NONDESTRUCTIVE EVALUATION OF CONCRETE STRUCTURES AS A KEY FACTOR IN DECISIONS TO DECOMMISSION NUCLEAR POWER PLANTS

OBJECTIVES

• Evaluate the life span of nuclear power plants based on age-related degradation of concrete structures
• Use climate data to determine aging mechanisms
• Using existing plant data, determine the criteria for decommissioning a plant
• Create scenarios life extension plan scenarios for existing plants in order to determine decommissioning likelihood

Aging

Concrete

Steel Reinforcements

Infrared

Thermal Stresses

Corrosion

Fatigue

Degradation

Cracking

Spalling (Chipping)

Deterioration

Material Loss

Non-Destructive Evaluation Methods

Tests Performed

- Visual inspection
- Audio and sonic methods
- Infrared thermographic techniques
- Magnetic methods
- Electrical half-cell potential

Information Gathered

- Member dimensions
- Location of cracking, delamination, and debonding
- Presence of voids and honeycomb
- Steel reinforcement location and size
- Corrosion activity of reinforcement
- Damage from freeze-thaw, chemical attack, and fire

Scenarios

Diablo Canyon

Plymouth Pilgrim

Sequoyah

Diablo Canyon is located in Plymouth Pilgrim is located outside of San Luis Obispo, on Cape Cod Bay, and Sequoyah is located in Soddy-Daisy, Tennessee. California. It is situated on Massachusetts. Because of its location, the coast, between 3 active fault lines. Due to its to chemical corrosion and environmental factors location, Diablo Canyon is freeze-thaw cycling. It is affecting aging. However, constantly under likely that both are excessive loads from storm vibrational stresses. It also occurring together. Testing systems are the most is in a highly corrosive needed to prevent aging: active risk factor. Testing environment. Testing needed to prevent aging:
- Visual Inspection
- Impact Echo
- Half-Cell Potential

Decommissioning

By calculating the risk of age-related failure, and the cost so maintain the concrete structures in the plant, any power plant will fall into one of the four quadrants in the chart on the left. Each plant (no matter where in the chart) can then be given a value based on various criteria, and then can be placed in the second chart, which will then be used to determine whether a plant should be decommissioned or have its license renewed.

Case Studies

San Onofre Nuclear Generating Station

San Onofre was originally a demonstration project for Southern California Edison. Due to seismic activity, the plant was forced to endure over $700M in modifications. Because of the seismic activity, the plant had to modify its concrete structures to support the excess loads. The modifications doubled the non-fuel operations cost of the plant (compared to the national average) until finally it was decided that decommissioning was the most financially sound option.

Oyster Creek Generating Station

Oyster Creek is the oldest working nuclear power plant in the United States. Because of its location in New Jersey, Oyster Creek endures mild winters and warm summers. This leads to a lower occurrence of freeze-thaw cycling (a major factor in concrete aging). Though the plant receives ample amounts of precipitation, it has never endured any age-related damage to its concrete structures. Because of the number of homes is can supply with energy, it has been re-licensed until 2029.

Conclusions

1. Age-related degradation mechanisms are not the deciding factor in decommissioning a power plant
2. Age-related degradation causes the majority of operation and maintenance cost
3. If aging structures are not repaired, costly failures can occur causing unplanned outages and more cost for the plant
4. If the cost to maintain the plant is higher than decommissioning costs, the plant will be shut down
5. In order to prevent excess costs and extend the life of nuclear power plants, NDEs should be used to determine the location and extent of degradation in order to create repair and maintenance schedules
6. Using an approach that monitors cost, risk, and value of a plant over time based on the quantitative results of NDE testing, more strategic, long-term decommissioning decisions can be made.