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Information about Water Treatment for Power Plant Cooling Towers

1. **Slide Deck**
    - This supplement to the 2012 EPRI RFI is meant to serve as a brief guide for those unfamiliar with the power industry. It is based on the information and data from the references listed in Section 3.

2. **Comments about Cooling System Chemistry Parameters**

- Conductivity is an indirect measurement of the TDS. Conductivity systems range from low (1000 uhmos) to extremely high (30,000 umhos).
- Silica: A traditional limit based upon water treatment vendors advice was 150 ppm. Many plants continue to hold to that limit if they approach it (depending on how much silica is in their makeup water). However, some power plants in the Southwestern United States (Nevada and Arizona for example) have silica levels of 200 to 240 ppm and some are now proposing an extension to 300 ppm. This is accomplished with the use of polymeric dispersants.
- Hardness (Calcium and Magnesium): Expressed as $CaCO_3$. The amount of hardness allowed is a function of pH, temperature, alkalinity, conductivity, and of course hardness content. There are calculations used in the industry (such as Langelier Saturation Index – LSI) that determine the risk of certain levels. Some systems operate at hardness levels above 3,000 ppm $CaCO_3$, but most systems operate well below that figure.
- Chloride: The amount allowed is determined by the temperature of the water, the pH and the exposed metallurgy. Some metals, like SS 304 are not very tolerant of chloride and therefore the allowed amount will be very low (100 or 200 ppm). Other alloys are very tolerant for chloride, such as SeaCure or titanium. Levels can reach 3000 to 5000 ppm chloride.
- Sulfate: This parameter is also a function of temperature, pH and metallurgy such as chloride, but can also be affected by the amount of sulfuric acid used in the cooling tower. Also, since calcium sulfate (gypsum) is a common scale in cooling systems, the calcium concentration will factor into the sulfate limit selected by the plant. Some systems operate above 10,000 ppm SO_4, but most plants are well below that (1000 to 5000).
- Phosphate: This chemical can be found in the makeup water, or it (or chemical containing forms of phosphate) can be added intentionally for scale and steel corrosion inhibition. Typically the level of phosphate should not be very high. Levels can reach 10 to 20 ppm, but most systems are much less than that. Dispersants are often employed to inhibit calcium phosphate scale. This parameter is also important in that many states currently have (and many more have pending) regulations on nutrient discharge, of

which PO4 is included. This means the industry is looking for non-phosphate treatment strategies for alternative corrosion and scale treatments.

- Alkalinity: This is a function of pH. Addition of sulfuric acid for pH control will destroy alkalinity as CO_2 is released in the plume. Typically most systems are below 100 ppm total alkalinity but I some systems can reach the 200 to 300 ppm range.

3. Reference List

1) *Use of Degraded Water Sources as Cooling Water in Power Plants*, EPRI, Palo Alto, CA and California Energy Commission, Sacramento, CA: 2003, 1005359.

   -Relevant chapters:

   - Executive Summary
   - Chapter 2: Water Quality Requirements for Cooling Systems
     - 2.1, 2.2, 2.3
   - Chapter 5: Commercially Available Technology
   - Chapter 6: Emerging Technologies

2) *Reuse of Treated Internal and External Wastewaters in the Cooling Systems of Coal-Based Thermoelectric Power Plants*, DOE/NETL: September 2009, DE-FC26-06NT42722

   -Relevant chapters:

   - Chapter 5: Reuse of Secondary Treated Municipal Wastewater as Alternative Makeup Water for Cooling Systems
   - Chapter 7: Reuse of Ash Transport Water as Alternative Makeup Water for Cooling Systems
   - Chapter 8: Blowdown Management for Use of Impaired Water in Cooling Systems

3) Survey of High Recovery and Zero Liquid Discharge Technologies for Water Utilities, WateReuse Foundation: 2008, 02-006a-01

4) *Water Use for Electric Power Generation, EPRI, Palo Alto, CA : 2008,* 1014026. Note: This publication is free for EPRI Members only.

5) *Use of Non-Traditional Water for Power Plant Applications: An Overview of DOE/NETL R&D Efforts*, DOE/NETL: November 2009, DOE/NETL-311/040609

   -Relevant chapters

   - Chapter 4: Thermoelectric Power Plant Water Quantity and Quality Needs
   - Chapter 5: Treated Municipal Wastewaters/Reclaimed Waters
   - Chapter 9: Recovered Plant Discharges

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Operating Conditions

Typical operating conditions for some water cooled condensers, steam turbines, and gas turbines are listed in Tables 1 to 3, respectively. Please note that most data for condensers and steam turbines are based on limited information from current fossil and nuclear power plants only.

Table 1. Condenser Cooling Water Thermal Data Ranges

Capacity, BTU/kWh	Flow, gpm/MW	Temp Rise, °F
5000 (Fossil) -6500 (Nuclear)	400-1000	10-30

Source: EPRI reports and communications.

Table 2. Steam Turbine Steam Flow Thermal Data Ranges

Heat Rate* BTU/kWh	Efficiency**	Flow lb/MWh	Exhaust Temp °F	Exhaust Pressure in Hga
9000-10000	34-38%	5000-7000	80-110	1-2.5

* Turbine heat rate
** Turbine efficiency
Sources:
1. EPRI reports and communications.
2. Gas Turbine World 2010 GTW Handbook, Vol. 28, pages 96-103, 2010.

Table 3. Gas Turbine Gas Flow Thermal Data Ranges

Heat Rate* BTU/kWh	Efficiency**	Flow lb/s/MW	Exhaust Temp °F	Exhaust Pressure psia
7000-21000	16-45%	5-25	750-1200	14.7

* Defined as fuel energy input for the power produced.
** Defined as power output divided by the rate of fuel energy input.
Source: Gas Turbine World 2010 GTW Handbook, Vol 28, pages 82-89, 2010.