LP Turbine Breakable Diaphragms
Robinson Experience

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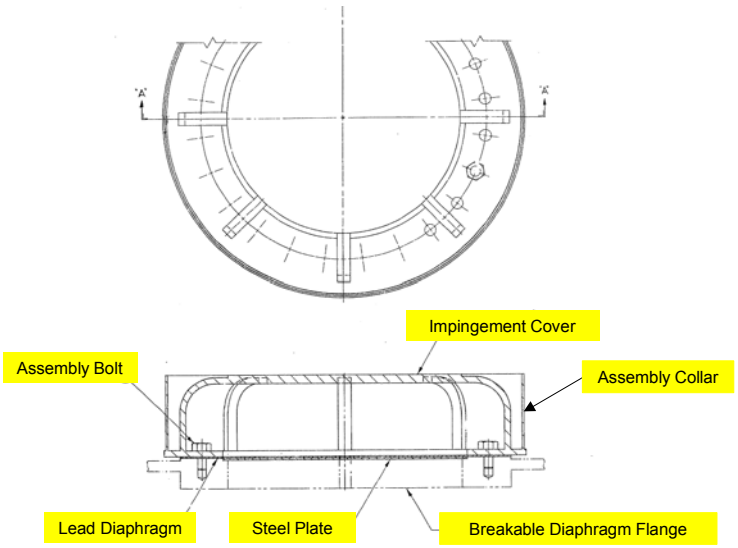
LP Turbine Breakable Diaphragms

- Purpose – Protects LP turbine and condenser from damage by excessive internal pressure
- Four diaphragm assemblies on each LP turbine outer cover
- Thin diaphragm is broken by underlying steel plate when excessive pressure occurs in the condenser



LP Turbine Breakable Diaphragms

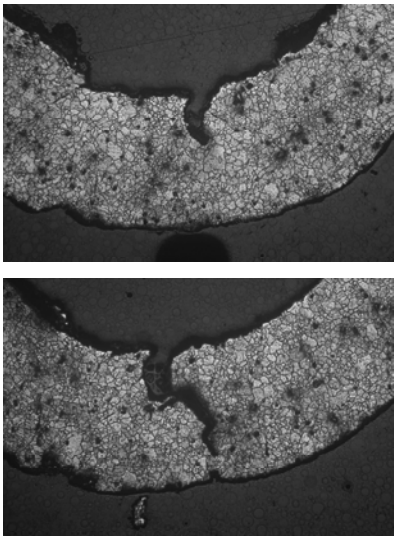
- Diaphragms are susceptible to fatigue cracking that results in:
  - Increase condensate oxygen level thereby adversely impacting secondary side chemistry
- Diaphragms are susceptible to corrosion that results in:
  - Lead and copper contamination that accelerates steam generator tube and turbine blade stress corrosion cracking

LP Turbine Breakable Diaphragms

- Robinson Failure Analysis
  - 'U' shaped deformation of diaphragm between retainer ring and steel pressure plate due to condenser vacuum
  - Transgranular cracking observed on inner and outer surfaces at the bottom of bend
  - Outer surface cracking was deeper and more severe
  - Cracking caused by low stress high cycle fatigue
  - Inner surface pitting (none thru wall) and significant amount of lead oxide coating on inner surface

LP Turbine Breakable Diaphragms

- Cracks were observed starting at the bottom of the "U" shaped bend in the region between the retainer ring and the circular steel plate. (~31X)



LP Turbine Breakable Diaphragms

- Robinson efforts to improve diaphragm reliability
  - Ensure steel plate is centered in flange opening so that diaphragm is not exposed to an excessive gap
  - Ensure no excessive step at the steel plate and flange surface that would deform diaphragm
  - Coat diaphragm with sealant during installation
  - Reduce torque on retaining ring fasteners
- Even with these actions, diaphragm reliability is still poor.

LP Turbine Breakable Diaphragms

- Leaks can quickly cause condensate oxygen to approach Action Levels and require prompt repair.
- On-line repairs consist of applying thin rubber patches and RTV over the leaking area.

Lead in Deposits

- Lead found in deposits in 75% of surveyed PWRs (Jonas, 1984) and 28 PWR SGs (Agrawal & Paine, 1989)
- Lead as PbO
- Lead as PbF_4O_7
- Pb, Cu in Steam Generator SCC cracks, sludge, and deposits (EPRI 1992)

Lead Corrosion can occur by:

- Ammonium bicarbonate
- Ammonium carbonate
- Ammonium Chloride
- Boric Acid
- Carbonic acid
- Steam

LP Turbine Breakable Diaphragms

- Robinson approach to leaking diaphragms
  - Breakable Diaphragm Assembly Covers
  - Designed and manufactured by Jonas, Inc.

LP Turbine Breakable Diaphragms

- Jonas covers are presently installed on 4 PWRs, 1 BWR, and 1 combined cycle unit.
- Hypalon outer fabric bonded to neoprene rubber pad.
- Cover is held in-place by a stainless steel band around the assembly collar.
- Collar drain opening must be plugged.

LP Turbine Breakable Diaphragms

- Cover seals leaking diaphragm thus eliminating air in-leakage.
- Diaphragm repair can be deferred without impacting plant operation.
- Cover also acts as a diaphragm leak indicator.
- Cover design may be stiffened to eliminate need for lead diaphragm.