# Wet Scrubbers: Upgrading & Results

By Magnus Rundqwist

# Synopsis/Abstract

Wet Scrubbers

Wet scrubbers, many installed 20-30 years ago, are aged to a point where they may be ready for replacement or a major renovation.  In today's regulatory environment, these older wet scrubbers may not meet new the requirements.  But before committing to higher cost options such as ESP or WESP,  the wet scrubber may be worth a second look.  This presentation will address the options of upgrading existing wet scrubbing equipment and how to predict the results of such upgrades.

WECHSLER
ENGINEERING | CONSULTING

WECHSLER
ENGINEERING | CONSULTING

# Why wet scrubbers in the first place?

- Economics
- Performance (not only PM)
- Simplicity
- “Familiar” Equipment
- No fires
- Real estate

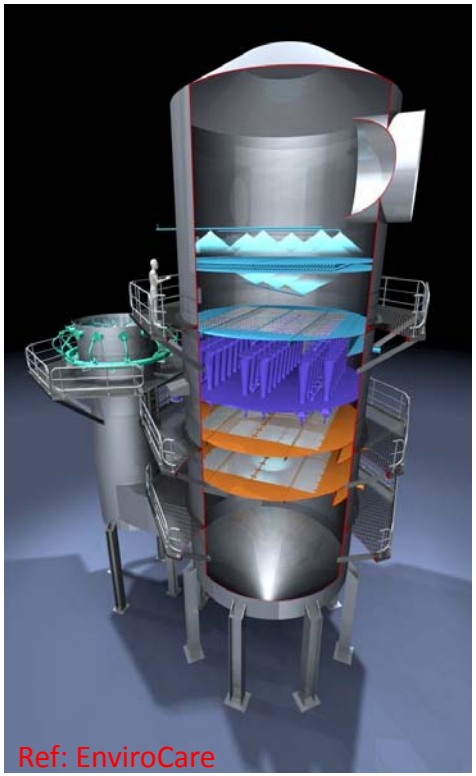
# Particulate Scrubbers - “Low-end” and “Mid-range”

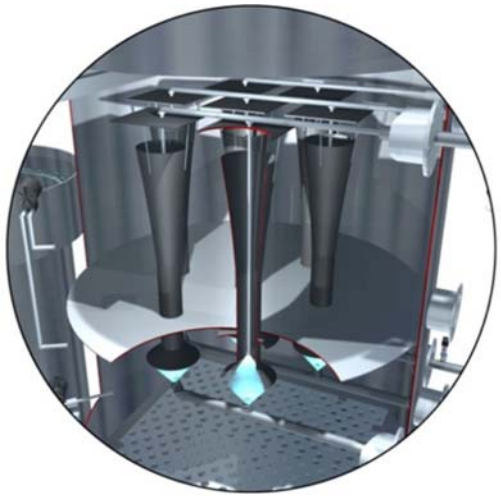
Venturi Quench followed by a separator for droplet removal

Additional stages can be installed to further improve condensation and capture

# Particulate Scrubbers
# - High Performance Type

Quench followed by one or several condition stages, multiple venturis followed by a mist eliminator



# What type of PM scrubber or scrubber retrofit is needed?

- Depends on what particulates we are targeting:

- “Rocks” (>5micron)

  or

- Fines (>2.5 micron)
- Super Fines (<2.5 micron)

  or

- Submicron Particulates, Aerosols & “Smoke” (<1,0micron)

# Options/Choice

In most cases a Low End scrubber can be upgraded to a Mid-range or High Performance scrubber

| Particle "Type" | Low End Scrubber | Mid Range - Scrubber | High Perform.- Scrubber | ESP | WESP |
|---|---|---|---|---|---|
| "Rocks" | ✓ | ✓ | ✓ | ✓ | no |
| Fines | ✓ | ✓ | ✓ | ✓ | P |
| Super Fines | some | ✓ | ✓ | ✓ | ✓ |
| Submicron | no | no | high % | ✓ | ✓ |
| Aerosols & Smoke | no | no | some | no | high % |

# Cost? (cost index installed basis)

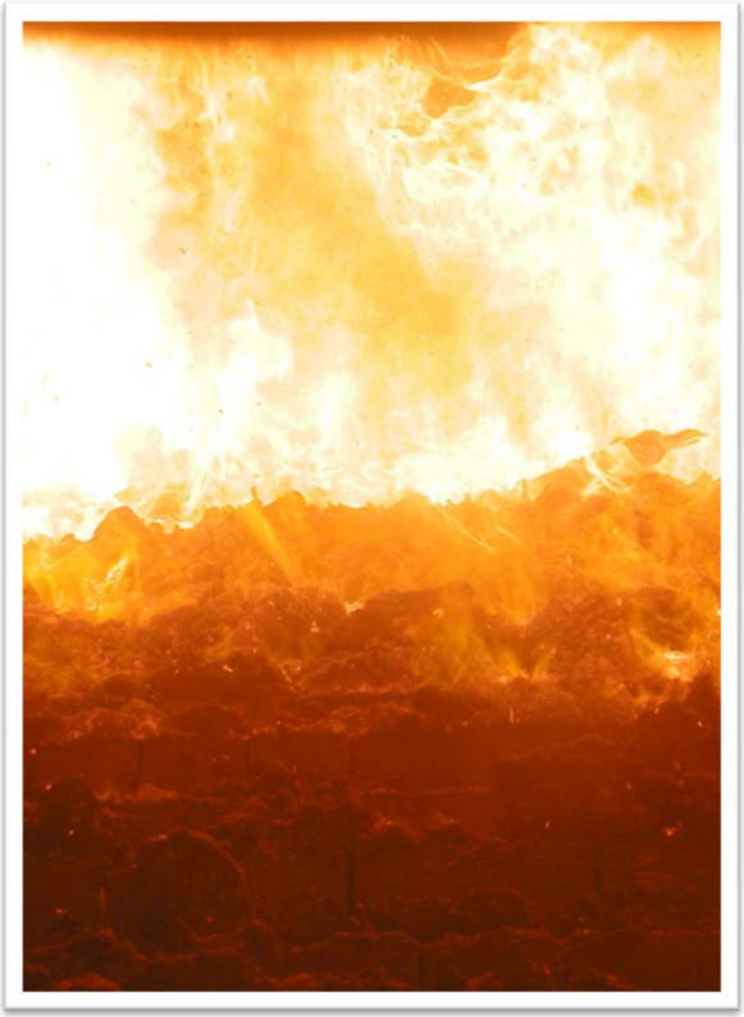
| | |
|---|---|
| New WESP: | 1.00 |
| New ESP: | 0.7-0.9 |
| New High End. Scrubber: | 0.5 |
| New Low-Mid range Scrubber: | 0.3 |
| Scrubber Upgrades: | 0.05 and up |

It makes sense to investigate if it's feasible to upgrade. →→→→→→

# First, get the most out of your existing scrubber.

Optimize Inlet Conditions:

- Fuel choice
- Fuel distribution
- Boiler/combustion tuning
- Carry over
- Air Leaks
- BMS?
- OFA system?
- Upstream equipment?



