Assessing the Reliability of Digital Meters

Electricity customers are accustomed to the rotating disk and numbered dials of traditional electromechanical meters, but many U.S. utilities are upgrading to solid-state electronic meters—often referred to as smart meters.

Manufacturers and utilities use various tests and equipment to verify that these meters meet new and stringent requirements from the American National Standards Institute (ANSI). Typically, each meter is calibrated and verified during manufacturing, and prior to installation utilities often test the accuracy either of each meter or of random samples. States generally have established requirements on how utilities are to check for accuracy.

Nevertheless, some problems and unit failures are inevitable, and solid-state meters have been met with mistrust in a number of early deployments. Most significant are complaints that the meters are inaccurate, resulting in higher electricity bills. EPRI has conducted field tests and performance assessments of solid-state meters (1017833) and has prepared a white paper to help utilities understand and communicate lessons learned from electronic meter replacement programs (1020908).

Accuracy—Real and Perceived

As with most products, meters tend to fail very early or very late in their service lives, with a low, stable failure rate over most of their years of service. The majority of solid-state meters entering service today are elements of advanced metering systems that are being mass-deployed. With an entire meter population being installed at once, failure rates are likely to increase sharply, but not unexpectedly, in the first year or two. If meters develop calibration problems such as high registration after they are put into service, an exaggerated percentage of the customer population could experience higher bills during a new deployment.

Also, software problems or sensitivities in the electronic circuitry can cause accuracy glitches. Such errors, however rare, may be difficult to detect before field deployment and can complicate diagnosing problems for solid-state meters.

The transition from old to new devices also presents bookkeeping challenges. When a meter is replaced, a closing read from the old meter must be made, then combined with consumption measured by the new meter for that billing period. Although replacement is generally automated to minimize human mistakes, this "data splicing" adds opportunity for error.

In some cases, the problem lies with inaccuracy of the old meter. The most common "failure" mode for electromechanical meters is reduced registration. Anything that increases drag on the meter's rotating disk—worn gears, corrosion, moisture, dust, or insects—can cause it to run slow, resulting in reduced charges. If the meter slows gradually over many years, the customer is unlikely to notice and may become accustomed to lower electricity bills. When such meters are replaced, the sudden correction to full accounting can raise doubts about the new meter. EPRI research shows that about 0.3% of old meters may be underbilling by 10%–20% at the time of their replacement. In a service area of a million meters, this would amount to 3,000 residences.

Watching Time of Use

Installation of new meters may enable new rate structures, such as time-of-use or critical peak pricing. These make the grid more efficient by giving consumers incentive to use less energy during times of peak consumption and to use more when energy is readily available.

While new rate structures may benefit customers on average, individual results depend on the degree to which the consumer heeds the high and low price signals. Customers who select time-based rate plans and do not modify their behavior accordingly can incur higher bills, even though lower bills are possible. Because a new rate plan may go into effect at about the same time as a meter replacement, homeowners may mistakenly associate increased bills with metering errors.

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EPRI Testing, AEP Field Application Validate Reliable, Cost-Effective Weld Repair Technique

Nuclear power plants typically contain thousands of socket welds to seal joints in small-diameter piping systems. Plant operators have become concerned in recent years over the increased rate of weld failures due to high-cycle vibration fatigue. Dealing with such failures can be expensive and time-consuming. Standard repairs require that the leak be isolated, the problem joint cut out and replaced, and in some cases the entire pipe section changed out. Outages associated with fatigue failures have resulted in shutdowns as long as seven days, with revenue losses exceeding $300,000 per day.

Faced with a cracked and leaking socket-welded joint in its D.C. Cook Unit 1 pressurized water reactor, American Electric Power (AEP) successfully applied a faster, more economical repair supported by EPRI testing and analysis. EPRI's work and this first-of-its-kind repair have cleared the way for U.S. Nuclear Regulatory Commission (NRC) acceptance of the procedure for future applications.

A More Economical Alternative

D.C. Cook personnel discovered the leak during plant heat-up following a refueling outage. The crack was in the plant's reactor coolant system—an ASME (American Society of Mechanical Engineers) Class 1 socket weld in an elbow fitting to a ¾-inch pipe. Traditional repair would have required draining the reactor vessel and removing the reactor vessel head, a complicated procedure that would have added an estimated million dollars in maintenance and downtime costs. To avoid an extended shutdown, D.C. Cook asked the NRC for permission to use the EPRI-tested alternative—applying a weld overlay in accordance with ASME Code Case N-666. The NRC approved the request, and plant personnel proceeded with a successful repair.

The technique uses a structural weld reinforcement that covers the outside surface of the pipe, fitting, and original weld. First, the active leak is controlled by peening weld metal over the fatigue crack. The crack is then sealed with a weld bead over the peened area. Finally, the structural overlay weld is added, using weld metal that matches the base metal composition.

Testing and Analysis

EPRI began developing and testing the procedure in 2001 at its Welding and Repair Technology Center in Charlotte, North Carolina, with the assistance of AmerenUE and Pacific Gas and Electric Company (PG&E). To produce test samples with realistic failure modes and crack development, researchers induced vibration fatigue by mounting pipe specimens on a shake table. The resulting cracks were repaired with the overlay weld technique under various temperature and pressure conditions, and the test specimens were again subjected to high-cycle fatigue until failure, allowing a direct comparison with the original socket weld fatigue life. Tests were performed on ¾-inch and 2-inch pipes of both stainless and carbon steel, and for cracks initiated from both the toe and the root of the original weld.

Nuclear power plants have thousands of socket welds that are susceptible to fatigue failures.

Test results and corroborating finite-element analyses demonstrated that a joint repaired by the weld overlay method has fatigue strength equal or superior to that of a standard socket weld. As a result, the Board of Nuclear Codes and Standards in 2006 passed Code Case N-666, which specifies the design, fabrication, and examination requirements for the socket weld overlay repair.

EPRI's comprehensive testing and AEP's first-ever application have confirmed the effectiveness and reliability of the overlay weld technique for socket weld repair and facilitated its availability to the industry at large. Code Case N-666 is now listed in Revision 16 of Regulatory Guide 1.147 without conditions. Revision 16 is expected to be approved this year, and as a result, future applications will not require regulatory approval through a relief request.

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