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Regular preventive maintenance at this jewel in the crown of America's scientific research community demands super-sensitive, reliable and accurate instruments.

Even the most complex equipment is still the sum of its parts, and those parts need regular preventive maintenance.

That's the philosophy followed by a guy named Mitch Adamus, senior technician at Fermi National Accelerator Laboratory (Fermilab). Located outside of Chicago, Fermilab houses the Tevatron, the world's highest-energy underground particle accelerator, located inside a tunnel measuring four miles in circumference.

The Tevatron accelerates protons and antiprotons, and the particles collide at tremendous speeds–close to the speed of light. The resulting data helps some of the brightest minds in the world answer such questions as "How was the universe created? How does it work?"

As might be expected, plenty of exotic components go into this complex equipment, along with regular wiring, connectors and protective devices–all exposed to extremely high energy and subject to degradation. It's Adamus' job to ensure this complicated backend operates correctly on demand. That means scheduling component testing during lab downtimes, tracking performance and predicting when to replace parts to prevent untimely failures.

The job is not easy–and, for the most part, calls for highly sensitive instrumentation. A case in point is insulation resistance testing and other kinds of high-resistance tests that Adamus oversees.

Standard measurements

- **Cable tests**

To ensure the integrity of large coaxial and high-voltage cables in various systems, the technicians hi-pot them at 5 kV. "The high-voltage cable is the typical point of failure,"Adamus says."When these fail, they break down at low voltages." The fault is usually apparent—these items don't degrade so much as fail outright because of the severity of the environment.

"If they pass at 5 kV,we can assume they are good,"Adamus says."If they don't pass at 5 kV,we know they're bad."

Methodology

To hi-pot cables, Fermilab technicians use a Fluke 1550B MegOhmMeter set to 5 kV. Then, they apply this voltage between one conductor and the cable shield. Because these cables fail catastrophically rather than deteriorate, the technicians are looking for pass or fail conditions. If the meter shows a high resistance, the technicians then test between another conductor and shield and repeat this process until they observe a failure (low resistance) or have tested all of the conductors.

• **Matching MOVs**

The Fermilab technicians also use the 1550B to match Metal Oxide Varistors (MOVs) that form parallel groupings in various tube socket assemblies. These MOVs are for transient voltage surge suppression. They're grouped because a single MOV simply can't handle the energy of that environment. By grouping them, Fermilab effectively gets one large MOV.

But, there's a catch. Due to Kirchoff 's Law, electricity will divide in reverse proportion to the resistances presented to it. This means that if the MOVs are not closely matched, one MOV will take the brunt of the surge and then fail—and that lowers the effectiveness of the group of MOVs.

Fig. 2. Main control room of Ferbilab's accelerator complex *(Photo used by permission of Fermilab)*

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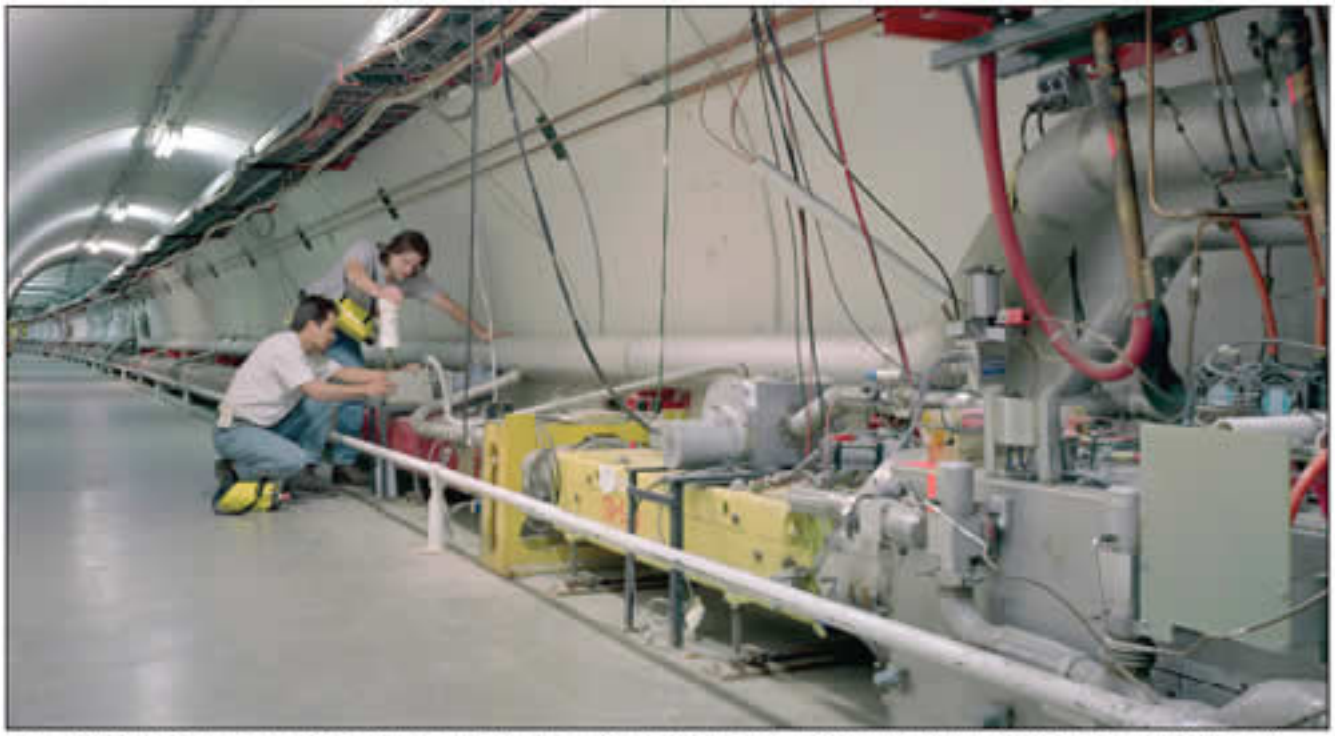

Fig. 3. View of Tevatron in A-Sector inside the main ring tunnel. *(Photo used by permission of Fermilab)*