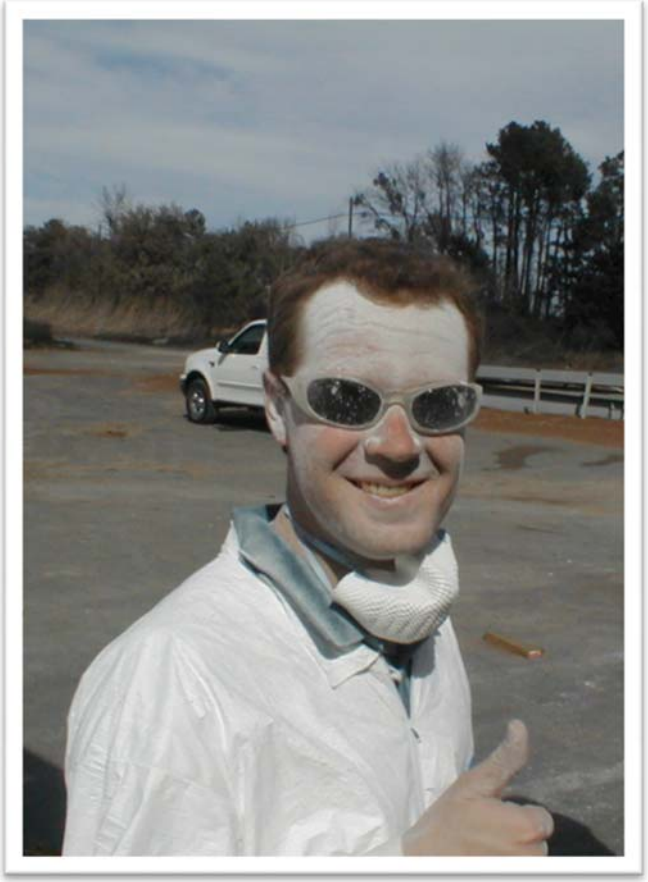
# Then, assess your existing scrubber

- Note any process or mechanical conditions that could/are affecting performance.
- Determine best performance “as-is“.
- Is the scrubber suitable to be upgraded and to what extent?

