Steam Chemistry Best Practices in a Steam Methane Reformer

ELLIE PALOMO

Nalco Water, an Ecolab Company

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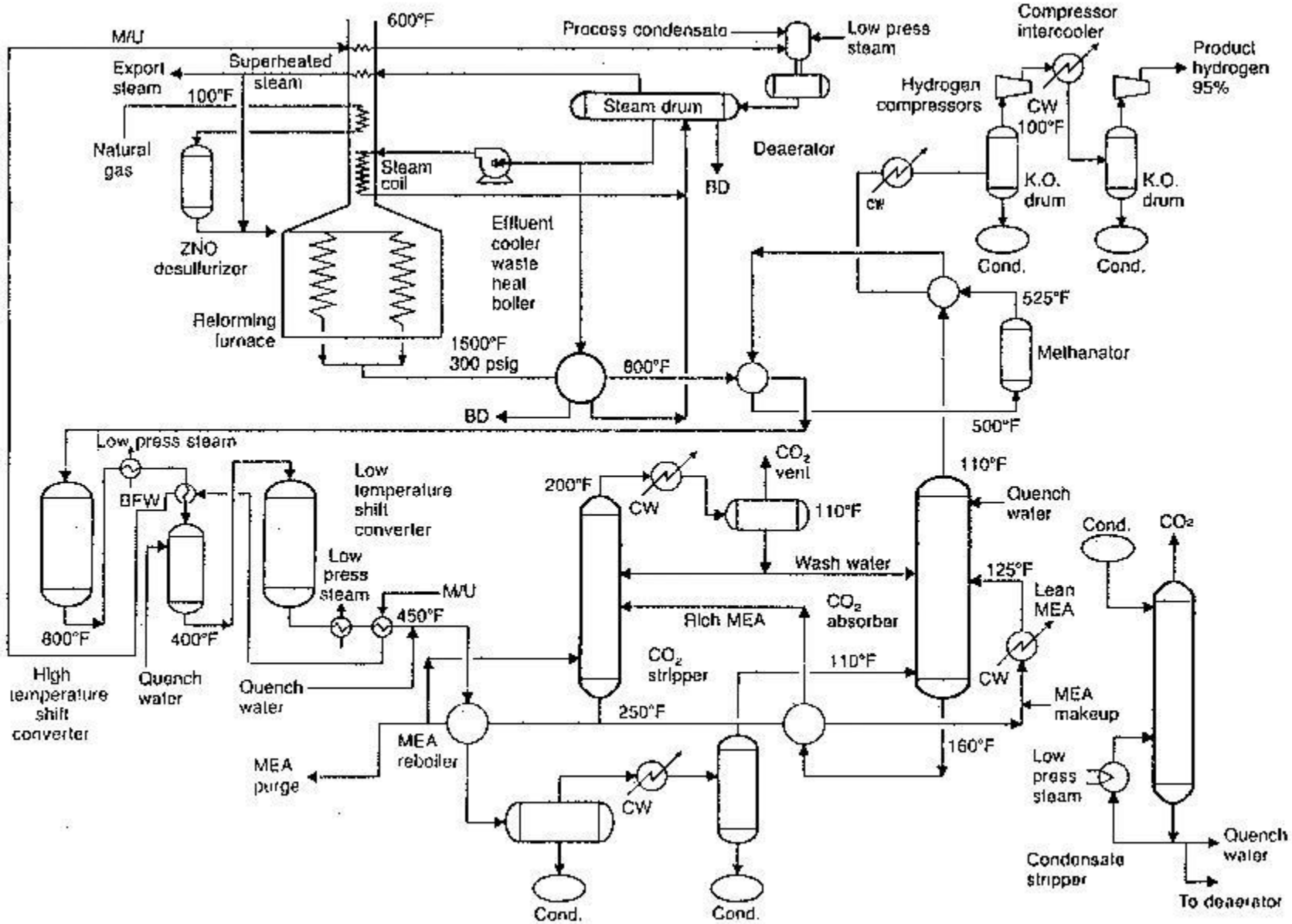
Steam Methane Reformer (SMR) Steam System Overview



Fundamental Mission of a Boiler System

- To produce the required amount of steam
- To produce the required pressure steam
- To produce the required purity steam
- To produce steam safely and efficiently

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Why Treat Boiler Water?

