LOOKING up

Advances in fire science, fire protection engineering, and risk assessment have driven improvements in fire protection at nuclear power plants, and a Canadian company applies those advances and NFPA 805 to increase safety and lower costs

by JOHN NICHOLSON

KEVIN AUSTIN, senior technical officer with the Fire Safety Programs Section at Bruce Power in Ontario, Canada, first met American fire protection experts Ron Rispoli and Frank Garrett, two members of the NFPA Technical Committee on Fire Protection for Nuclear Facilities, at the November 2000 NFPA Fall Education Conference in Orlando, Florida. That chance encounter has turned into a valuable partnership that has saved one of the world's largest nuclear facilities time and money.

At the time, Bruce Power was contemplating upgrading the fire protection systems at its nuclear power plant, which generates enough electricity to supply approximately 15 percent of Ontario's power needs. The facility, located on 2,300 acres (931 hectares) on the shore of Lake Huron midway between Port Elgin and Kincardine, houses two power stations (four nuclear reactors per station), as well as supporting infrastructure, which includes its own training center, a maintenance facility, emergency power facilities, and a visitors' center. >>

Aerial view of Bruce Power's facility in Ontario, Canada.

When they met Austin, Rispoli was working at Entergy's Arkansas Nuclear One Station, and Garrett was at the Palo Verde Nuclear Generating Station in Arizona. In its infancy, Palo Verde had successfully managed several fire protection challenges, and Garrett thought Bruce Power might benefit from the lessons they had learned. He invited Austin and other Bruce Power fire protection officials to spend a week touring the Palo Verde plant and talking to the experts.

"If you want to learn how to bake a cake, talk to someone who's done it–and then borrow their recipe," says Austin.

And learn they did. During their week in Arizona, Bruce Power's fire protection experts became familiar with NFPA 805, *Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants*, which promised to make retrofitting an existing nuclear facility less difficult by providing equivalencies to the requirements of the prescriptive codes they originally intended to follow.

Upgrades complied

Bruce Power convinced Canadian regulators that its upgrades complied with Canadian Standards Association N-293, *Fire Protection for CANDU Nuclear Plants*, which references NFPA 803, *Fire Protection for Light Water Nuclear Power Plants*, and NFPA 805 as its equivalent.

Convinced that the type of upgrades their plant needed could only be cost-effectively implemented using performance-based standards, Bruce Power's fire protection experts hired Engineering Planning and Management, Inc. (EPM) of Framingham, Massachusetts, to do a technical analysis of their facility, applying the concepts of NFPA 805.

EPM's performance-based assessment focused on the types of fires that could occur at Bruce Power. They then addressed their size and the damage they could do to the equipment needed to safely shut down each station's four nuclear reactors. Although the fire protection shutdown equipment may consist of a small portion of all the shutdown equipment in an area, the prescriptive approach doesn't deal with it individually. Rather, it focuses on the location of all the safe-shutdown-related equipment, regardless of its relation to fire hazards. The performance-based assessment is not as conservative as the prescriptive assessment in this aspect, but it allows for a far more realistic analysis of a nuclear plant's safe-shutdown capability.

Recognizing that taking the next step and implementing the changes would be huge, Bruce Power looked to the experts, namely members of the NFPA 805 technical committee, for help.

"These guys helped set the standard for all the U.S. plants, and the U.S. style of light water reactors " says Austin, who approached Wayne Holmes, the chair of the NFPA 805 technical committee. "We had the designs and, to a large degree, the programs identified. Now we needed to access some application insight."

PHOTOGRAPHS: BRUCE POWER

One of Bruce Power's turbines is housed in this building.

The technical committee

The NFPA Technical Committee on Fire Protection for Nuclear Facilities, formerly the Committee on Atomic Energy, has been involved with cutting-edge technology since 1953. Its first standard, NFPA 801, *Radioactive Materials, Facilities Handling Fire Protection for Nuclear Facilities*, was adopted by the NFPA membership at the 1955 Annual Meeting.

As reactors evolved, the committee developed NFPA 802, *Fire Protection Practice for Nuclear Reactors*, which was adopted in 1960. Following a serious fire at the Brown's Ferry Nuclear Power Plant in 1975, the committee developed NFPA 803, which was adopted in 1978.

