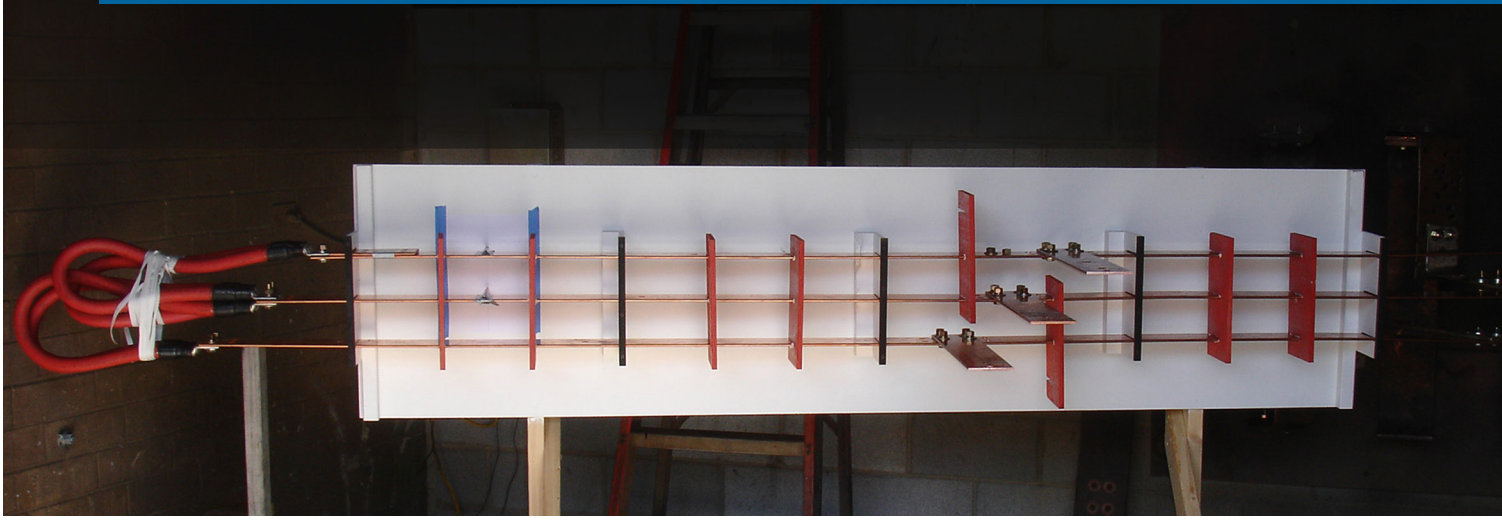
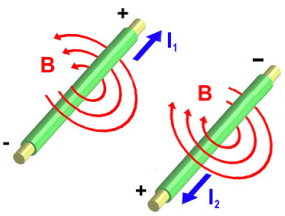
Magnetic Bus Bracing
Equipment Life Extension and Modernization

Electrical Sector
Low and Medium Voltage
Power Circuit Breakers



Magnetic Influence

When electric currents pass through conductor systems, they generate magnetic fields. For two parallel round conductors, the magnetic fields are circular. Based on "the right hand rule" the two conductors repel each when the current flows in opposite directions.



Ampere's Law

For alternating currents the fields are time-varying. The magnetic fields create forces on the conductors that are directly proportional to the square of the current and inversely proportional to the conductor separation. If unrestrained the conductors can experience substantial movement during a short circuit event.

$$\frac{F}{l} = M\,\frac{2\times10^{-7}\,i_1 i_2}{d}$$

Qualifying Bus Bracing

IEEE C37.20.1 and IEEE C37.20.2 require manufacturers to test bus configurations to specific short circuit current ratings. This ensures there is no movement that is mechanically or electrically detrimental to the bus or insulating components. Calculations determine the location of insulating components (bracing) to prevent movement of the bus conductors prior to test. High-power lab testing at the rated short circuit current parameters verifies the calculations. As long as the switchgear is applied within its original tested rating, the bus bracing is sufficient.