Boiler Water Treatment Objectives:

- Corrosion Control
- Deposition Control
- Steam Purity

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Treatment Success Requires Balance

Balanced M-O-C Approach to Total System Protection

Mechanical

- Consider all aspects inherent to steam system design

Operational

- Understand how plant operational decisions impact performance

Chemical

- Water chemistry and related interaction

Boiler Treatment Program Components

Pretreatment

Objective: Prepare makeup water for use in the boiler

- Choice of pretreatment depends on feedwater purity demands
- Common solutions include softening, reverse osmosis and demineralization

Preboiler

Objective: Combine makeup and condensate to required feedwater (FW) purity

- Feed a non-sulfite oxygen scavenger and maintain target FW pH for corrosion control
- Maintain ASME guidelines to minimize metals transport and deposition in PGB

Boiler Internal Treatment

Objective: Match the treatment approach with likely contaminants in the FW

- Internal treatment chemistry and supplemental iron dispersant commonly used
- Boiler cycle control is critical in removing suspended solids from the boiler

Steam / Condensate Treatment

Objective: Provide protection for export steam condensate system metallurgy

- Hydrogen plant condensate system is protected by stainless steel, export is not
- Feed amine to export steam header when required

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SMR Boiler Program
-Key Considerations-

1. Process condensate challenges
2. Avoiding reformer fouling/deposition
3. Catalyst poisoning prevention
4. Minimize condenser corrosion risk
5. Proper boiler cycle control

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SMR Process Condensate Considerations

- Process condensate is returned exclusively as boiler feedwater
- Can be laden with CO_2 at a pH of 4.3, (or pH >7)
- Can contain high levels of iron (up to 1.0 ppm)
- Boiler feedwater often exceeds recommended ASME guidelines
- Supplemental iron dispersant needed to prevent deposition
- Non-precipitating boiler treatment recommended
- No amine treatment required
  - Except for export steam applications

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Contaminant Concentrations in Condensate

Species	Units, ppm as…	Hot Process Condensate	Cold Process Condensate	ASME Feedwater Guidelines
Total Iron	Fe	1.6	0.66	≤ 0.02
Copper	Cu	< 0.026	< 0.009	≤ 0.01
Inorganic Carbon	C	1.6	30	N/A
Organic Carbon	C	5.1	22	< 0.2
Methanol	CH_3OH	6.1	40	N/A
Formic Acid	CHOOH	6.4	1.1	N/A
Ethanol	C_2H_5OH	1.4	4.0	N/A
Acetic Acid	CH_3COOH	3.3	1.7	N/A

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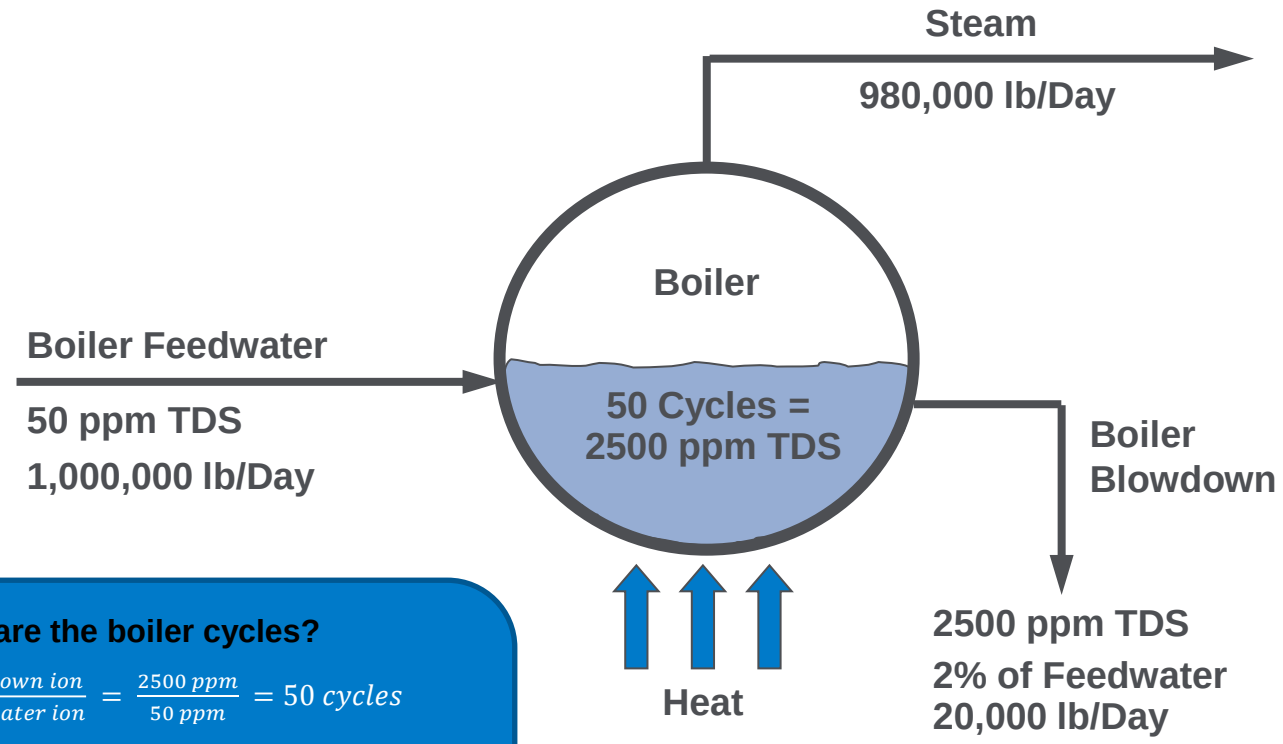
Cycles of Concentration Study



