REINHOLD ENVIRONMENTAL Ltd.

2018 APC & Wastewater Round Table & Expo Presentation

July 23 & 24, 2018 in Lexington, KY / Hosted by East Kentucky Power Coop

WET SCRUBBER 101

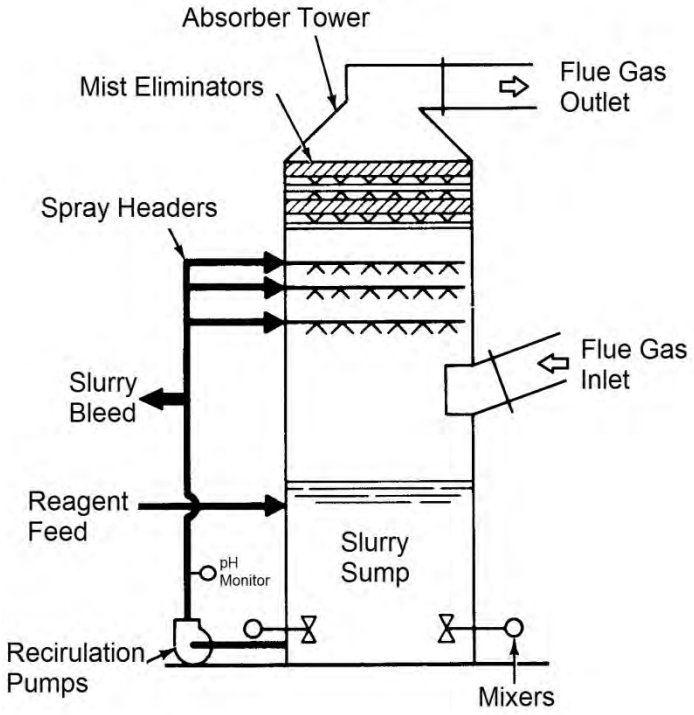
Steve Wolsiffer

Ron Richard

Senior Consultants

RE Consulting

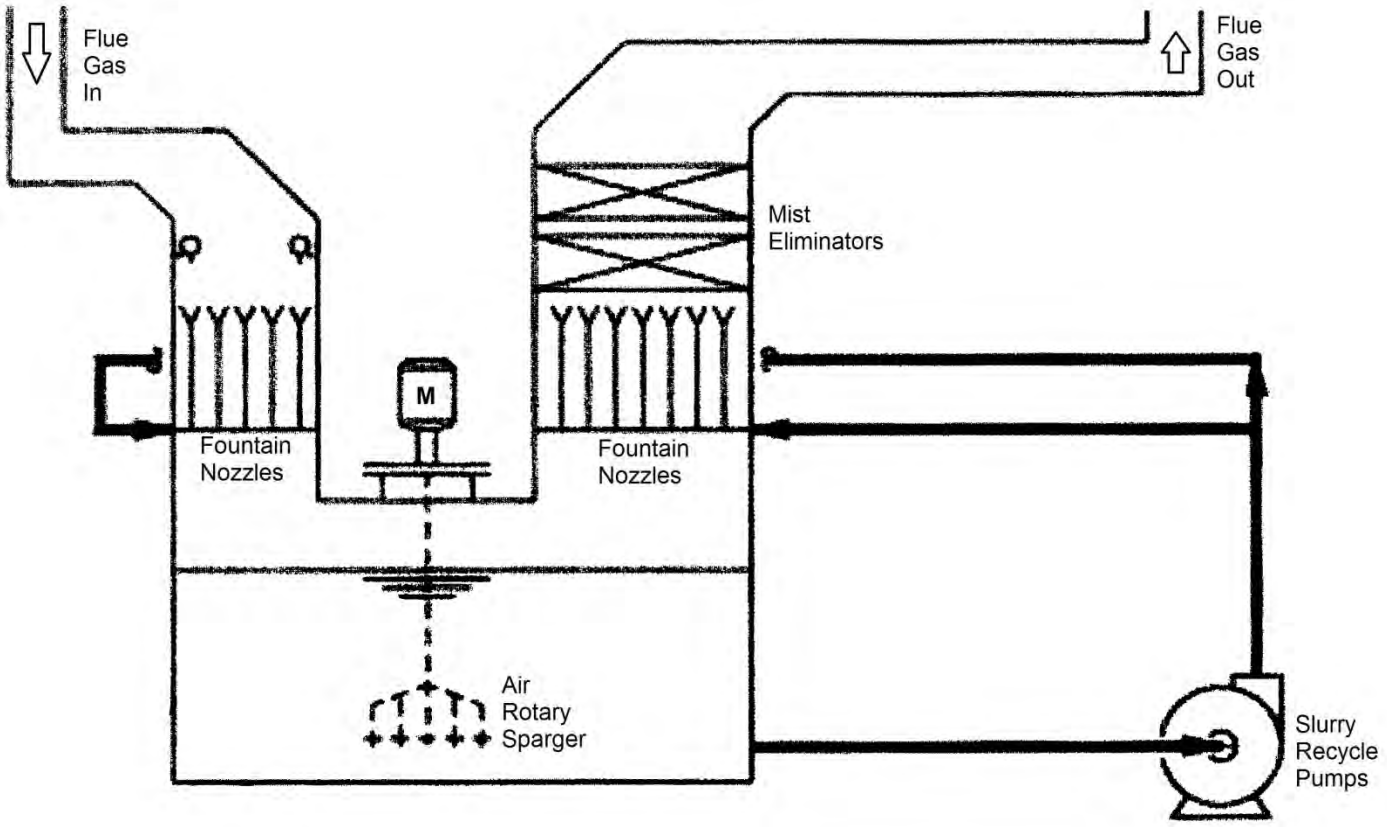
Spray Tower Absorber



Spray Zone

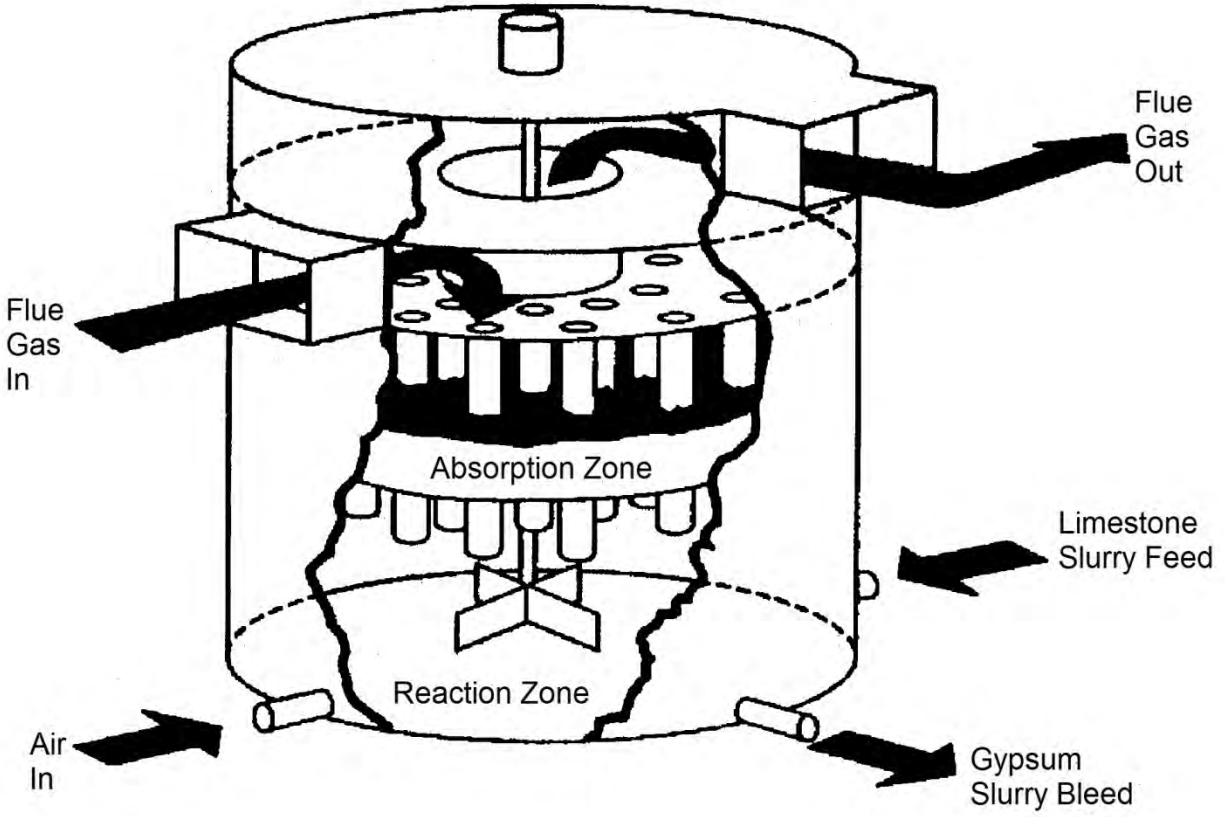
Spray Headers and Nozzles

Fountain Nozzle Absorber



Fountain Nozzles