# How do we know?

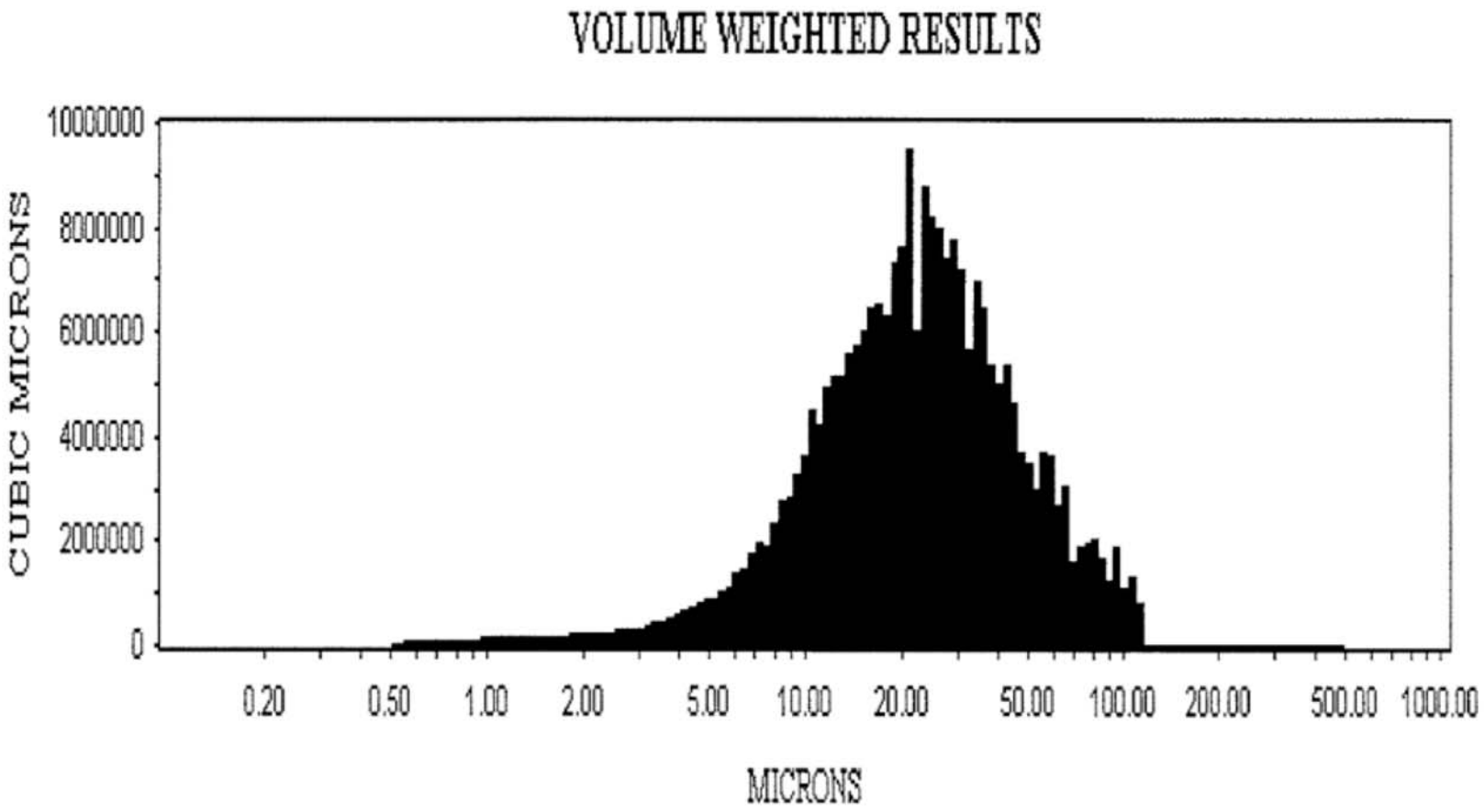
# -Get to know the inlet condition

- Particulate Loading (lbs/h)
- PSD -Particulate Size Distribution
- Chemistry



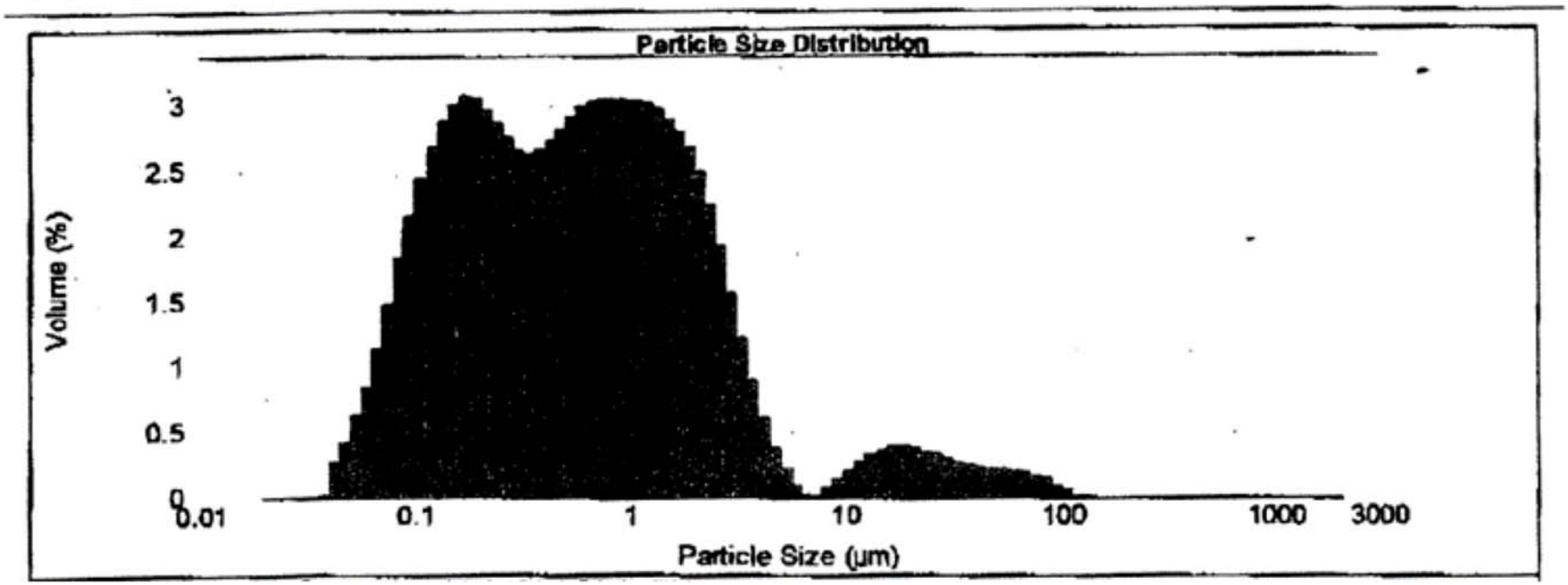
# Examples of PSD analysis

Ref: Lime Kiln



# Examples of PSD analysis

Ref: Bark fired Power Boiler (large)



# Examples of PSD analysis

Ref: Bark fired Steam Boiler firing Sander dust

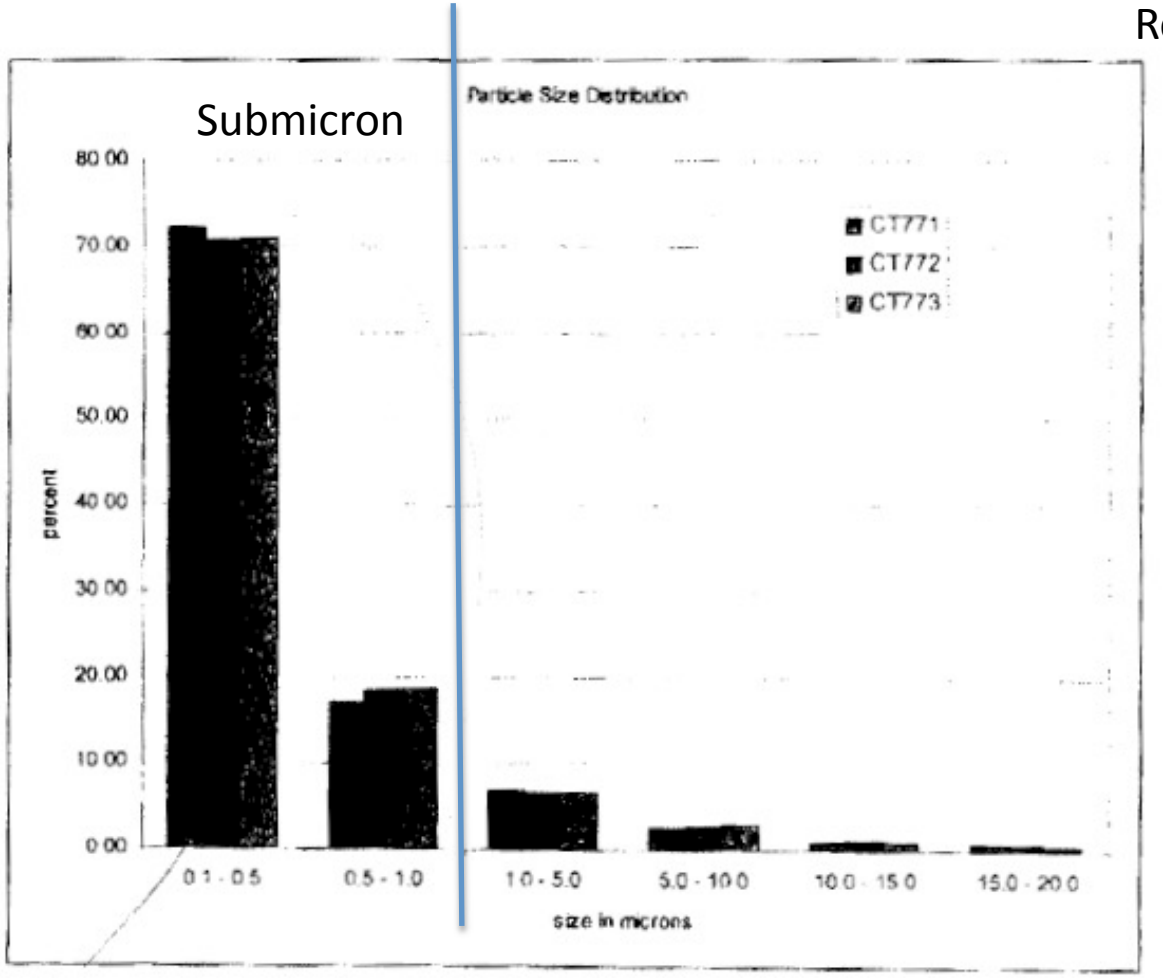
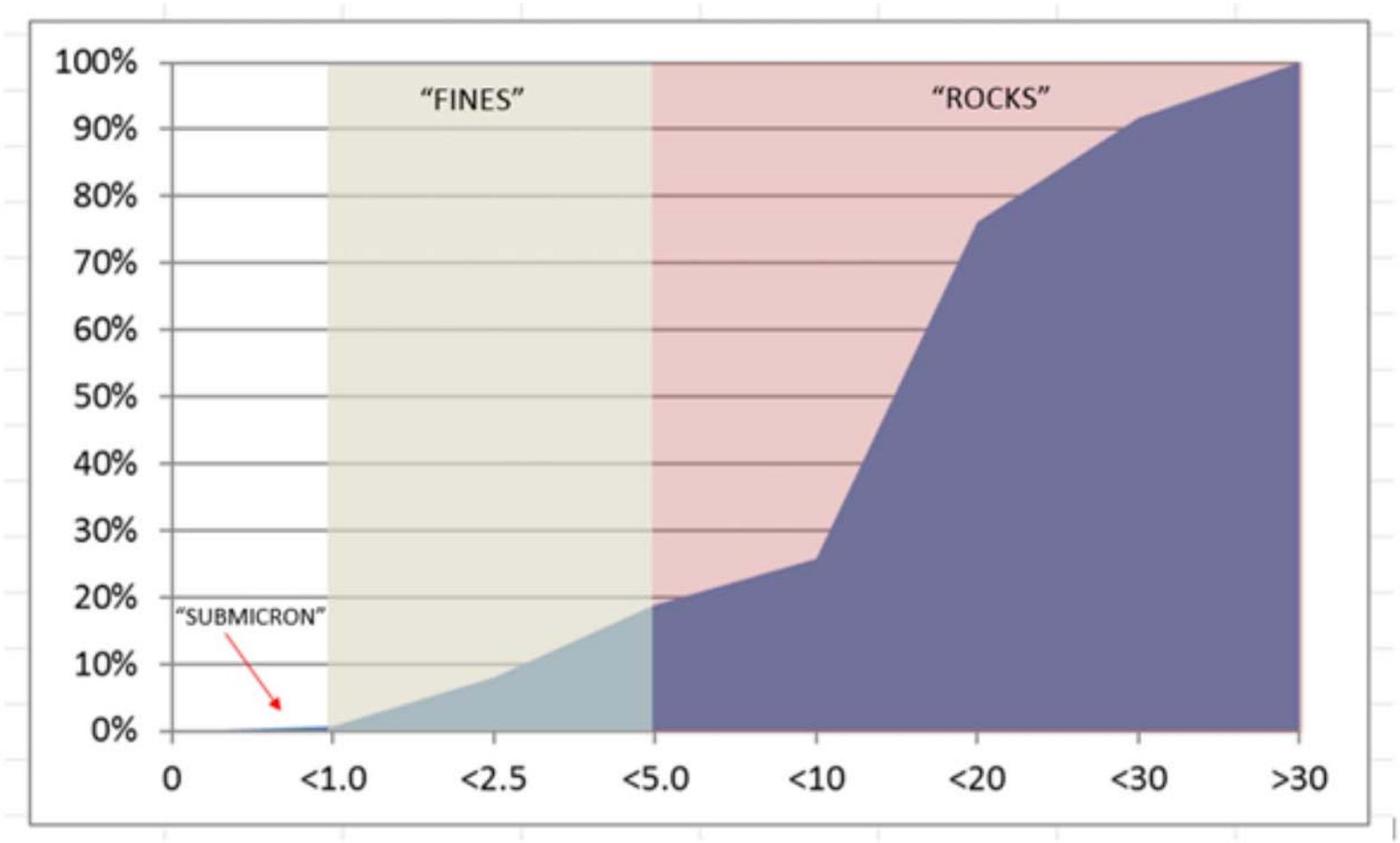