What are the boiler cycles?

$$\frac{blowdown\ ion}{feedwater\ ion} = \frac{2500\ ppm}{50\ ppm} = 50\ cycles$$

How much blowdown is that?

$$\frac{100}{Cycles} = \frac{100}{50} = 2\%\ Blowdown$$

Feedwater = Steam + Blowdown

HOWEVER

This only applies to ions that stay soluble. As FW purity increases (and ions decrease), TDS or conductivity is no longer a representative control strategy for boiler cycles. Consider inert TRASAR™ monitoring for most accurate cycle control.

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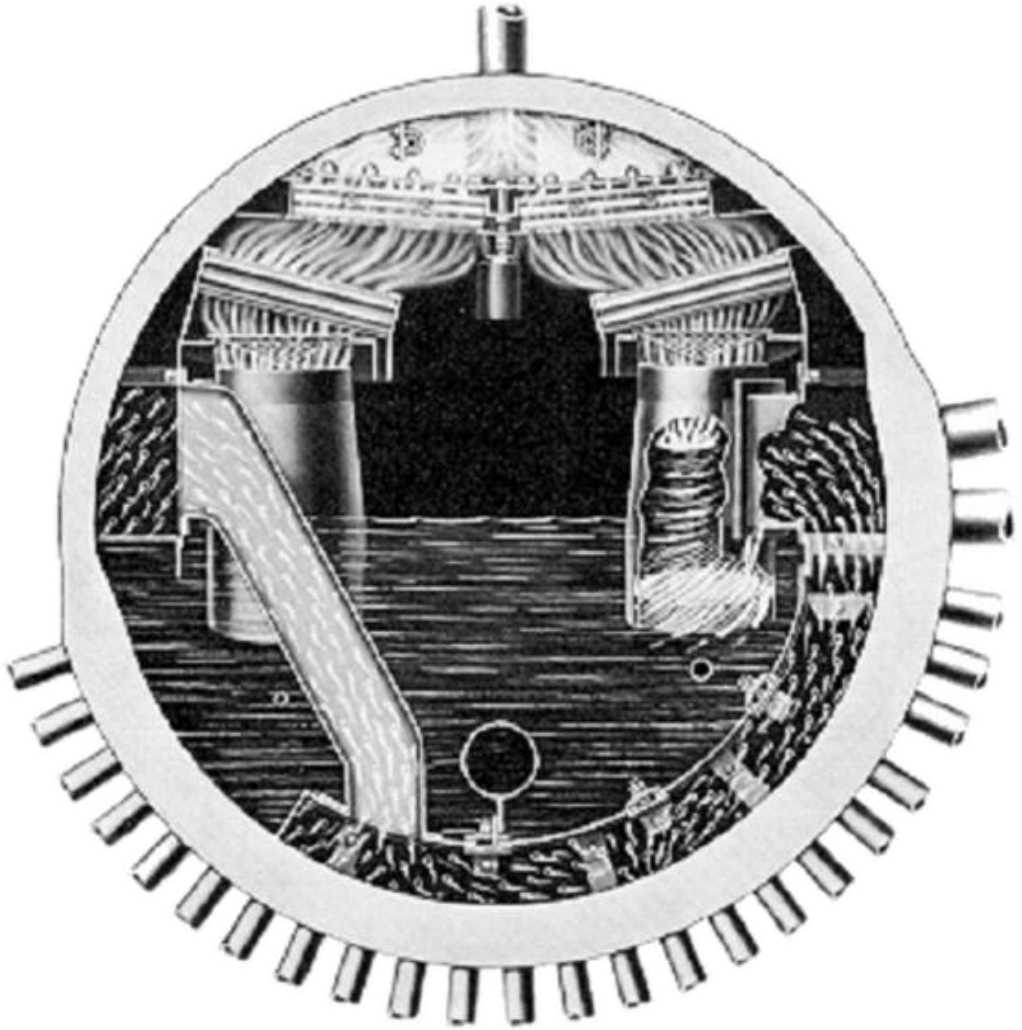
Steam Separation Equipment