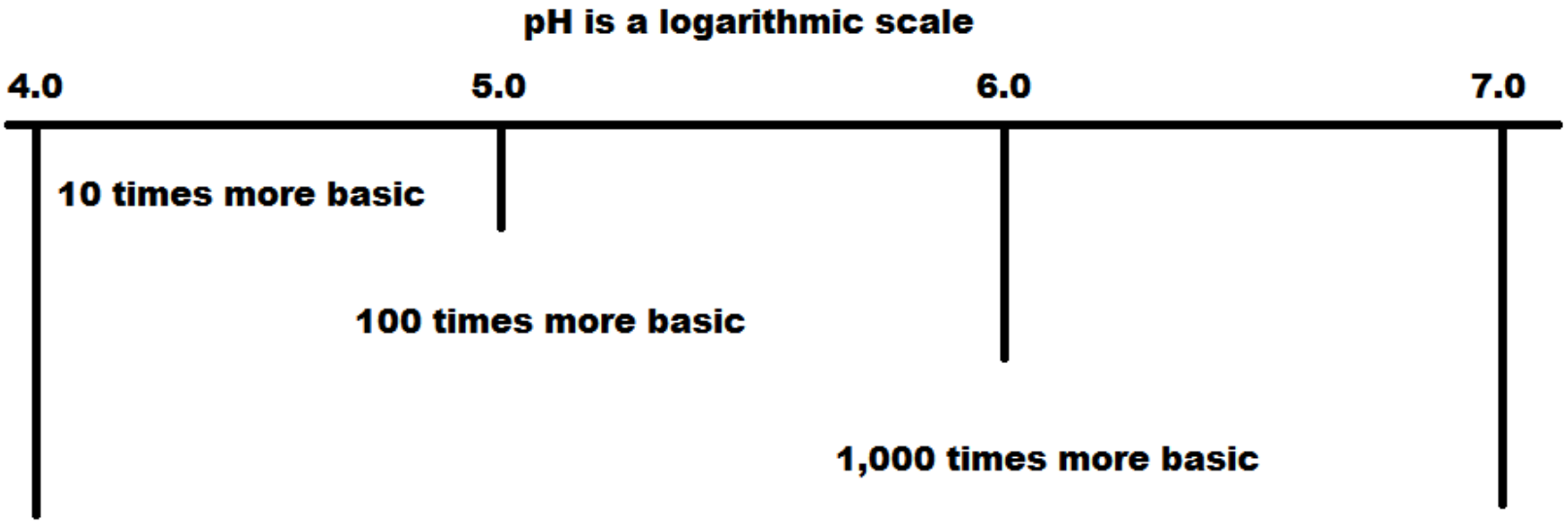
Jet Bubbling Reactor



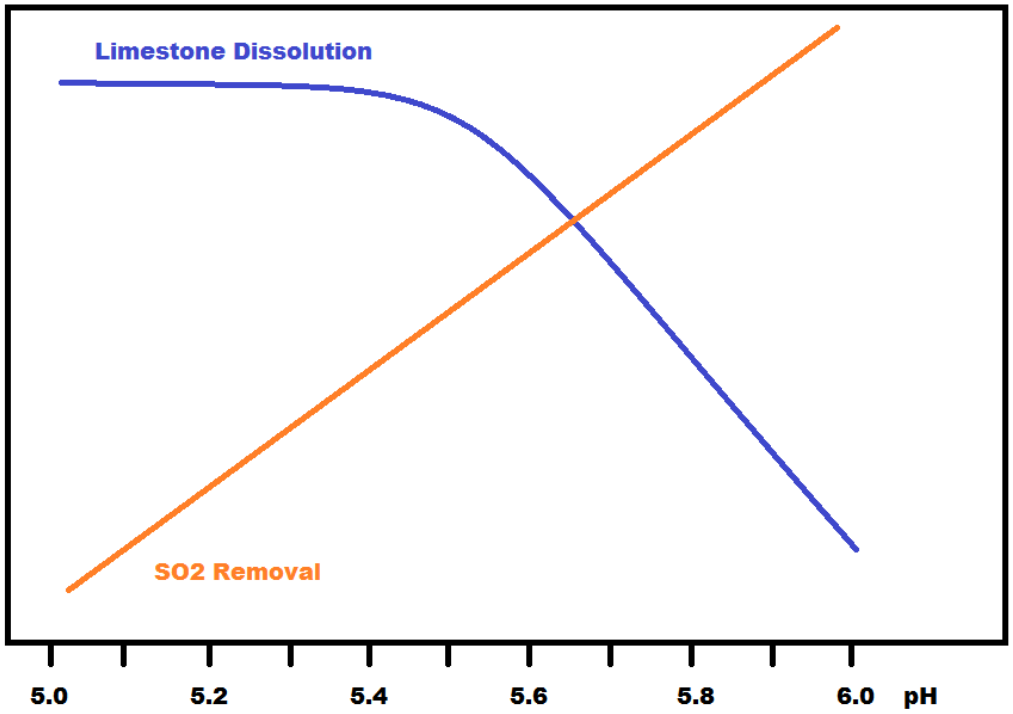
pH

pH Scale

- The pH scale ranges from the strongest acids near pH 0 to the strongest bases near pH 14 with the neutral point in the middle at 7.0. Limestone scrubbers operate in the 5 – 6 range of the scale. Lime scrubbers operate in the 6 – 6.5 range of the scale.


pH is a logarithmic scale
4.0
5.0
6.0
7.0
10 times more basic
100 times more basic
1,000 times more basic

Why Limestone Scrubbers Operate in the 5 -6 pH Range



Density

- The early scrubbers operated with slurry densities in the 10% range. This reduced pump HP required as well as reducing abrasive wear on pumps, mixers and piping.

Density

- As EPRI did research on growing better gypsum crystals, it became apparent that there was a definite advantage to having higher slurry densities if one wanted to improve gypsum quality.

Density

- **With better materials of construction available, most FGD systems operate in the 15% - 30% density range to produce better crystals which dewater more easily and provide a reagent reserve for SO_2 and gas flow changes.**

Chlorides and Fluorides

- All coals contain varying amounts of chlorine and fluorine.
- When the coal is burned, these become part of the combustion gases and are removed by being condensed onto the fly ash particles or being scrubbed out in the FGD system.

