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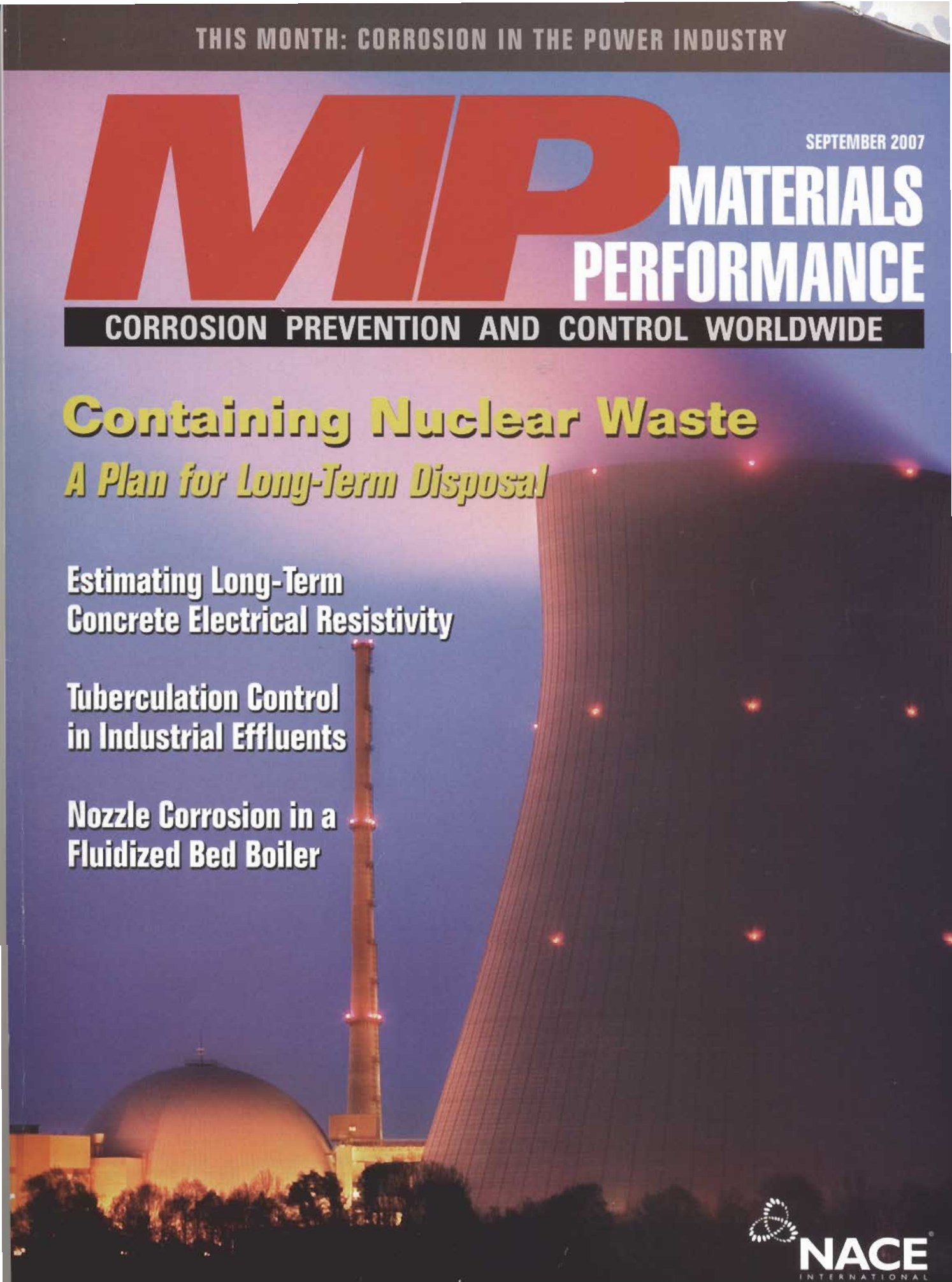

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Sensors signal when damage is detected

Sensors that can find fatigue damage, hidden cracks in hard-to-reach locations, disbonded joints, erosion, impact damage, corrosion, and other defects commonly encountered in aging aircraft are now being developed and studied by researchers at Sandia National Laboratories (Albuquerque, New Mexico).

