Plenary Session

The Current International Position on Major Inspection Concerns

Long-Term Operation of Light Water Reactors

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ABSTRACT

Today’s global economic environment is challenging the utility industry. The surge toward development of new nuclear power plants is hindered by the limited availability of credit, increasing commodity costs, and unanticipated difficulties in fabrication and construction. Financial incentives and societal imperatives for low carbon footprints will drive utilities toward increasing emphasis on renewable energy sources. The barriers against construction of new thermal power plants and the intermittent nature of most renewables are causing utilities to focus even more on maximizing the utilization of existing baseload assets.

The United States’ nuclear fleet is operating more safely, efficiently, and reliably than ever before. All units are expected to receive license extensions from the original 40-year period to 60 years, using a mechanism established long ago in the controlling regulations. Many utilities, along with the regulator and the US Department of Energy, are exploring the technical basis that will be needed for re-licensing units to operate beyond 60 years, to 80 or perhaps even 100 years of life. Long-term operation will require continued reliable management of the primary pressure boundary including repair or replacement of components as they experience service-related degradation. Many piping systems, steam generators and reactor vessel closure heads have already been replaced. Even the pressure vessel can be replaced or annealed at need. The processes for management of these components are well understood.

The processes for management of other components and systems are less mature. The industry must prepare for the inspection and maintenance of cabling and concrete, for example. Protection against leakage of contamination into groundwater will require maintaining the integrity of tanks and piping, above-ground and buried, for which few management programs exist today. These new component management requirements will bring many new NDE challenges for us to solve.

UPDATE ON US POSITION ON NUCLEAR POWER

A review of the prospects for new nuclear power plants was presented at the 6th International Conference in Budapest, in October 2007. Today the outlook is still positive but less definite. The costs of construction have increased, due in part to increasing prices of construction commodities, and the global economic downturn has complicated the availability of secure financing. Greater attention and public acceptance is accorded to renewable energy options and their economic viability is increasing. The projected need for new generation is somewhat less than the projections of 2007. And finally, there is uncertainty as to the timing and magnitude of economic penalties to fossil power generators for their emissions of greenhouse gases. Figure 1 shows projections of the US generation portfolio through 2050 under various assumptions for the cost of CO2 emissions and of nuclear build; it is clear that the utilization of nuclear power is sensitive to both of these difficult-to-predict parameters.
Figure 1 - Contrasting technology portfolios over time

United States public policy under the current administration seems to be cautiously receptive to new nuclear build, though there is attention to the issue of long-term storage of spent fuel. Public opinion continues to trend toward greater acceptance of nuclear power as a power generation option that does not produce greenhouse gases.

LONG-TERM OPERATION

Long-term operation (LTO) is the safe, high-performance operation of current nuclear power plants to 60 years of life or beyond. In the US the original operating licenses were for 40 years, and the licensing regulations included a process for renewing those licenses for an additional 20 years. Most or all US power plants are expected to receive these license renewals. A new regulatory framework will be necessary for operation beyond 60 years.

Several factors encourage LTO. There appears to be no fundamental technical limitation to plant life at 40 years or even at 60 years; the US fleet today is operating at record-high capacity factors as the oldest plants are now passing the 40-year mark; with the difficulties of starting new nuclear or fossil baseload units, the electricity from the existing units will be needed even more; and nuclear’s emission-free operation is very attractive. A survey of US nuclear utility executives (Figure 2) showed that 88% considered it “likely” or “very likely” that their companies would pursue operation beyond 60 years. Other supportive stakeholders include the US Department of Energy, Nuclear Regulatory Commission, the Nuclear Energy Institute, and the International Atomic Energy Agency.
Industry must develop a technical basis to support utilities’ LTO decision processes. The technical basis may include identification and quantification of potential “life-limiting” issues; life cycle management needs; opportunities for modernization and power up-rates; and enabling technologies. EPRI is currently engaged in several LTO-related projects in the fields of materials aging, nuclear fuel, safety analysis, and information and controls and information technology.

**EPRI LTO NDE PLANS**

EPRI’s support of the NDE needs for long-term operation are at an early stage. In many cases it is expected that a component will require NDE as part of its aging management, but the specific, necessary NDE capabilities are not yet precisely known.

It is probable that power plants’ concrete infrastructure will require NDE for detection of degradation and perhaps for confirmation of mechanical properties. The nearer-term concerns may include spent fuel pools, cooling towers, and concrete piping; longer-term needs may include the containment building and other large infrastructure. Figure 3 shows a cylindrical core that was removed from the spent fuel pool at a decommissioned nuclear power plant in the US. The core is about 150mm in diameter. At the top of the core is a stainless steel liner plate that is 6mm thick. Dark discolorations in the concrete at the liner interface, and also about 70mm below the liner, are traces of water seepage believed to have resulted from cracking in the liner. Degradation of the Water damage to concrete in a core sample removed from a decommissioned nuclear power plant in the US.

Concrete matrix and of the reinforcing steel could each be a significant NDE concern. One of the technical challenges in this and other applications will be accessibility; the NDE techniques may have to be conducted through meters of concrete. EPRI is collaborating closely with Electricité de France in developing a reference manual, aging issues matrix, and civil infrastructure LTO toolbox for utility use in managing concrete aging. NDE research is expected to begin in earnest in 2011.

Another EPRI activity being carried out by the NDE Program, though not related to NDE technology, is developing risk-informed repair and replacement approaches. Safety-related components are categorized according to their safety significance. Many safety-related components have relatively low quantitative significance in a plant’s probabilistic risk assessment. The new approach will allow the use of commercial-grade components and approaches in the repair or replacement of these low-significance, safety-related components. Power plant owners will benefit from much lower component costs and from a much broader selection of vendors.
Not all NDE needs are known yet, but a list of probable targets can be suggested: assessment of the integrity of safety-related electrical cables; radiation damage to the reactor vessel and components internal to the vessel; thermal aging embrittlement of cast stainless steels; assessment of buried piping and tanks, of many types of composition and coatings; and, no doubt, many more.

CONCLUSION

The continuing operation of existing nuclear plants also amplifies the value of nuclear energy as a non-carbon-emitting electricity source. Nuclear power plants worldwide represent more than 370 GW of CO2-free generating capacity. Simply replacing an existing nuclear plant with a new nuclear plant will have minimal impact on overall CO2 emissions; to take full advantage of nuclear’s contribution as a zero emitter, both new and existing nuclear plants are needed. It’s in the public interest, therefore, to ensure that existing plants keep running for a long time.

Efforts are currently underway to determine whether these assets can operate perhaps to 80 years or more. An EPRI survey of senior executives from 23 of the 26 U.S. nuclear operating companies showed strong interest; the executives cited both the solid economics and low-carbon footprint of existing nuclear plants as key factors impacting their responses.

The decision to extend nuclear plant life, however, is not a conventional financial exercise. Decisions must address life-limiting challenges, asset management of critical equipment, and modernization opportunities. Research and development is necessary to identify and overcome key technical barriers and to deploy cost-effective modernization approaches that will enable plant owners to establish a sound, defensible technical basis for operation beyond 60 years. Technical barriers include issues such as materials aging, while modernization opportunities include items such as advanced diagnostics that can support continued high-performance operation of nuclear plants worldwide.

The technical challenges to long-term operation will include many new NDE applications. Our industry will be challenged over the next decade to develop these solutions.