Chlorides and Fluorides

- Chlorides have only a small negative effect on SO_2 removal.
- Chlorides have a major impact on the corrosion of FGD components.
- Most of the fluorides stay condensed on the fly ash particles.

Limestone Blinding

- If fly ash makes it into the absorber towers, the fluorides and aluminum on the fly ash particles will dissolve into the slurry and react with the limestone.
- They will form aluminum fluoride compounds which will prevent the limestone particles from dissolving.

Limestone Blinding

- This will cause the SO_2 removal capacity to drop.
- There is no easy way to recover from this. The most successful remedy is to drain the slurry out of the absorber tower and start over with new slurry.

Temporary Limestone Blinding

- This occurs when the unit is running at significantly reduced load for an extended time (ie: weekend) and then is quickly returned to higher loads.
- The symptoms are:
  - The limestone feed valve is wide open
  - The pH is constant
  - The SO_2 removal is dropping

Temporary Limestone Blinding

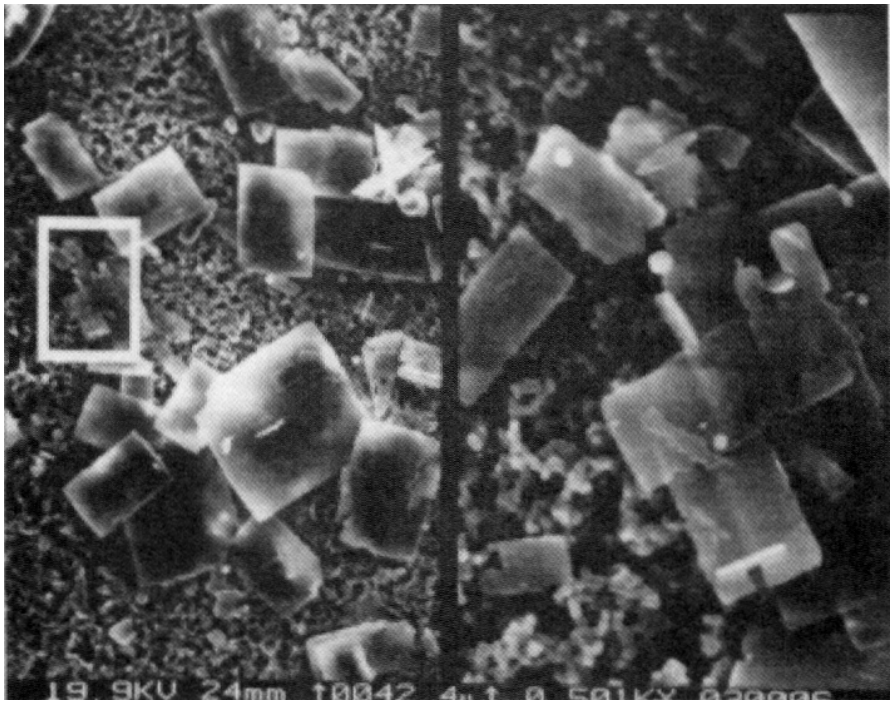
- To recover to normal operation:
  - Close the limestone feed valve
  - As long as the pH remains the same, do nothing but wait
  - When the pH starts to drop, return the limestone feed valve to normal automatic operation

Oxidation

- As the SO2 is removed, it will react with the calcium in the lime or limestone and form calcium sulfite or calcium sulfate depending on how much oxygen is in the absorber slurry.