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Best Practices

Hydrogen Plant Boiler Program Selection Guide

Purpose	Considerations	Feed Point	Soft Water Makeup	Demineralized Water Makeup
Oxygen Scavenger	1. No Sulfur Compounds 2. Maximize boiler cycles	Piping between DA stripping and storage section	Passivating Scavenger	Passivating Scavenger
Feedwater pH Control	1. If required 2. Minimize ammonia	Boiler feedwater	Neutralizing amine	Neutralizing amine
Internal Treatment	1. Minimize ammonia generation 2. Iron dispersant capability 3. TRASAR capability for cycle control and system diagnostics 4. Maximize cleanliness	Boiler feedwater	All-polymer treatment	All-polymer treatment
Supplemental Iron Dispersant	1. If chelant or phosphate internal treatment programs are utilized	Boiler feedwater	All-polymer treatment	Utilize polymer dispersant
Condensate Treatment	1. To protect export steam 2. Hydrogen plant condensate system is protected by stainless steel	Export steam header	As required to protect plant systems	As required to protect plant systems

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What about feeding caustic for pH control?

There is RISK. Caustic chemistry should NOT be fed to the feedwater if you have stainless steel feedwater heaters and feedwater on the shell side. This can create conditions that lead to stress corrosion cracking of the stainless steel tube joints.

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Best Practices

- Industry standards such as ASME guidelines
- Nalco experience and research
- Proprietary technology
- SPC!

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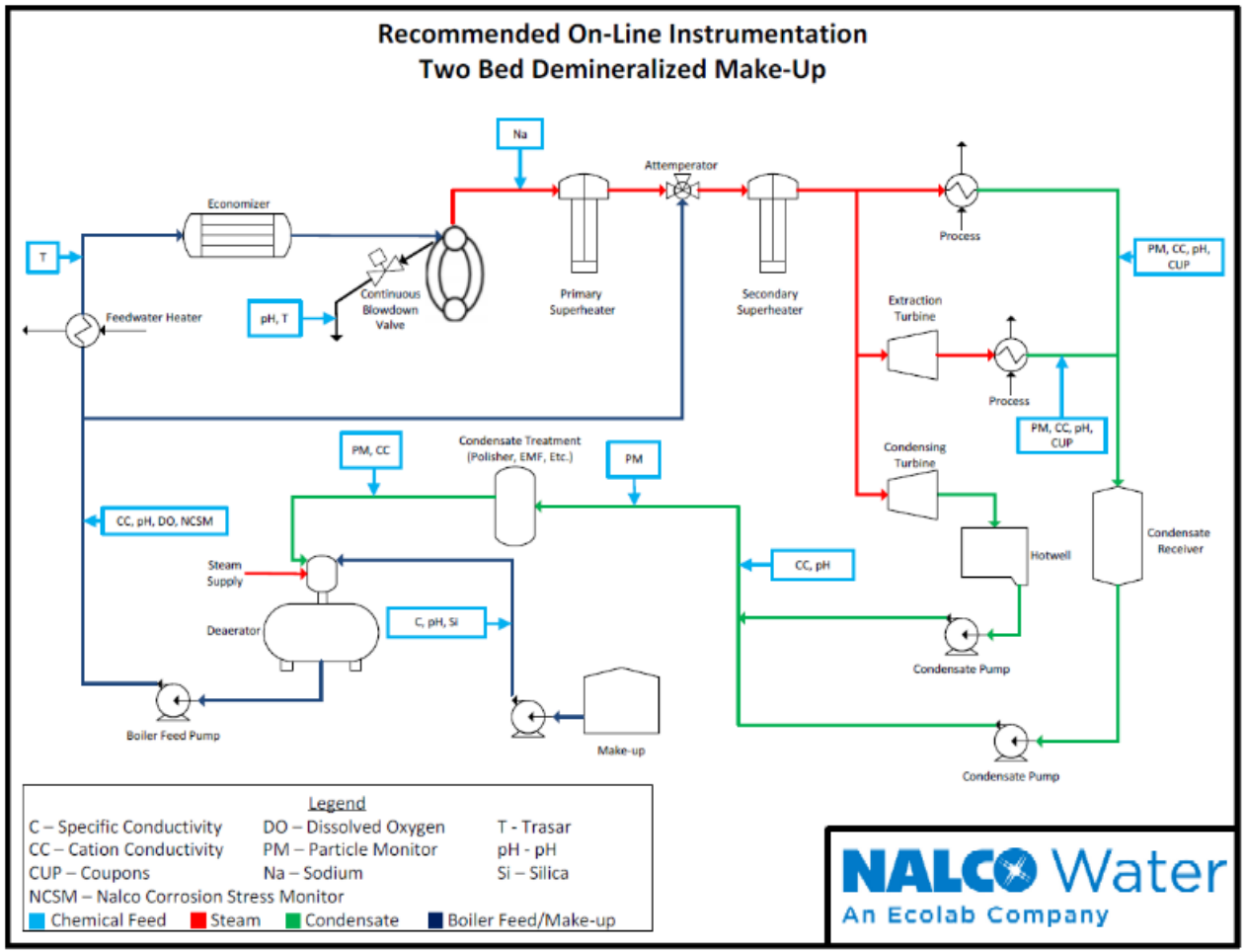
Best Practices