Many of NFPA 803's prescriptive requirements were similar to those found in Appendix R of 10 CFR 50, a portion of the U.S. Code of Federal Regulations that addresses fire protection at nuclear power production facilities. Appendix R was added to 10 CFR 50, Part 50.48, which provides requirements for fire protection plans and programs, in 1981 to codify other fire protection documents the Nuclear Regulatory Commission (NRC) had produced over the years to help the U.S. nuclear power industry implement the federal regulations. Though many of Appendix R's prescriptive requirements for fire protection programs, fire hazard analysis, fire protection features and systems, and safe-shutdown capabilities were similar to those found in NFPA 803, the appendix didn't reference NFPA 803.

In 1986, the NRC issued Generic Letter 86-10 to assist in the implementation of fire protection regulations. Among other things, Generic Letter 86-10 states that engineering evaluations by a fire protection engineer can be used to demonstrate alternative compliance with the prescriptive requirements of Appendix R.

Prompted by the NRC's desire for a performance-based consensus fire protection standard for nuclear power reactors, the committee began work on NFPA 805 in the late 1990s. It was the first NFPA technical committee to work on a standard that incorporates performance-based options.

NFPA has since withdrawn NFPA 803 and replaced it with NFPA 804, *Fire Protection for Advanced Light Water Reactor Electric Generating Plants*, and NFPA 805, which address both nuclear safety and fire protection. The NFPA membership adopted NFPA 805 in 2001.

Outside assistance

Why didn't Bruce Power look within its own borders for the appropriate standards? Primarily because the Canadian Standards Association's first standard regulating nuclear power plants, issued in 1995, focuses on new, rather than existing, construction. Appendix D of this standard contained references to existing plant upgrades and the use of analysis to improve protection. This was an excellent opportunity to apply performance-based concepts of NFPA 805. The Bruce Power plant was built during the '70s and early '80s.

"Performance-based fire protection standards provide a balanced approach to optimized fire protection," says Austin.

The first of the two Bruce Power stations, Bruce A, was taken off-line in the late 1990s. Bruce A generates around 3,140 MW of power using four CANDU reactors. A CANDU reactor–CANDU stands for "Canada

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Deuterium Uranium"–uses natural uranium as fuel and "heavy" water (D_2O) as a neutron moderator and coolant. Heavy water is similar to regular, or light, water in many ways, except the hydrogen atoms in each water molecule are replaced by deuterium, a rare but stable hydrogen isotope. Canada, Argentina, South Korea, Romania, China, India, and Pakistan all operate CANDU reactors; there are none in the United States.

Despite the differences in reactor technology, the fundamental fire safety objectives for CANDU and light-water reactors are the same: To shut down the reactor in the event of a fire, allow the plant's occupants to evacuate safely, and prevent a breach that could lead to radioactive contamination in the surrounding area

To achieve those objectives, Bruce Power spent approximately C $15 million (US $10.19 million) to install in Bruce B, which was still on-line, a state-of-the-art Vesda Air Aspiration System, which can detect extremely low levels of combustion products in the air during the very early stages of a fire.

The company also improved the station's turbine generator fire suppression system.

"Analysis showed us that turbine generators are at risk of bearing fires," says Austin. "Take the oil away, it's metal on metal. Things get real hot in a hurry–a few seconds, and you've got a fire."

New system features

One of the features of the new system is the ability to isolate portions of the sprinkler system rather than having to isolate the entire system for sectional maintenance or during turbine outages when only certain zones need to be isolated for turbine work. This allows minimization of impairment. For example, during a turbine outage, two unique sprinkler zones added to the bearing locations can be isolated during maintenance with little impact on the overall protection features. Two 0.5-inch (1.27-centimeter) orifice directional nozzles above the turbine skirt and two below protect each of the 10 turbine generator bearings. The nozzles are rated for 250°F (121°C) and provide a 65- to 80-degree water-spray pattern on each side of the turbine for maximum coverage. The nozzles have baffle plates to keep them from cold-soldering adjacent sprinklers.

A massive turbine at Bruce Power's plant in Ontario, Canada.

PHOTOGRAPH: BRUCE POWER

Two of the four units at Bruce A are scheduled to return to service in 2003. The cost of Bruce A's upgrades is expected to be slightly lower than that of Bruce B's due to use of previously approved designs and the fact that the work is done when the units are off-line.