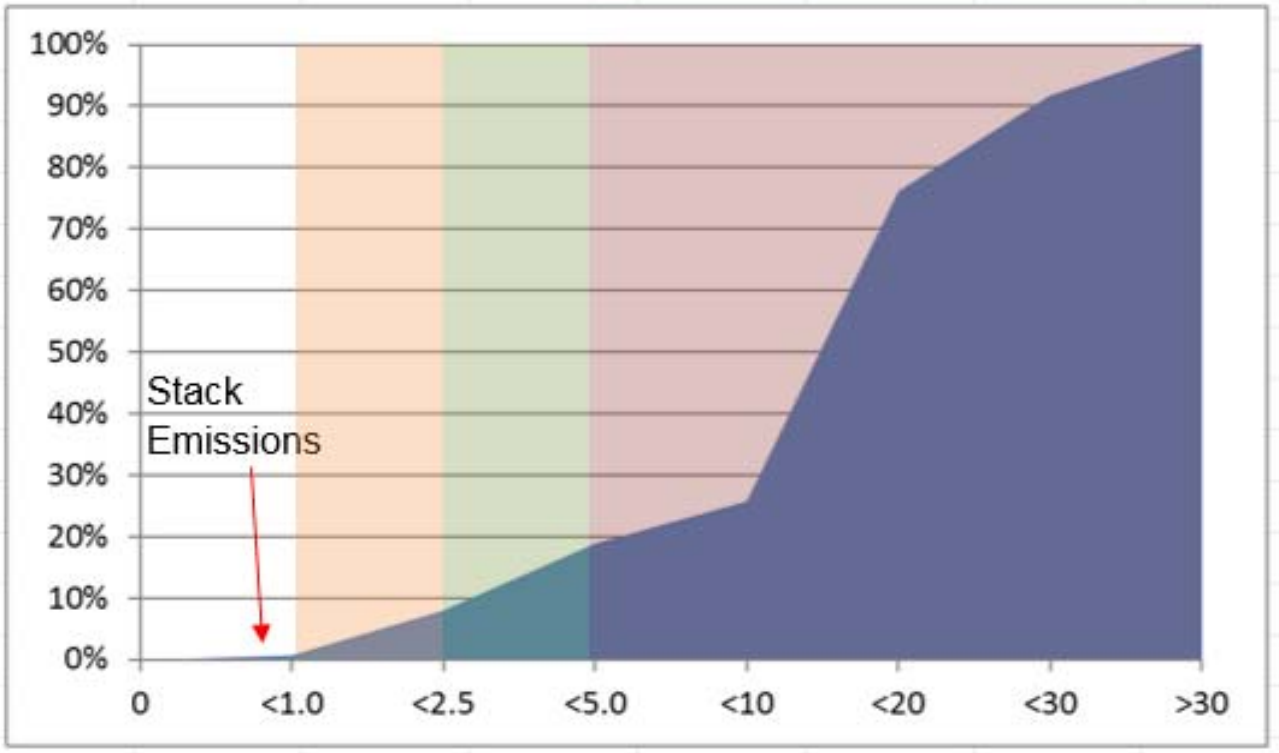

Figure 1: Particle size distribution as a function of count percent

# Inlet Particulate Loading Summarized



# What will the predicted result be?

**HIGH REMOVAL EFFICIENCY**
"ALL" scrubbers should be able to get ~100%




**VARIABLE REMOVAL EFFICIENCY**
Depending on dP, conditioning stages, residence time,

**HIGH REMOVAL EFFICIENCY**
Scrubbers with good Good Venturi/Quench & Mist Eliminator

# Case study 1 -Bark Fired Boiler

The Challenge: To improve particulate emissions on a limited time schedule and budget

Equipment: B&W Boiler with new OFA system, Multiclone, un-conventional fixed venturi scrubber

Inlet Conditions: Due to time constraints the inlet conditions were not studied in detail. However, the inlet temperature was high risking flash evaporation re-releasing that particulate from the re-circulation water into the flue gas

