Condensate Polishing in ACCs

Andrew Howell

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Condensate Polishing

If properly designed, installed, maintained and operated, ensures that condensate directed towards the boiler / HRSG will be high quality and have minimal contamination.

When is Condensate Polishing required?

- Once-through boilers
- Nuclear-powered steam generators

When (otherwise) is Condensate Polishing recommended?

- When the source of contamination is potentially highly damaging (e.g. cooling with seawater or other high-dissolved solids waters)
- When there is no toleration for contaminated-related availability / reliability issues
- Hybrid-cooled (wet-dry) ACCs

What types of condensate polishers are used in power generation?

Deep bed

Different configurations but all contain ion exchange resin in large vessels such that both extended operation with minor ionic contamination and significant contamination events can be addressed adequately. Will capture particulates but not designed for this purpose. Regeneration of resin poses a risk of steam cycle contamination if not performed properly.

Powdered Resin

Operate with thin layer of crushed resin and fibrous material deposited onto multilple filter elements such that an ionic contamination event can be addressed for a short period of time. Performs well at capturing particulates. Resin is disposed of and replaced, not regenerated.

Sources of Steam Cycle Contamination (dissolved, most common sources)

Water-cooled power plants:

- **condenser tube leaks (primary contamination concern)**
- air inleakage
- boiler makeup system failures
- chemical feed contamination
- poor practices in regeneration of deep bed polisher resin
- decomposition of resin at elevated temperatures

Air-cooled power plants:

- **air inleakage (primary contamination source)**
- boiler makeup system failures
- chemical feed contamination
- poor practices in regeneration of deep bed polisher resin
- decomposition of resin at elevated temperatures

Contamination risk: water-cooled vs. air-cooled plants

Cooling water ingress:

contributes significant concentrations of chloride and sulfate, primary corrodents for under-deposit corrosion and failure in boilers / HRSGs and for LP turbine blade cracking failures. These corrodents can be removed by condensate polishers.

Air ingress:

contributes primary constituents in air - 78% nitrogen, 21% oxygen, 1% argon, 0.04% carbon dioxide. Carbon dioxide can be removed by condensate polishers.

Air ingress for ACCs

Primarily a performance issue, air blanketing of heat exchanger tubes

Primary chemistry influences:

- carbon dioxide – minimal corrosion influence
  - lowers pH slightly
  - contributes to cation conductivity
  - exhausts anion resin if condensate polisher in service
- oxygen – minor effect on corrosion at normal elevated pH operation

Condensate polishing can remove corrodents from various sources but the most common contaminant in ACCs that can be removed by condensate polishing is carbon dioxide, which is relatively benign.

Condensate Polishing at ACC Operating pH

- ACCs typically operate near pH 10 with ammonium hydroxide
- At pH 10, cation and anion resin are ineffective at capturing and retaining monovalent cations and anions:
  - NH_4^+ is at high concentrations at pH 10 and displaces e.g. sodium Na^+
  - OH^- is at high concentrations at pH 10 and displaces e.g. chloride Cl^-
- Divalent cations and anions are better-retained – Ca^{2+}, SO_4^{2-}
- Powdered resin polishers are rendered meaningless at pH 10
- Deep bed polishers are poorly-effective at pH 10

Condensate Filtration for ACCs

- Particulate iron removal from ACC condensate is a priority need for all ACC plants
- Powdered resin polishers are very effective for particulate removal, but removal of ionic constituents (IX resin) is not particularly helpful
- Deep bed polisher equipment may remove particulates but the polisher / resin is not particularly helpful
- Full-flow condensate filtration very effectively removes particulate iron from condensate

Condensate Polishing for Once-through Steam Generators with ACCs

- Polishers are necessary for once-through steam generators to minimize contamination
- Potential options for effective polishing:
  - reduce pH with neutralizing amines
  - reduce pH with filming chemicals
  - must confirm the effectiveness of changes before enacting
  - development of resin that is effective for contaminant removal at pH 10
- Cation resin should be operated in ammonium form at the pH of steam cycle operation (at or near 10)

Hybrid-cooled (wet-dry) systems and condensate polishing

- Water-cooled condensers in hybrid cooling systems should be designed with rugged HX tubes to minimize the chance of cooling water in-leakage
- Leaks in wet condenser may cause major steam cycle contamination
- Deep-bed polisher should be installed to capture contamination from leaks in WCC for a limited period of time
- Polishing will allow capture of contaminants from WCC leak while leak is resolved or to allow plant shutdown to be quickly accomplished

Contamination control without polishing

- Polishing may have low effectiveness for most ACC plants, but steam cycle contamination can still be a major damaging influence
- Potential sources of contamination, though uncommon, should be given particular vigilance in this case – e.g. boiler makeup water, chemical feed contamination

Conclusions

Condensate polishing is problematic in use with air-cooled condensers and multiple factors should be evaluated to determine whether polishers are useful for a specific power plant situation, and if installed, how to select, design and operate polishers for optimum performance under ACC conditions.

Questions / Discussion