Bus Bracing Upgrades

Many power systems incur changes over time and the short circuit capability of the system often exceeds the original rating of the switchgear. Modern circuit breaker technology incorporated into conversions can compensate for the high short circuit currents, but the bus system usually requires additional bracing to prevent damage during a maximum short circuit event. A system cannot be rated any higher than its lowest rated component.

Qualifying Bracing Upgrades

It is impractical to install additional bracing and take the entire switchgear to a high-power lab for qualification testing. A more reasonable approach is to perform calculations and build sample bus structures based on the calculations. The calculations indicate where additional braces should be added to compensate for the increase in short circuit currents. The samples are tested in a high-power lab. After testing, the bus system is analyzed and the results correlated to the original calculations. This approach can save $3,000-$8,000 per switchgear structure as compared to replacing with new equipment.

100% Confidence factor

Eaton's Power Breaker Center has established a calculation methodology that yields conservative results within 5-10% of the actual lab test measurements. Adjustments can be made for copper or aluminum bus, compensation for different insulating materials, different spacings between bus bars and the shape and configuration of the bus conductors. The calculations and tests are based on using any bus configuration and material, so the method is not specific to any particular manufacturer's bus design. The methodology has been tested in hundreds of high-power lab tests while doing qualification testing of numerous low voltage and medium voltage circuit breaker conversions. The same testing is utilized in the qualification of Eaton's new replacement power circuit breakers. This methodology has been successfully proven and tested by Eaton for over twenty years.

Re-Qualification Process

Eaton's Power Breaker Center has trained a number of Eaton's Power Systems Engineers (PSE) on the details of bus bracing calculations due to the high demand for this service. Eaton researches the existing switchgear bus configuration by visiting the customer's site during an outage of the switchgear requiring analysis. The calculations are performed and a report is generated to determine if additional bracing is required. The report also indicates the location of the additional braces. The bracing materials are designed, fabricated and sent to the customer's site for installation by a qualified Eaton Service Engineer.

New Certification Labels

The Engineer also attaches a label to each structure to certify its new bus bracing rating. The new certification is backed by Eaton and is valid unless additional changes are made to the switchgear.

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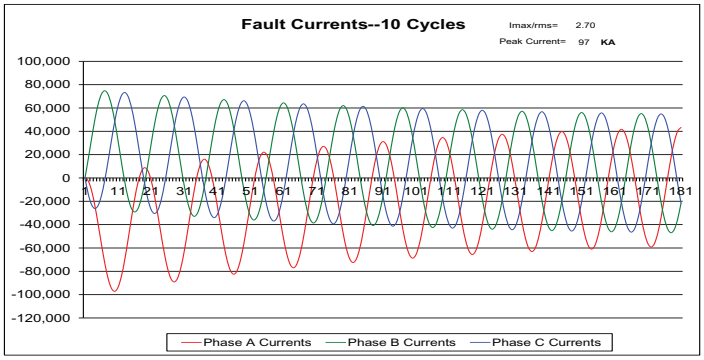
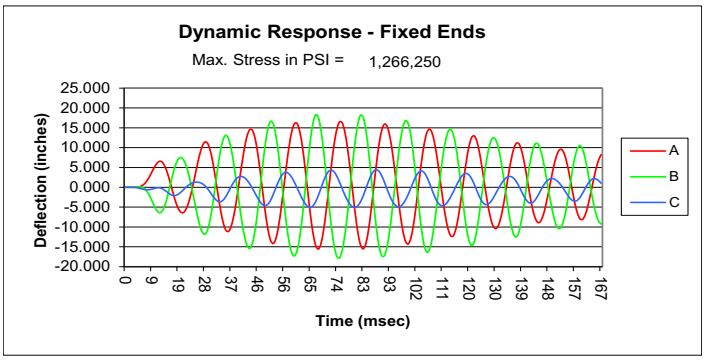