Like nerve endings in a human body, in situ sensors offer levels of vigilance and sensitivity to problems that periodic checkups can't, says Dennis Roach, who leads a Sandia team that is evaluating some of the first sensor systems for aircraft. "With sensors continually checking for the first signs of wear and tear, you can restrict your maintenance efforts to when you need human intervention," he says.

These sensors are components of structural health monitoring (SHM). SHM incorporates nondestructive inspection (NDI) technologies currently used in manual inspections into the aircraft structure itself. Widespread adoption of SHM could significantly reduce maintenance and repair expenses for commercial aircraft, says Roach.

The Sandia team already has developed or evaluated several types of economical, dependable sensors that can be mounted on aircraft structures where flaws are expected to form. "If I usually get fatigue damage in this area above a door, that's where I am going to install a crack detection sensor," Roach says.

One promising SHM sensor, a Comparative Vacuum Monitoring (CVM) sensor, is a thin, self-adhesive rubber patch, ranging from dime- to credit card-size, that detects cracks in the underlying material. The rubber is laser-etched with rows of tiny, interconnected channels or galleries, to which air pressure is applied. Any propagating crack under the sensor breaches the galleries and the result change in pressure is monitored.

Dennis Roach with a Comparative Vacuum Monitoring (CVM) sensor th shows galleries etched into the sens underside. Photo courtesy of Randy Montoya.

The CVM sensors are inexpens reliable, durable, and easy to apply, s Roach. An even more significant adv tage, he adds, is that they provide eq or better sensitivity than is attainable w conventional inspection methods. Th sensors were tested in a lab and valida on three commercial aircraft beginn in April 2005.

Sandia also is developing or evaluat a variety of other sensor systems. Te nologies being considered include flexi eddy-current arrays, capacitive micron chined ultrasonic transducers, piezoel tric transducers that can interrog materials over long distances, acous emission sensors, embedded fiber opti nickel strip magnetostrictive sensors, a conducting paint whose resistan changes when cracks form underneat

"When we set out to do NDI, in back of our minds we knew that even ally we wanted to create smart structu

that 'phone home' when repairs are needed or when the remaining fatigue life drops below acceptable levels," Roach says. "This is a huge step in the evolution of NDI."

The researchers envision networks of sensors mounted on commercial aircraft that one day would check continuously for the formation of structural defects, possibly reducing or eliminating scheduled aircraft inspections. Ground crew technicians would plug a laptop or diagnostic station into a central port on the aircraft to download structural health data. Eventually "smart structures" fitted with many sensors could self-diagnose and signal an operator when repairs are needed. Ultimately an integrated network of sensors could monitor not only structural elements, but also the health of electronics, hydraulics, avionics, and other systems.

The SHM sensor work is an extension of Sandia's Airworthiness Assurance Program, which focuses on development and evaluation of NDI technologies to aid human inspectors as they go over an aircraft frame or fuselage skin inch by inch looking for the consequences of aging. Such inspections are strictly regulated to maintain a high degree of aircraft safety.

Several commercial airlines working with Sandia are considering SHM applications and are conferring with The Boeing Co. (Chicago, Illinois) and the Federal Aviation Administration (FAA) about the use of embedded crack detection sensors to address specific maintenance requirements.

SHM techniques also could monitor the structural well-being of spacecraft, weapons, rail cars, bridges, oil recovery equipment, buildings, armored vehicles, ships, wind turbines, nuclear power plants, and fuel tanks in hydrogen vehicles, Roach says. Sandia already is applying SHM to a variety of structures.

Sandia is a National Nuclear Security Administration laboratory.

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