Erler Engineering Ltd.

Design and Construction Impact on Prestressed and Reinforced Concrete Containment Degradation

Bryan A. Erler
Erler Engineering Ltd

NRC Regulatory Information Conference
March 10, 2011

March 10, 2011

Background

As a member of an expert panel charged to evaluate corrosion mechanism for the steel liners in nuclear concrete containments. I dealt with the design, construction and operation issues. This presentation is based on my input to the expert panel.

March 10, 2011 Erler Engineering Ltd.

Topics of Discussion

- Summary of Liner Corrosion
- Summary of Design and Construction Requirements
- Operating Experience
- Conclusions

March 10, 2011 Erler Engineering Ltd.

Summary of Liner Corrosion

- Three cases of through wall corrosion found in three reinforced concrete containments due to foreign material left in place
- One case of through wall corrosion was found due line construction improper repair
- Two cases of embedded foreign material found during modifications but no through wall corrosion
- Seven cases of internal surface corrosion due to failure of coatings or moisture barriers

March 10, 2011 Erler Engineering Ltd.

Plant Design and Construction

- Containment System Design
- Containment Structural Design
- Liner Design

March 10, 2011 Erler Engineering Ltd.

Containment System Design

- The containment building is only an element of the containment system
  - Isolation valves, bellows, sprays and chiller system
- **Dry Containments**
  - Used for Pressurized Water Reactors -PWR
  - Steam released directly in containment from the LOCA
  - Results in 50-60 psig design pressure
  - Containments are larger
  - Some dry containments are subatmospheric

March 10, 2011 Erler Engineering Ltd.

Containment System Design

- **Pressure Suppression Containments**
  - Boiling Water Reactors-BWR and PWR, ice condenser containments use water or ice to reduce the LOCA design pressure and size of containment
  - Design Pressure 15-45 psig
  - Reduce design pressure results in lighter reinforcing or prestressing
  - Creates potential environmental conditions susceptible to corrosion

March 10, 2011 Erler Engineering Ltd.

Containment Structural Design

- Concrete containments are designed to ASME B&PV Section III Div 2
- The design is controlled by the design pressure and seismic level
- **Reinforced concrete dry containments**
  - Typically cylindrical with hemispherical dome with heavy #18 reinforcing bars
  - Placing of the concrete is challenging

March 10, 2011 Erler Engineering Ltd.

Containment Structural Design

- **Prestressed concrete dry containments**
  - Typically cylindrical with hemispherical or shallow dome with light reinforcing bars except in discontinuities
  - Placing of the concrete relatively easy
  - For shallow domes congestion of the crossing post-tension tendons can cause concrete placing problems

March 10, 2011 Erler Engineering Ltd.

Containment Liner design

- The liner is not structurally relied upon for the design strength of the containment
- The liner is anchored to the inside of the containment wall by studs and angles at a regular spacing
- Because the liner is subjected to higher temperatures and has higher coefficient of expansion it induces a tension into the concrete wall and compression the liner

March 10, 2011 Erler Engineering Ltd.

Containment Liner design

- The liner design criteria in ASME Section III Div 2 is a strain and deflection limit criteria rather the strength based
- The design of the liner anchor welds are sized to assure that the anchor weld would fail first prevent liner tearing
- Bulges in liners between the anchors are acceptable but could potentially be a corrosion starter
- Some liners for BWR suppression pools are stainless steel which are good for corrosion prevention but add to the liner expansion effect.

March 10, 2011 Erler Engineering Ltd.

Review of Operating Experience Related to Containments Design

- Due to dense and large reinforcing bars in reinforced concrete containments foreign material left in the concrete have led to liner corrosion
- Prestressed containments are less susceptible to foreign material left in the concrete (2 small material have been found)

March 10, 2011 Erler Engineering Ltd.

Review of Operating Experience Related to Containments Design

- Suppression containments with water or ice may lead to in conditions susceptible for corrosion
- Maintenance of liner coatings and moisture barrier is critical for corrosion prevention
- The moisture barrier between inside concrete slab and the liner can accumulate water

March 10, 2011 Erler Engineering Ltd.

Observations

- There is extensive data available on liner degradation for concrete containments
- Most serious conditions were as result of an original construction condition not general aging
- No condition found resulted in the containment failing to it's 10CFR50 Appendix J integrated leakage test
- Inservice Inspection ASME Section XI IWE and IWL can identify inside originated degradation early
- General good housekeeping and liner coating maintenance can prevent corrosion

March 10, 2011 Erler Engineering Ltd.

Conclusion

- Plant design and construction may influence the susceptibility of liner corrosion from the concrete side
- Subatmospheric dry containments or pressure suppression are not believed to increase the susceptibility of liner corrosion from the concrete side
- NDE techniques are currently not adequate to locate small areas of foreign material

March 10, 2011 Erler Engineering Ltd.