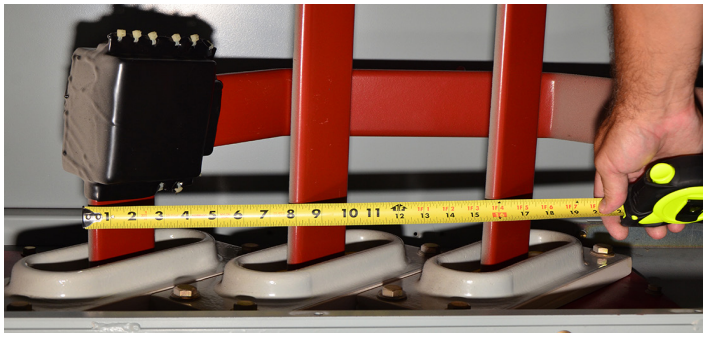
Three-Phase Short Circuit

Three-phase fault waveforms are generated based on the required maximum short circuit rating for the new circuit breaker conversions and the associated requirements of IEEE C37.20.1 or C37.20.2 and C37.59 switchgear standards. The results of these calculations are used to generate the associated magnetic forces on the primary bus conductors in the switchgear.



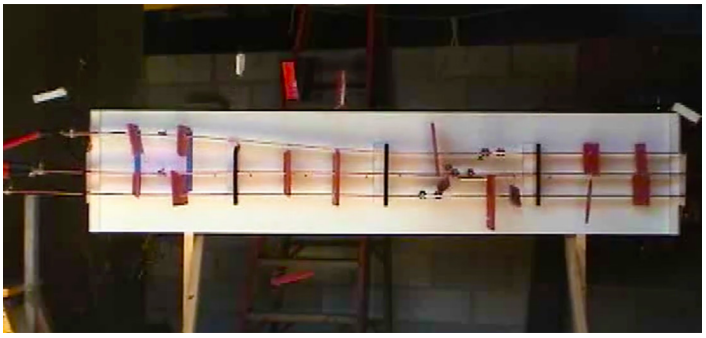
Fixed-Ends Beam Analysis

The bus conductors in each vertical switchgear section are further analyzed as beams with fixed ends to predict the possibility of the bus system reaching a resonance condition. This is not a common occurrence, but it is possible and can cause catastrophic failure.



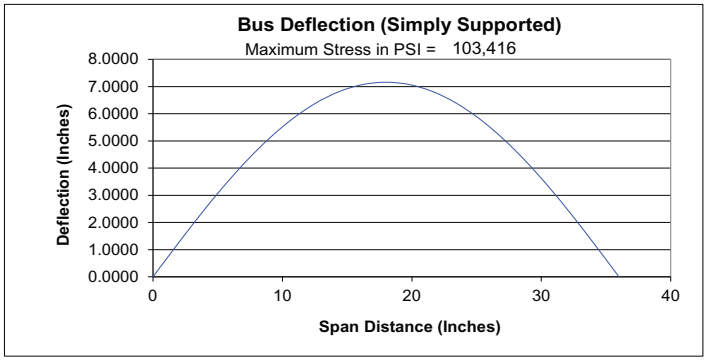
Field Measurements

Each switchgear structure is de-energized and the bus system is grounded. Detailed measurements are taken of the bus system by an Eaton Service Engineer. The engineer also photographs each bus configuration and all existing insulation and bracing components. All data is submitted to the Eaton Power Systems Engineer (PSE) to perform the bus bracing study.



Resonance Conditions

Mechanical resonance can occur if the bus bracing is located at specific points that enhance the system's vibration. Resonance, although rare, can occur in low voltage as well as medium voltage systems. Eaton's analysis helps prevent incorrect bracing placement and reduces the propensity for resonance.



Simply Supported Beam Analysis

The bus conductors in each vertical switchgear section are analyzed as a uniformly loaded beam at various frequencies to determine there deflection. Based on the general information, Eaton recommends limiting the deflection of bus components to 1/150th of the unsupported length to avoid damage to insulating components during a short circuit event.

Bus Properly Braced

Eaton uses a systems approach to bus bracing. We use processes that position braces at the optimum location, utilize proper materials and proven methods of installation. This results in a professional installation that provides over 50 years of trouble-free service. It is also fully tested to the bracing currents of the appropriate IEEE Standards and has very little or no corona discharge. Contact your local Eaton representative or visit our website at www.Eaton.com/ELEM for more information.

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