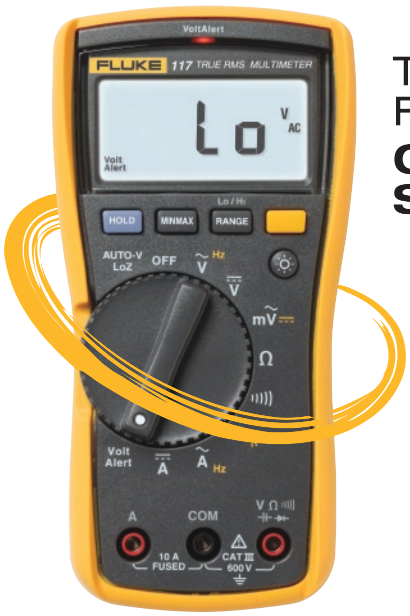
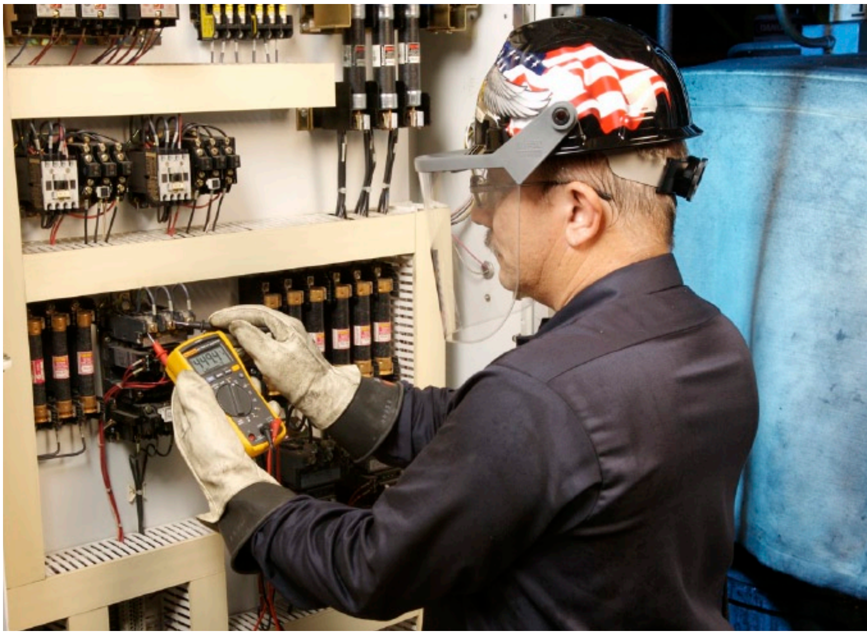
Measuring the invisible; Ghost voltage detection with the Fluke 117 DMM

Application Note



Testing Functions
Case Study



Tool: Fluke 117 DMM

Profile: Steve Mathey, Plant Engineer D. S. Brown Co. bridge component manufacturer

Measurements: LoZ voltage

The spectacular collapse of Tacoma Washington's famed "Galloping Gertie" suspension bridge taught bridge builders an important lesson: Phenomena you can't see can be just as important as those you can.

It's a principle that Steve Mathey, plant engineer for bridge component manufacturer D. S. Brown Co., knows well. When a phantom problem interrupted tests of a key part for the third Tacoma Narrows suspension bridge, Mathey was ready.

In November 1940, just four months after the first Tacoma Narrows bridge opened, the wind through the Narrows began to gust to 42 miles per hour, and the bridge started to twist in the wind. An hour later, as crowds gathered, a 600 foot section of the center span broke free and fell into Puget Sound below. Minutes later, the rest of the span followed.

It would be ten years before a replacement bridge—engineered not just for such obvious needs as traffic loads, but to withstand the invisible force of the wind—was complete.

Fast forward to 2007: The Puget Sound region had grown fast, and the 1950 bridge was a bottleneck for traffic heading across the sound from Tacoma. So a third Tacoma Narrows suspension bridge, with a price tag of $849 million, was under construction right beside the 1950 model. At D. S. Brown's manufacturing facility in Minneapolis, MN it was time to test the immense expansion joints that make it possible for a bridge to survive in this challenging environment.

Wind, water . . . and earthquakes

The Narrows is a natural pinch point that separates the upper and lower sections of Puget Sound. If you want to dive for the world's largest octopus, this is the place. But the engineering challenges are many. This is an earthquake zone; a quake of magnitude 6.8 struck just 15 miles from here in 2001. The high winds of winter storms shoulder against the 510 foot bridge towers, the 2800 foot center span (fifth-longest among U.S. suspension bridges) and its supporting cables. The towers are anchored in concrete caissons that stand in 150 feet of salt water, down by the bones of Galloping Gertie. Currents rush past at more than eight mph as the water reverses direction four times a day, rising and falling up to 15 feet in seven hours. The currents are so powerful that the site is being considered for tidal generation of carbon-free electric power.

Under such forces, the bridge moves almost like it's alive. The deck is designed to move sideways 15 feet in a 150-mile-an-hour windstorm. Even on a normal day, the towers move four to six inches as heat affects the cables. It takes a special expansion joint to make the connection between bridge deck and land, and that's the specialty of D. S. Brown. Where conventional expansion joint devices are limited to primarily longitudinal movements, the company's Maurer SystemTM Swivel Expansion Joint Assembly is designed to take everything the Tacoma Narrows can dish out. In Tacoma, Mathey said, that means up to five feet of movement at each of the bridge's two joints. The accordion-like joints allow the bridge deck to expand and contract with temperature, wind, traffic or seismic motion.

