# Technical Guidance Document: Steam Purity for Turbine Operation

## The International Association for the Properties of Water and Steam

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# Why do we need a technical guidance document on steam purity for turbine operation?

We have one for feedwater and boiler water…

- Turbine is the most sensitive and expensive component in a water steam circuit
- Some boilers does not supply steam for a turbine
- Some turbines get steam from other sources than traditional boiler
  - Geothermic
  - Process steam
- Composition of the steam is very different from boiler water
- Composition of the steam can be fairly different from feedwater
  - Particularly at load transition
- Emphasize the importance of turbine protection
  - Highlight the problems which can exist
  - Indicate how these problems occur and can be avoided
  - Provide a set of normal steam purity limits for all kinds of turbines
  - Provide sufficient discussion that the reader can customize these normal values to actual plant configurations

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# Nomenclature and Definitions

- Very good survey of terms used used in PPC
- New or anusual abrevations

  CACE - Conductivity after cation exchanger
  PTZ - Phase Transition Zone
  TSP - Trisodium Phosphate

# Introduction: Purpose of Document and How to Use it

- Some general priciples

  Inspections - deposits, crevices
  Carryover - contamination
  Attemperations - contamination
  Solid alkalization - Na
  Proprietary chemicals

# Background

Comprehensive explanation of problems of PTZ

- Chemical environment in steam turbines

  Path of Impurities into the steam

  Nucleation of Early Condensate Droplets

  Formation of Liquid Films on PTZ Surfaces

  Influence of Steam Purity on Early Condensate Nucleation and Liquid Films

  Deposition

  Shutdown Environment

- Damage mechanizms in steam turbines

  Deposition

  Corrosion - SCC, CF, FAC, Solid particle erosion

# Requirements to limit the effects of poor steam chemistry

- **Steam Purity Parameters**
  Impurities - CACE, degassed CACE, Na, Cu, Fe, Al, TOC, $O_2$,
  Conditioning agents - $NH_3$, amins, red.agents
- **Monitoring instrumentation**
  Another IAPWS Technical Guidance Document
- **Layup**
- **Mitigating Consequences of bad Steam Chemistry**
  Commissioning - adequate cleaning of the circuit
  Unforeseeable situation – cooling water ingress
  Deposits - insoluble / soluble in water
  Acid conditions
  Degradation of water/steam separation

# Table of Chemistry Limits

- Steam Purity for normal operation

## Condensing Turbines with Superheated Steam

| Parameter | Unit | Normal / Target Values |
|---|---|---|
| Conductivity after cation exchange @ 25℃ | µS/cm | < 0.20 |
| Sodium as Na | µg/kg | < 2 |
| Silica as $SiO_2$ | µg/kg | <10 |

## Condensing Turbines with Saturated Steam

| Parameter | Unit | Normal / Target Values |
|---|---|---|
| Conductivity after cation exchange @ 25℃ | µS/cm | < 0.30 |

- Development of Limits for Startup

| Na | CACE * | Restrictions |
|---|---|---|
| µg/kg | µS/cm | |
| > 20 | > 2 | Do not pass steam to turbine |
| 10 … 20 | 1 … 2 | - Steam production < 40% nominal<br>- Max 30 min per startup |
| n … 10 | n … 1 | Max 8 hours per startup |
| | | |

- Development of Action Levels
- Development of Shutdown Limits
  CACE > 1 µS/cm

# Road Map Approach to Customize Steam Purity Limits to Plants with Specific Features

- **Turbines for Cycling or Peaking Operation**
- **Turbines with Extended Periods of Shutdown**
- **Backpressure Turbines**
- **Turbines for Industry and Process Supply**
- **Turbines with Solar and Biomass Steam Generating Systems**
- **Turbines with Geothermal Steam**
- **Turbines with Steam Generated in Nuclear Power Plants**
- **Ultrasupercritical Turbines with Steam Temperatures >600°C**
- **Turbines in Plants with Boilers using Phosphate Treatment**
- **Turbines with Steam containing elevated levels of Silica**
- **Turbines in Power Cycles containing major components with Copper or Aluminum**

# Turbines with Steam Generated in Nuclear Power Plants

- ***Saturated steam from Boiling Water Reactors***

| Parameter | Unit | N |
|---|---|---|
| Conductivity @ 25℃ | µS/cm | < 0.10 |
| Mechanical Carryover * | % | < 0.1 |

- ***Saturated steam from Pressurized Water Reactors***

| Parameter | Unit | N |
|---|---|---|
| Conductivity after cation exchange @ 25℃ | µS/cm | < 0.20 |
| Sodium as Na | µg/kg | <10 |
| Mechanical Carryover * | % | < 0.5 |