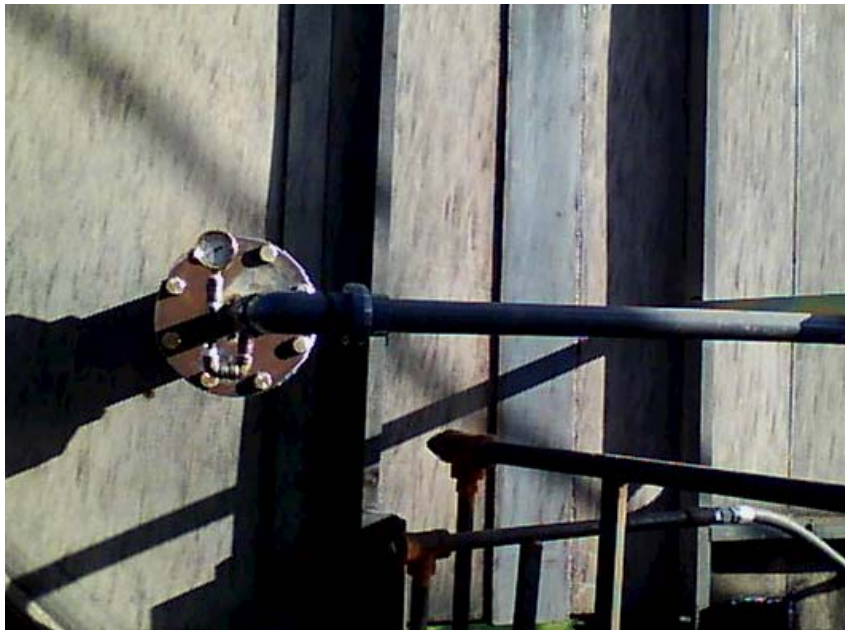
# Case study 1 -Bark Fired Steam Boiler

Solution (Short Time-frame, a couple of days!)

- Tighten in-leakage air leaks prior to the ID fan
- Install a pre-quench spray nozzle in the duct-work

# Case study 1  -Bark Fired Steam Boiler

Pre-quench Lance installed



# Case study 1 -Bark Fired Steam Boiler

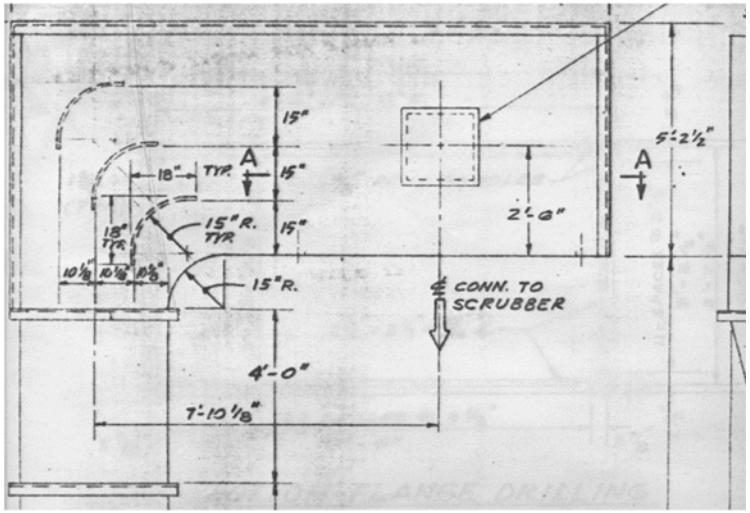
Results: Improved PM emissions 15-30%*

Note: Difficult to estimate exact contribution in performance, Several parameters were changed while testing. However, turning the pre-quench on-off gave a clear visual improvement of the plume.

# Case study 2 -Wood Fired Power Boiler

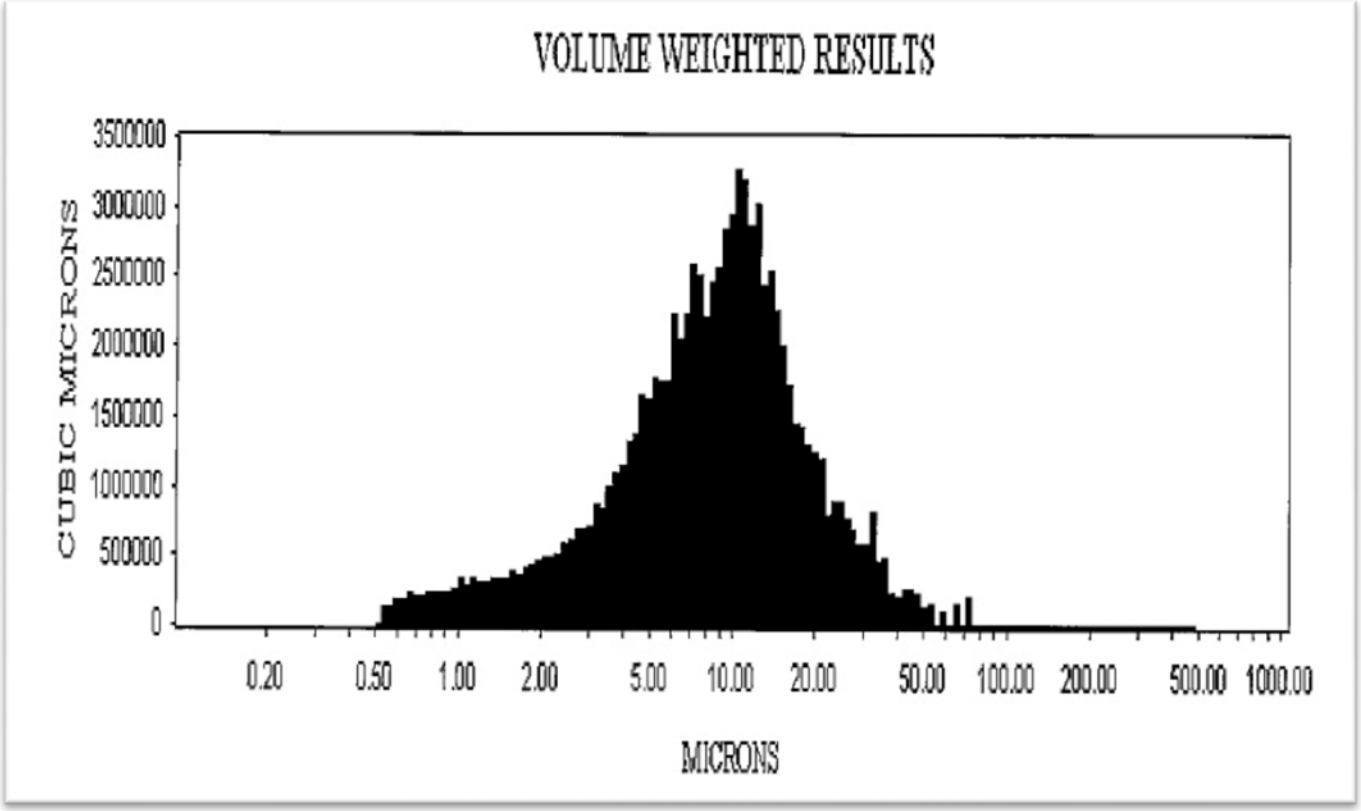
The Challenge: Mill considered new scrubber, but on a limited budget pm emissions must improve with 15%