Quality control is critical, so even this 100-ton product—so large it was shipped on an 80-wheeled trailer—had to be tested through its range of motion before it could be delivered. That's where the phantoms caused problems for Mathey's team. When the joint was placed on a test bed early in 2007, the fixture would not move.

"We have a giant fixture that joint was mounted in, and we had to open and close the joint at various speeds and record the forces that were required," said Mathey. "We had a certain spec we had to meet for opening and closing force. We wrote a program and hooked up a PLC (programmable logic controller) to make the thing open and close." String pots were wired to the PLC to signal the joint's speed and position. Proximity or "prox" switches were positioned as safety devices to stop the joint from extending beyond its correct range of motion. Powered by six electric motors, the test setup was, in Mathey's words, "a pretty big, impressive fixture." But it wouldn't go. A test with a standard digital multimeter showed voltage coming from a prox switch.

Phantom voltage: 'There's nothing going on here'

"The prox switch, which is a low current device, was giving a signal back into the PLC of about 60 volts, so we thought we had a bad card," Mathey said. "But when we used the Fluke 117 meter's LoZ setting, there was no voltage there. It was just a phantom voltage. We were quickly able to determine what the problem was.

"The LoZ says wait a minute, there's nothing going on. It's zero," Mathey said. "That enabled us to go ahead and find the real problem: a prox switch was out of position."

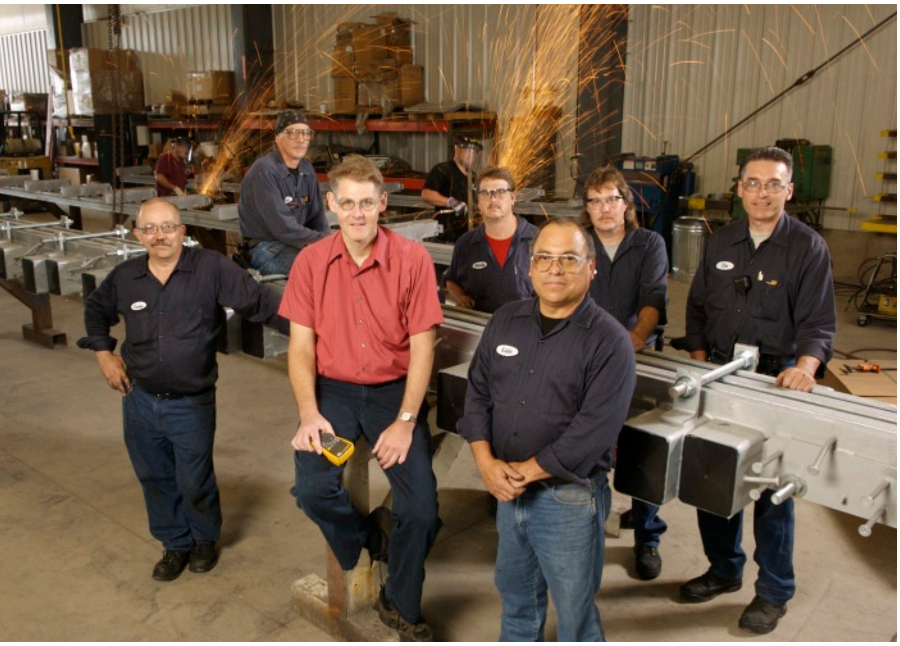
Such experiences have made Mathey an enthusiast for LoZ test capabilities. "I have been a big proponent of LoZ," he said. "Fluke has been the only company I know of that has ever made a LoZ meter. Anybody who's used a digital meter quickly recognizes that phantom voltages will throw a rookie and an experienced guy off. They came out with the LoZ, which is essentially connecting a low impedance load across the meter so it can read what's actually there.

"It's a high-end feature for me. We used Fluke 12 series meters here almost exclusively for first line troubleshooting and for that one feature, the LoZ. So when they came out with the 117 series it was only natural that we would migrate to them."

In addition to identifying ghost voltage, Mathey uses the Fluke 117 to make sure that another D.S. Brown product, called Cableguard™ Elastomeric Wrap, gets installed correctly. If water seeps in, the thousands of thin steel wires that form each suspension bridge cable can corrode and break. Cableguard material is wrapped around the cable, then heated to 270 degrees for six minutes with a device that clamps over the cable. The heat seals the wrap into a monolithic covering that D. S. Brown estimates will last 40 to 50 years, far longer than paint systems.

But a quality job demands that the 480 volt, three-phase heater receives the energy required to heat the cladding—a challenge when the work is high in the air, and power must travel through hundreds of feet of cable. "There's always some problem with the generator or the wiring," Mathey said. "When checking power to the heating blanket we look for voltage, and particularly voltage drop. The worst I have seen is 410 volts (measured) on a 480 volt line." Testing with the Fluke 117 sorts those problems to ensure a quality installation.

On a Sunday in mid July, some 50,000 people swarmed over the brand new bridge to experience it as few will again: without cars. Thanks in part to the Fluke 117, the Gerties crossing the Tacoma Narrows in the future will not be galloping. They'll be driving.



From left to right: George McCartney, Dave Dussel, Steve Mathey, Randy Butler, Ed Gonzalez, Nathan Wilhelm, and Tim Powell

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