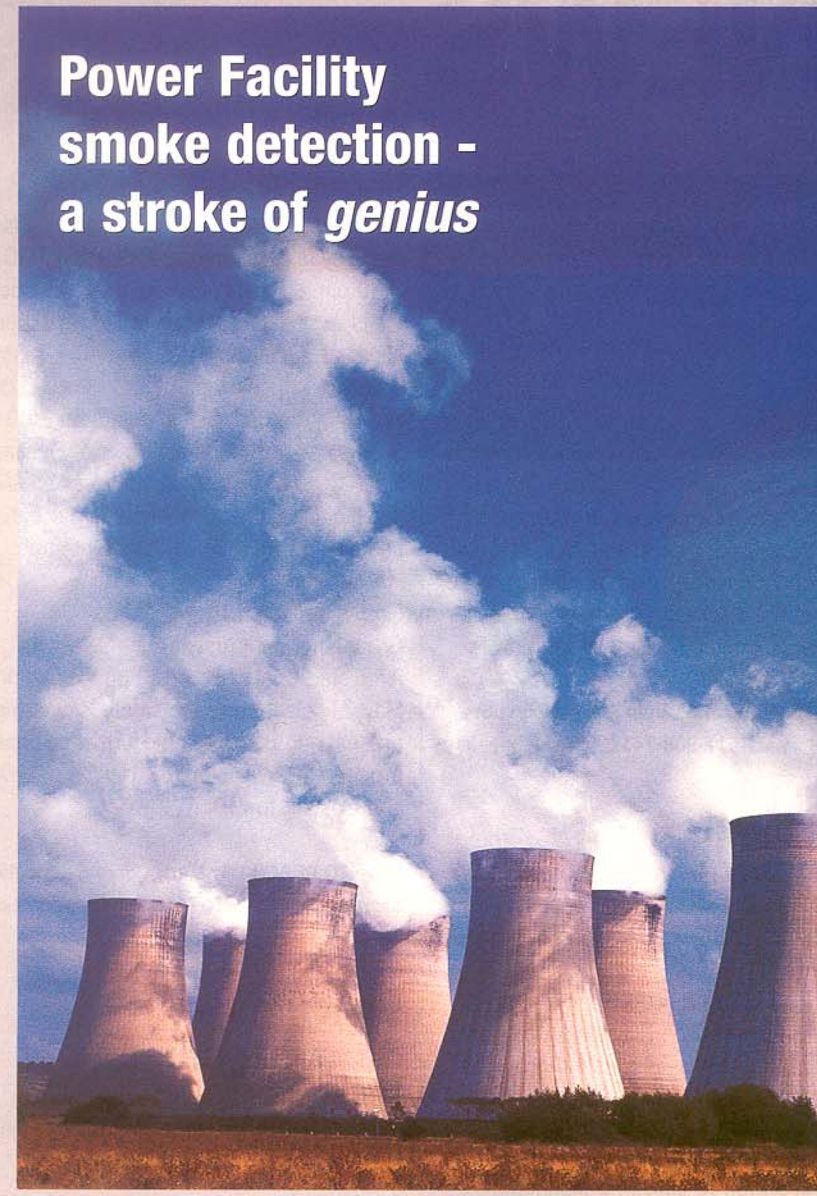
U.S. experts Rispoli and Garrett toured Bruce B in August 2001 to see the new fire detection system and other upgrades to the station. Bruce Power then approached Holmes, suggesting that Bruce Power host his technical committee's September 2002 meeting, which they did. The meeting, the first the committee held outside the United States, allowed Bruce Power to showcase some of the performance-based fire protection upgrades being implemented at Bruce A and B and helped stimulate interest in applying NFPA standards globally.

As a result of the meeting, Canadian power plant operators and regulators, and the CANDU Owners Group (COG) have expressed interest in using the NFPA standards and participating in NFPA's consensus standards-development process.

How is NFPA 805 faring in the United States?

The Nuclear Regulatory Commission has proposed a rulemaking that will endorse NFPA 805 as a referenced consensus standard (see the March 4, 2003, online "Inside the Beltway" at www.nfpajournal.org). At the same time, the nuclear industry is performing pilot implementation programs and developing implementation guidelines. Although due process results in a delay in implementing NFPA 805 in the United States, implementation of the standard at U.S. nuclear power plants is ongoing.

"During my two decades working with this committee, I've observed continuing adaptation to advancing technology. While the U.S. nuclear power industry is now a mature industry, it's continuing to grow in the application of fire safety principles," says Holmes. "During the same period, advances in fire science, fire protection engineering, and risk assessment have driven changes in how fire protection is applied at nuclear power plants."



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