Equipment: B&W Boiler, Multiclone, basic plum-bar venturi scrubber



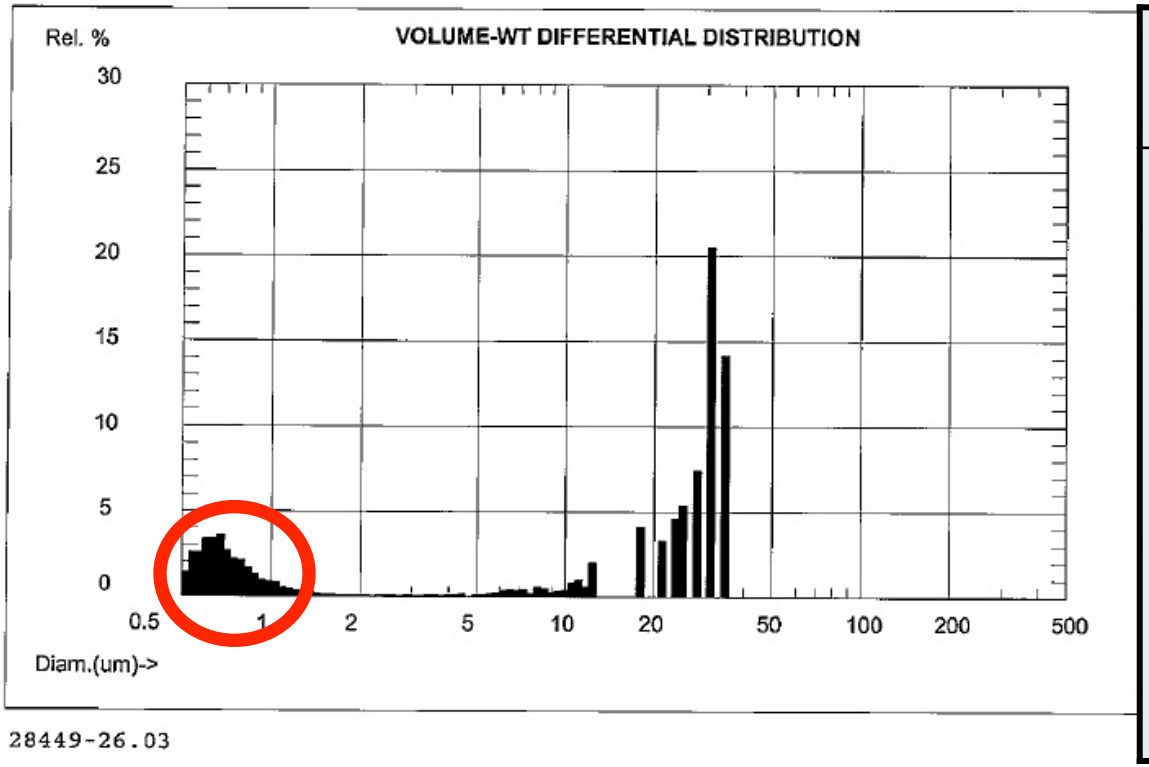
# Case study 2 -Wood Fired Power Boiler

Inlet conditions: PSD Analysis



# Case study 2 -Wood Fired Power Boiler

Outlet conditions: PSD Analysis & Chemical Analysis




| FILTER | |
|---|---|
| K | 60% |
| S | 29% |
| Na | 5% |
| Si | 5% |
| Al | trace<1% |

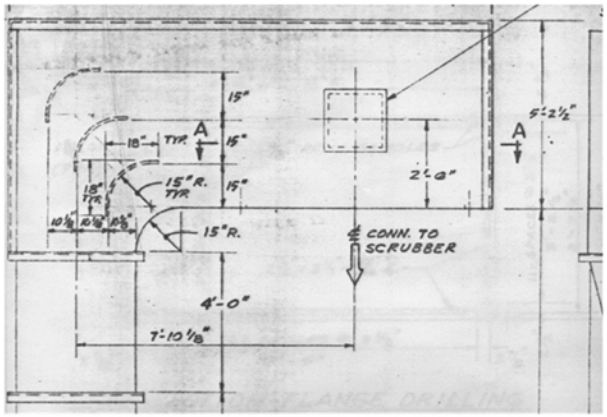
# Case study 2 -Wood Fired Power Boiler

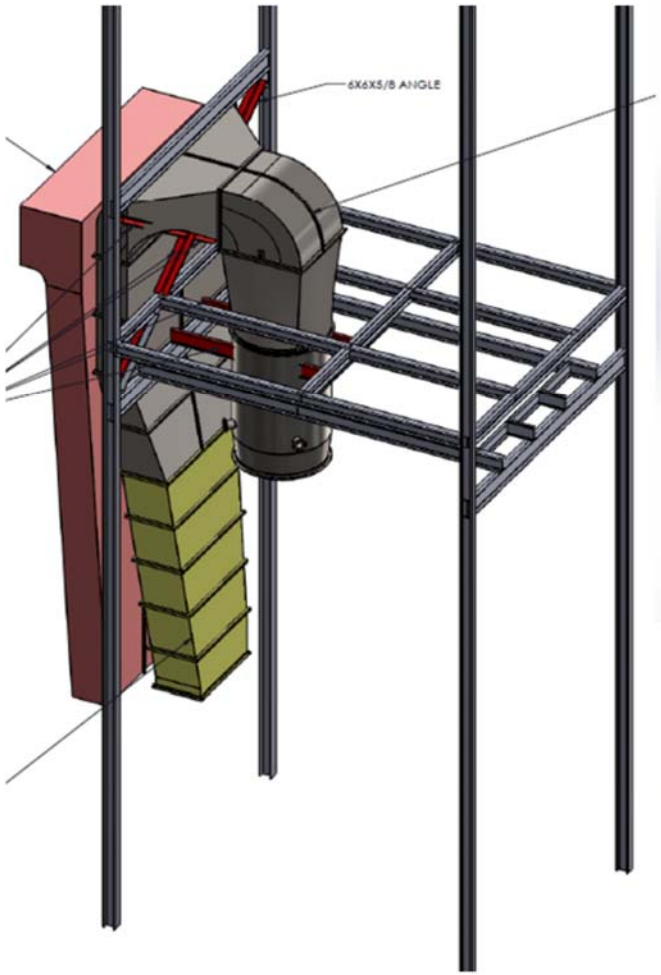
Solution: Modify the existing scrubber inlet ductwork from a sharp 180° to a “gooseneck design to distribute the flue gas enter the quench more evenly

