.1), to identify "hot spots" at electrical connections that require corrective action. Collect temperature data and compare in accordance with NFPA 70B reference 20.4.2.1.
- From time to time, busway should be inspected to spot trouble areas or changes in operating condition.
- Remove dust, dirt or other foreign matter.
- Remove moisture from leaks or condensation dripping from pipes.
- Verify that nearby equipment is not giving off excess heat.
- Check for missing or broken parts, improper spring tension, free movement, rust or corrosion, dirt, excessive wear, arc spatter, sooty deposits and tracking. Clean or replace parts as required.

Facilities that can Isolate Power for Electrical Testing

Facilities with operational flexibility can schedule electrical testing of busway during quiet periods, typically on a weekend or holiday. Due to the ability to schedule an electrical service outage, the overall reliability of the busway can be improved by performing the following *additional* maintenance tasks:

- Insulation resistance testing is one of the best and most cost effective methods for evaluating the electrical integrity of busway. NETA ATS-2013 Table 100.1, Insulation Resistance Test Values, states the recommended minimum insulation resistance is 100 mega-ohms up to 600 volts. Trends are identified by comparing resistance test data over time. Significant changes warrant further testing in order to determine cause.
- Manually adjust connections in accordance with manufacturer's recommendations.

Consider the Frequency and Extent of Electrical Preventive Maintenance Program (EPM)

Define Equipment Performance

Replacement sections for obsolete busway may need to be custom fabricated taking weeks to complete. The potential impact to business may be severe requiring temporary electrical cabling and connections to minimize business loss. The potential negative financial impact on the business shows the absolute need to implement a comprehensive Electrical Preventive Maintenance program (EPM).

The circuit breaker is a critical device designed to protect circuits, including busway, from overcurrent conditions. A circuit breaker automatically opens when it senses an overcurrent in addition to manual means to open the circuit. Slight overcurrent can be allowed for a short time, but as the current strengthens the protection device must open in fewer cycles. Short circuits must be interrupted instantly. Extreme overcurrent due to a busway short circuit can easily destroy both the entire busway and the originating switchgear. Arcing faults not properly suppressed represent personnel safety issues due to the real potential for arc flash.

Switchgear — source of initiating fault

2. NETA MTS-2015, Appendix B - Frequency of Maintenance Tests, in addition to NFPA 70B, 20.4.3 Housing, pertaining to visual checks.

Temporary cable due to failure of existing busway

Temporary cables to each floor of condominium due to busway failure

Temporary disconnects to each floor as a result of busway failure. As depicted in the temporary repair photos, emergency power restoration due to busway failure initially took five days. Entire busway had to be replaced due to severe arcing and destruction with additional downtime for permanent repair.

Power Restoration Influencing Factors to Consider

- Age of busway — is it obsolete?
- Availability of a qualified electrical contractor
- Accessibility
- Availability of rigging or special equipment required for repair
- Need to repair and restoration of other equipment and areas of the facility due to damage from electrical fire and contamination from activation of fire suppression systems
- Existence of a business continuity plan that addresses the restoration of the electrical distribution system including expediting temporary measures.

Maintenance Program Evaluation

Performing maintenance only in the case of a breakdown is not an acceptable strategy for any facility. Corrective maintenance may suffice for non-critical equipment whose failure would only result in an inconvenience. At the opposite extreme, operations may be 100 percent dependent on electrical equipment. Unplanned equipment replacement or retrofit will be challenging and may require significant cost and time. Valuable assets also may be jeopardized by the failure of electrical equipment.

As the equipment needs to be reliable, a strategy to avoid breakdowns needs to be put in place. The common theme among busway failures is the lack of adequate maintenance and testing, without which, the probability of failure increases. Lifetime busway reliability is readily achievable by adhering to a comprehensive EPM.

Emergency Contingency Considerations

- Recommended spare parts
  - o One pair of flanged ends for each busway rating used.
  - o An appropriate number of plug-in units.
- Relationship with a Certified NETA electrical contractor.

Developing a Strategy

Unleashing Your Maintenance Department's Full Potential through Reliability Centered Maintenance and Testing

Why is it necessary for maintenance departments to change the way they do business in today's world? Why should they implement reliability centered maintenance? What possible impact could such a program have on a facility's operation? For many locations, maintenance has been left relatively untouched. Today, that is changing. Why? Because reducing costs through more efficient maintenance procedures is now recognized as the key to providing the competitive edge people are looking for.

In other words, it's always been done that way; we have had no problems, so why change?

Busway is critical to the safe and continuous operation of a facility. Should failure occur, the business may experience financial loss associated with interruption of operations which can be catastrophic. In addition, electrical failures are associated with fire and heavy smoke causing evacuation of the facility and lack of access for an extended period. This can be especially devastating to manufacturers, hospitals and other healthcare providers.

Proactive not Reactive

In order to be considered a full contributor to the organization, the department must move from a reactive to a proactive mode of maintenance. It's not uncommon for a reactive maintenance department to spend a majority of its time working on emergency breakdowns. Implementing preventive maintenance on busway systems can be a step in the right direction. A company must go one step further and implement a reliability-centered maintenance program if it really wants to eliminate breakdowns and reduce maintenance costs. Information can be gathered to determine what a facility should expect from the distribution busway to help measure and compare current conditions to actual required performance in order to gauge when maintenance is needed.

Summary

Establish and maintain an EPM for distribution busway. Assign responsibility for developing, managing and maintaining this program to an individual knowledgeable of the electrical system. The program should formally document electrical equipment detailing inspection, servicing and testing requirements. The program should detail administrative controls including the review and retention of inspection, servicing and testing reports.

Your starting point for development and implementation should include:

- Inspection by the busway's OEM and completion of acceptance testing in accordance with NETA ATS standards.
- Operational inspections and tests.
- Maintenance tasks in accordance with NFPA Standard 70B, Recommended Practice for Electrical Equipment Maintenance, and NETA MTS standards.
- Written records of inspections and tests.
- Development of an inspection review timeline.

Following these guidelines will assist maintenance personnel in building a successful, reliability-centered busway management program as part of the overall maintenance strategy for their facility.

The financial benefit of increased equipment reliability is overall lower operating costs since the only sustainable means to lower maintenance spending is to reduce or eliminate equipment failures.

Other benefits of increased equipment reliability are improved safety in the workplace, decreased likelihood of interruption to business operations including possible loss of inventory and stock, and most importantly, maintaining customer goodwill.

Reference Sources

- All photos taken by Michael Garber, CNA Equipment Breakdown.
- ANSI/NFPA Standard 70B, Recommended Practice for Electrical Equipment Maintenance, is available from the National Fire Protection Association.
- ANSI/NETA Standard ATS-2013, Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems, is available from the International Electrical Testing Association.
- ANSI/NETA Standard MTS-2015, Standard for Maintenance Testing Specifications for Electrical Power Equipment and Systems, is available from the International Electrical Testing Association.
- ANSI/IEEE C37.23, Standard for Metal-Enclosed Bus, is available from either ANSI or IEEE.

Additional tools and resources from CNA are available to help reduce risks and exposures at www.cna.com/riskcontrol.