International Association for the Properties of Water and Steam

Guidance for Fossil and Combined Cycle Plants Operating on AVT, OT, PT and CT

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International Directions to Develop Guidance Documents

Many organizations issuing "guidelines"

- But don't appear to penetrate across multiples of countries, plants, manufacturers, AEs, EPCs, etc

- The "global" market has changed since 1990
  - Units designed in country A, manufactured in B, built in C, using specs/guidelines from D & E, or manufacturers F & G, etc
  - The world now needs truly international guidance on cycle chemistry which can be the foundation for guidelines in each country and for manufacturers and other organizations worldwide as for IAPWS-IF97

- IAPWS has this unique place in the world
  - International members and specialists
  - PCC has the framework for cycle chemistry guidance
  - with access to PCAS or other WGs as needed

International Direction to Develop Guidance Documents

Recent examples from the "global" market

- Two units (2003). Russian boiler, Italian turbine
  - Cycle chemistry guidelines from the 1980s, No carryover, no steam monitoring. No shutdown protection. SCC on both turbines
- One unit (2007). Japanese supercritical boiler, German steam turbine, German ACC
  - Cycle chemistry guidelines with no consideration for two-phase flow and pH between 8-8.5. Major ACC problems, BTF and need to clean boiler within two years
- One combined cycle unit (~12,000 hrs). Danish HRSG, US steam turbine, Supply for Process
  - Reducing agent. Mixed guidance. Grab samples. Major FAC in LP evaporator and deposits in HP evaporator

International Direction to Develop Guidance Documents

Recent examples from the "global" market

- 6 Korean HRSGs (2011) + 8 Italian Desalination Plants with Copper heaters
  - Cycle chemistry guidelines for each, FAC in HRSGs due to low pH to protect copper heaters
- 3 US/Israel Solar Receivers (2013). German steam turbine, US Feedwater Heaters and ACC
  - EPC cycle chemistry guidelines with no consideration for two- phase flow and pH ~9.0. Potential FAC in Feedwater heaters and severe FAC in ACC, and deposits in SRSG
- Somehow, somewhere along the path to commissioning plant the chemistry takes a back seat
  - Second class citizen

IAPWS Technical Guidance Documents

Highest Level Guidance/Guideline Documents for Conventional Fossil, Combined Cycle/HSRGs, Industrials, etc., which are designed to be used in, and be the basis of:

- **Guidelines worldwide** **(same concept as IAPWS-IF97)**
- **Organizations around the world including manufacturers, AEs, EPCs, etc for new units**

But can also be used by organizations without access to the "normal" guidelines organizations

- **This is an enormous number around the world**

Volatile Treatments (AVT and OT) for Fossil and HRSG Drum and Once-through Plants

Phosphate and NaOH Treatments (PT and CT) for Fossil and HRSG Drum Plants

Base Cases of Most Common Combinations

- Cumulative experience of 21 countries
- Many manufacturers
- Normal target levels for Key Minimum Level of Instrumentation
- Control Levels and Shutdown Limits
- Customizations for the suite of plants worldwide

Volatile Treatments (AVT and OT) for Fossil and HRSG Drum and Once-through Plants

Five Base Cases of Most Common Combinations Worldwide

- Fossil Drum Units. 17MPa (2500psi). All-ferrous feedwater, non-copper condenser and condensate polishing
- Fossil Drum Units. 17MPa (2500psi). Mixed-metallurgy feedwater, copper condenser and no condensate polishing
- Fossil Once-through Units. All-ferrous feedwater, non-copper condenser and condensate polishing
- Multi-pressure Combined Cycle Units. Independently fed LP, IP and HP. No reducing agent
- Multi-pressure Combined Cycle Units. LP feeding IP and HP. No reducing agent.

Technical Guidance Document

AVT(O) and OT for HRSGs with independently fed LP, IP and HP

Economizer Inlet (EI), Preheater Inlet or Feed Pump Discharge		
Conductivity, µS/cm	Consistent with pH	Consistent with pH
Conductivity after Cation Exchange (CACE), µS/cm	< 0.3	< 0.15
pH	9.2 – 9.8	9.0 – 9.8
Dissolved Oxygen, µg/kg	< 10	Per Recirculation Ratio
	AVT(O)	OT

Volatile Treatments (AVT and OT) for Fossil and HRSG Drum and Once-through Plants

Nine Customizations (how to deal with)

- Different drum pressures
- Two-phase flow situations
- Single-phase flow and varying materials
- Different condenser materials (copper) and cooling sources
- Condenser Leaks
- Makeup and condensate polishing
- Combined cycle plants w and w/o DA
- ACC and Heller (aluminium systems)

Phosphate and NaOH Treatments (PT and CT) for Fossil and HRSG Drum Plants

Four Base Cases of Most Common Combinations Worldwide

- PT for Fossil Drum Units. 17MPa (2500psi). All-ferrous feedwater, non-copper condenser, no condensate polishing
- CT for Fossil Drum Units. 16.5 MPa (2400psi). All-ferrous feedwater, copper condenser and no condensate polishing
- PT and CT for Multi-pressure Combined Cycle Units. Independently fed LP, IP and HP. No reducing agent
- PT and CT for Multi-pressure Combined Cycle Units. LP feeding IP and HP. No reducing agent.

Technical Guidance Documents

PT and CT for HRSGs with independently fed LP, IP and HP

HP Drum (14 MPa, 2000 psi) Blowdown (HPBD) / Downcomer (HPDC)		
Conductivity, µS/cm	< 15	4 - 12
Conductivity after Cation Exchange, (CACE) µS/cm	< 20	< 15
pH	9.0 – 9.4	9.2 -9.5
Phosphate, mg/kg	0.3 - 2	*Not applicable*
	PT	CT

Phosphate and NaOH Treatments (PT and CT) for Fossil and HRSG Drum Plants

Nine Customizations (how to deal with)

- Choice of PT vs. CT
- Different drum pressures
- Different HRSG designs
- Addition of NaOH
- Phosphate Hideout (> 0.3 ppm PO_4) and Return
- Condenser Leaks
- Dryout and circulation effects
- Different feedwater heater materials
- Deposits

The Future

(maybe my dream?)

- Chemistry and Plant Equipment are not Strangers
- All manufacturers, AEs and EPC contractors use the latest guidance freely available (not just through some membership)
- Plants/operators worldwide have access to the latest guidance
- Plants don’t operate with unknown chemicals
- Combined cycle plants are specified for AVT(O)
- Contaminants are dealt with: control and shutdown limits
- Proper selection of boiler/evaporator chemistry
- Pressure effects are considered