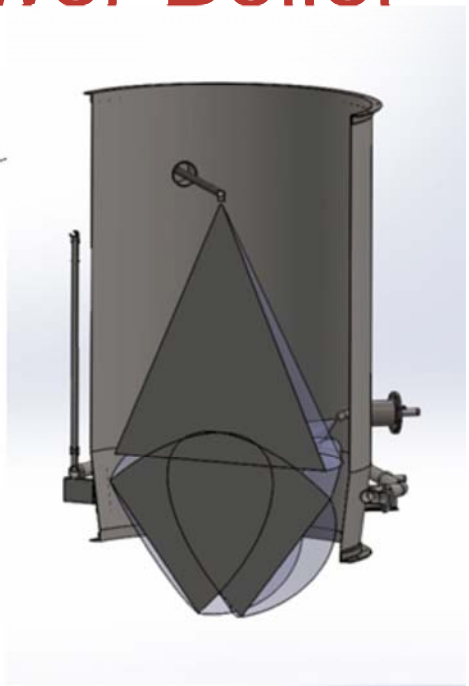
Install a Pre-quench to lower the flue gas velocity going into the existing quench and to promote condensation of Potassium

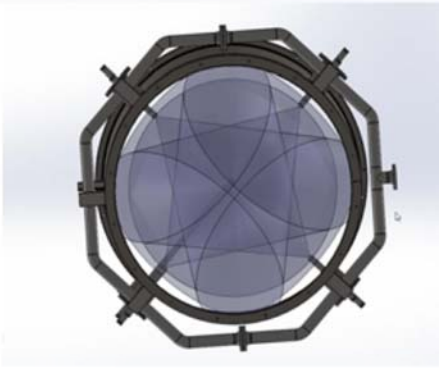
Improve spray coverage with an extra spray section

# Case study 2 -Wood Fired Power Boiler





# Case study 2 Wood Fired Boiler

Results: Improved PM emissions 15-20%* and 3” W.C. less dP (From 0.085 to < 0.065 lbs/MMBtu)

Installed cost << 1/3 of a new basic scrubber

Note: * Real results even better, the lowered dP resulted in a non-maxed out ID-fan improving the controllability of the Boiler

# Example
# -High Performance Scrubber Upgrade
## (BoilerMACT level)

#1: Install High Efficient quenching/conditioning stage

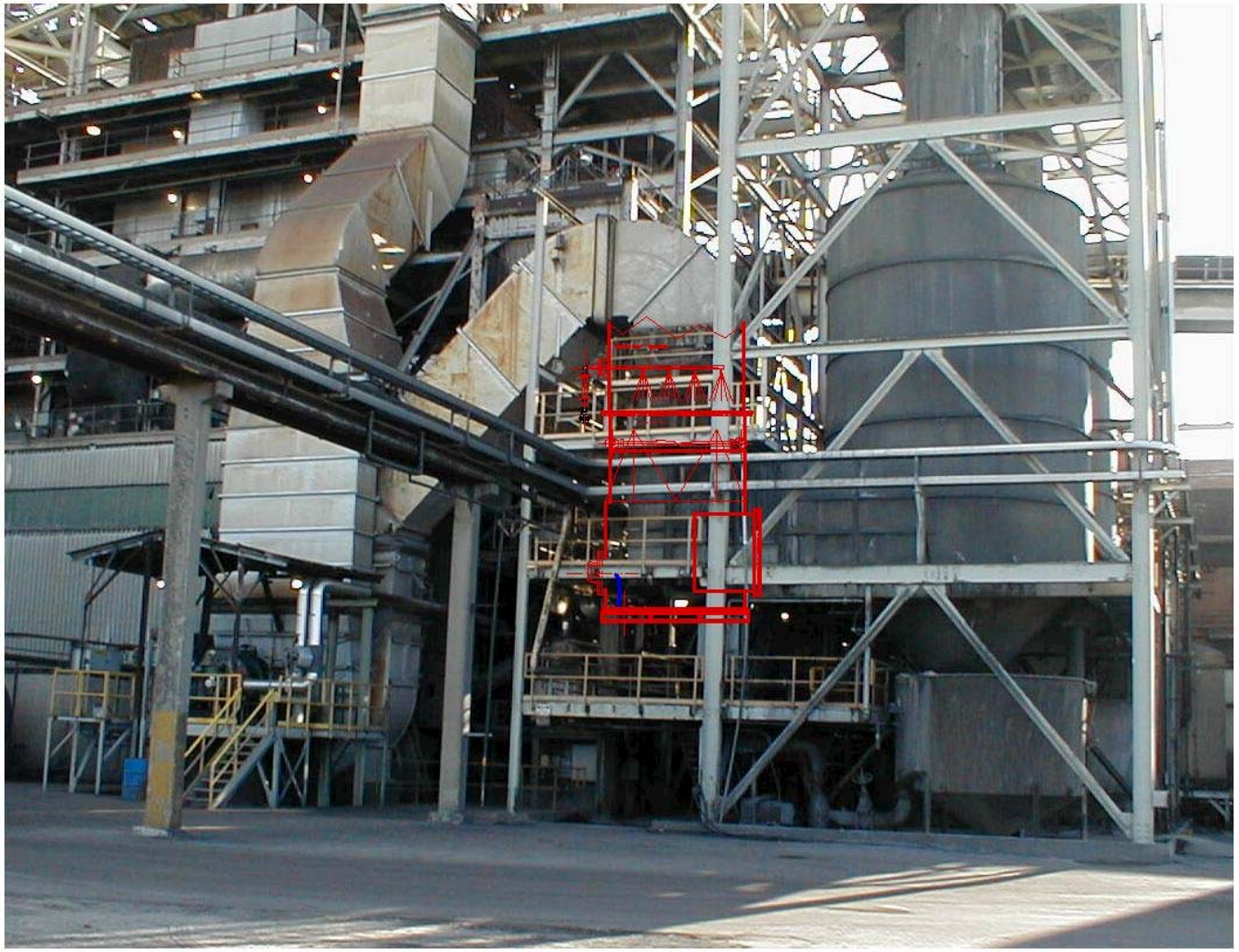
#2: Add additional conditioning stages if necessary
(Packed bed, Trays etc)