- Chemistry control parameters
- On-line analyzers
- Grab samples
- Chemical injection

Cycle Diagram Examples



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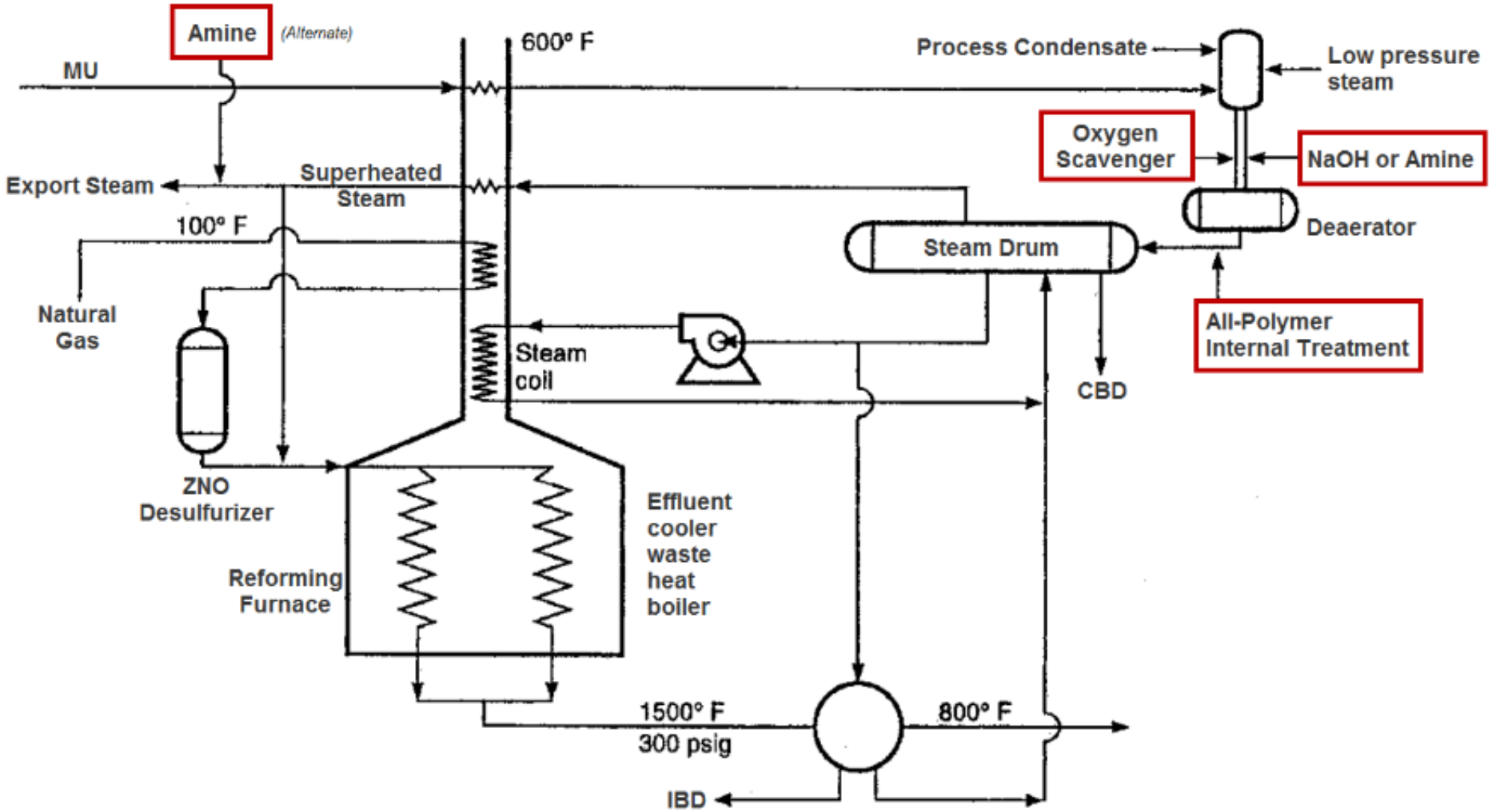
Recommended Chemical Injection Locations