#3: Multiple Venturis

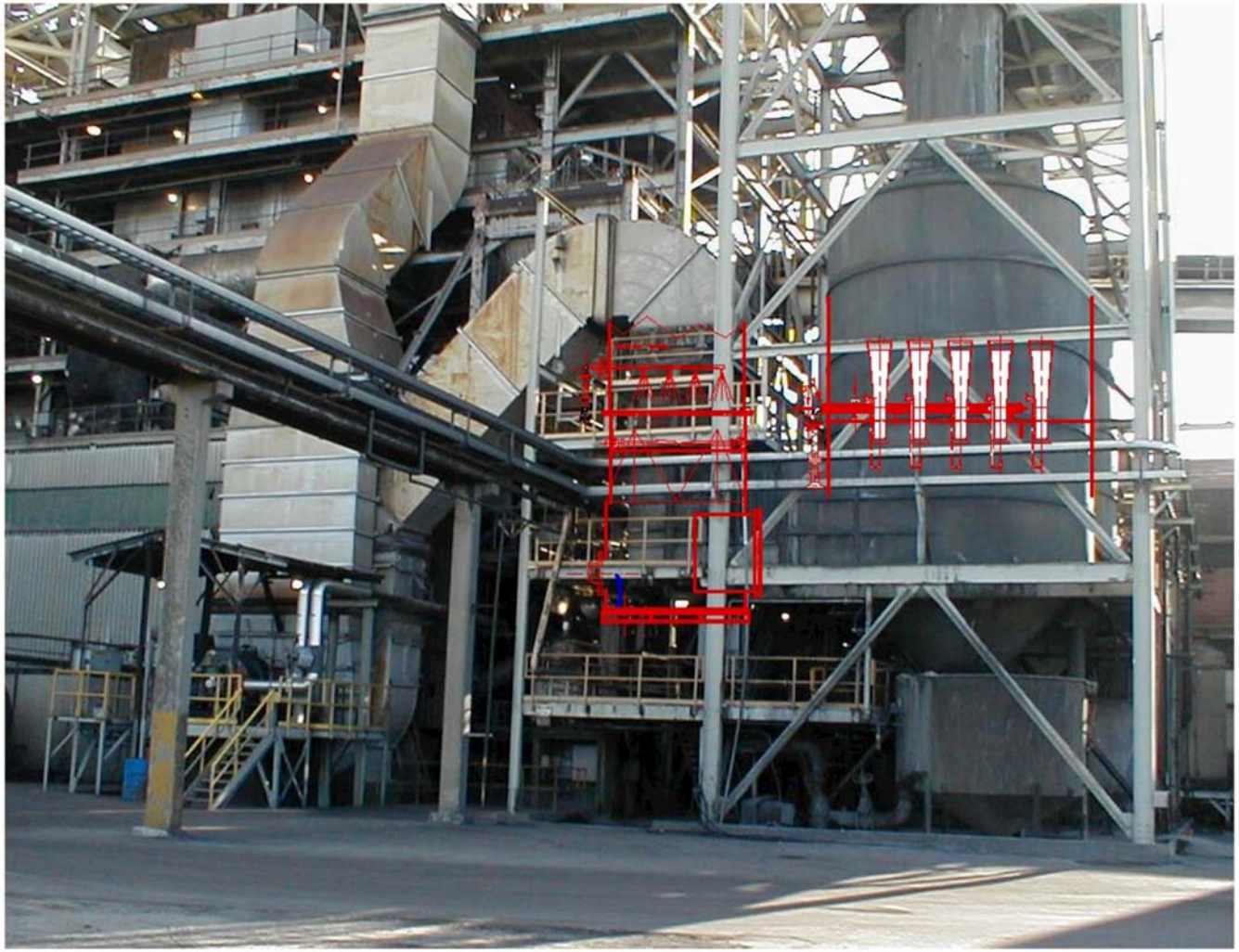
#4: High Efficient Mist Eliminator

# -High Performance Scrubber Upgrade

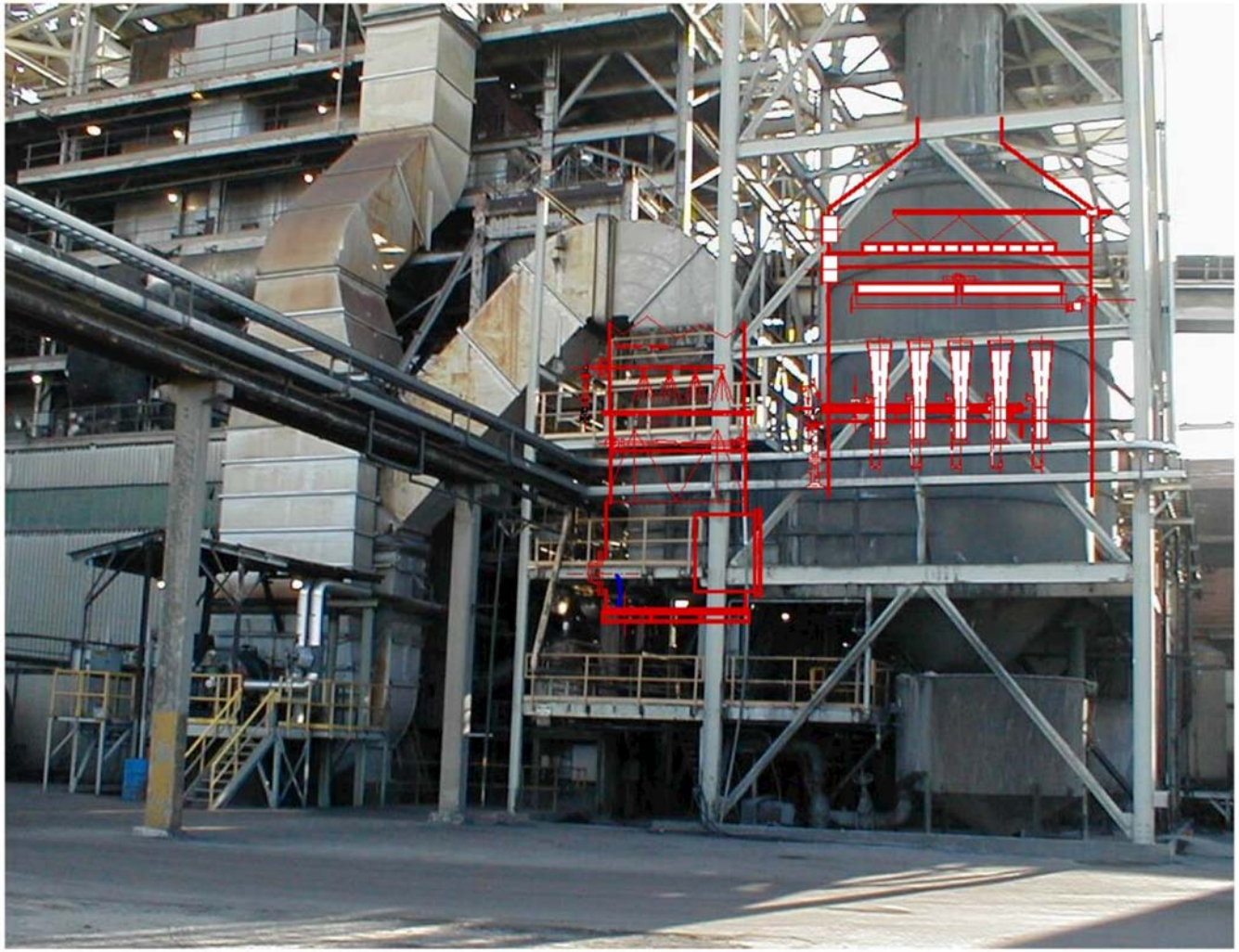
# -High Performance Scrubber Upgrade



# -High Performance Scrubber Upgrade



# -High Performance Scrubber Upgrade



# ENDNOTE

Before making large investments replacing a wet scrubber -This is the time to evaluate existing equipment

- Initial Scrubber Audit to determine the maximum performance "as-is“
- Optimize inlet conditions
- Develop potential solutions, -prioritizing:
  - No/low cost upgrade options of the system,
  - Feasibility to upgrades to existing equipment, or
  - Finally, complete replacements if necessary

# Thank You