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Steam Sampling

Why Sample?

- Provides VISIBILITY to potential issues before they become significant OPERATIONAL CONCERNS.

Where and How to Sample?

- Steam
- Isokinetic Nozzle
- Superheated or Saturated
- ASME & ASTM Guidelines

"What's measured improves"

Peter Drucker

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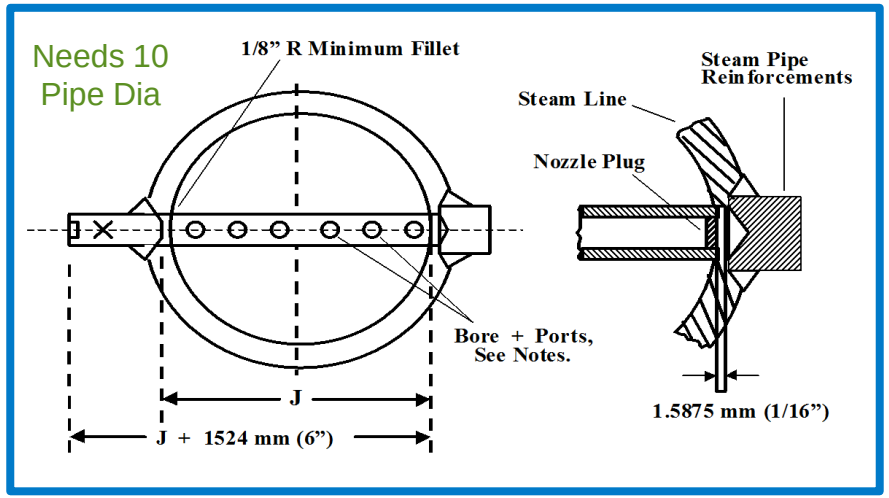
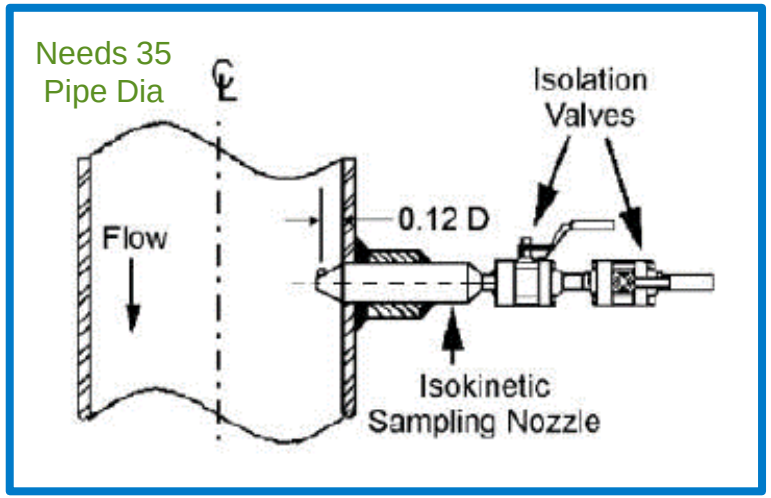
Isokinetic Steam Sampling

- Isokinetic Sampling
  - More than just having the right nozzle
  - Required for saturated steam
  - Suggested for superheated steam
  - Standards outlined in ASTM D1066



Multiport Style



Pitot Tube Style
-ASTM Recommended-

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Best Practices are a compilation of Lessons Learned

"Learn from the mistakes of others. There's not enough time to make them all yourself."

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