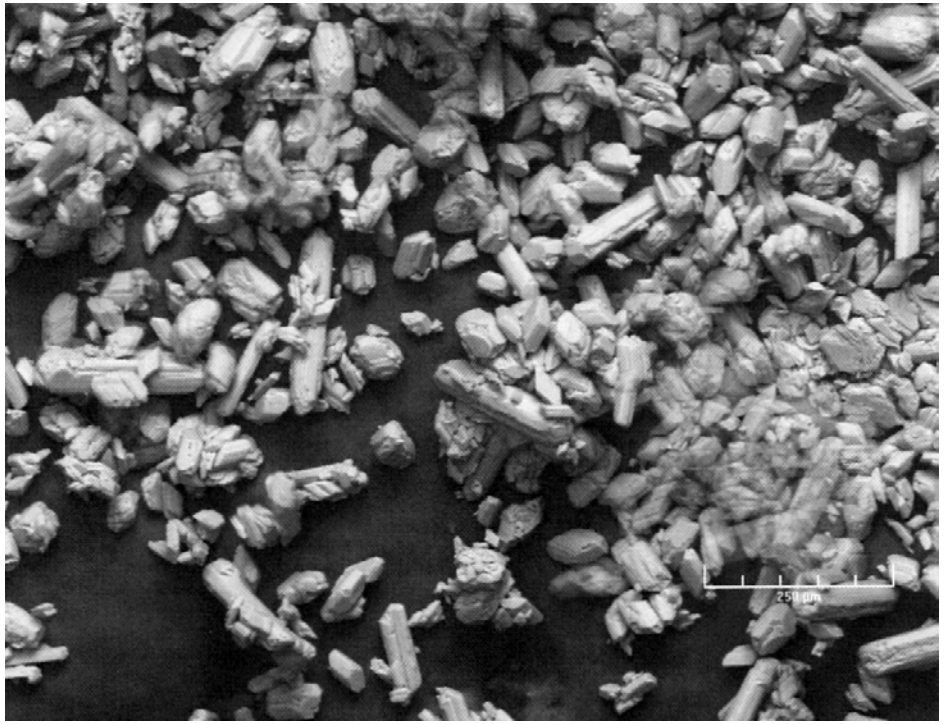
Calcium Sulfite ($CaSO_3$)

- Calcium Sulfite crystals are flat and rectangular like a piece of window glass. (most pronounced at lower slurry oxidation levels, <15%)



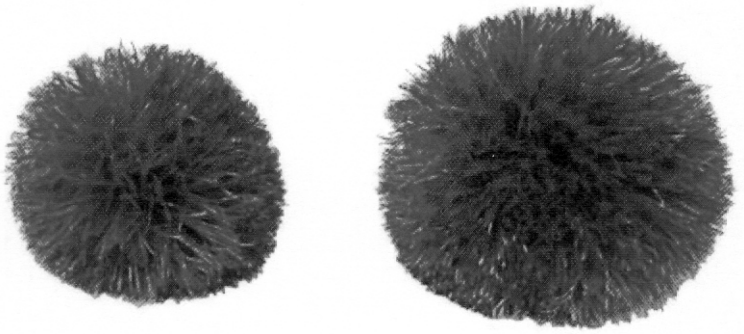
Calcium Sulfate

- Calcium Sulfate crystals are long thin columns. (Most pronounced at higher slurry oxidation levels, >85%)



You don't want to grow crystals similar to these (most pronounced in the slurry oxidation range 15-85%)

- They are very fragile.
- They have about the same density as the slurry, so they do not settle quickly.



When it comes to oxygen, more is not always better

- The recent severe corrosion of the 2205 duplex absorber towers seems to have been caused by the formation of persulfate which caused a cascade of events which ate holes through the tower walls very quickly.

ORP

- **The Oxidation-Reduction Potential is a measure of the tendency of the solution to either gain or lose electrons when it is subject to change by introduction of a new species. In the case of FGD we are adding oxygen.**

ORP

- It is measured with a probe that is similar to a pH probe.
- It is reported in units of positive or negative millivolts.

What ORP Do You Operate At?

- A negative number means you are in a reducing environment that will drive you towards producing calcium sulfite.
- +100 – +350 mV is considered a normal operating range to operate in.

What ORP Do You Operate At?

- +350 – +450 mV is a transitional zone where changes will begin to take place in the absorber slurry.
- Above +450 mV you will be changing the properties of the selenium, mercury and manganese with possible negative consequences.

Limestone Quality & Ball Mills

Limestone Quality

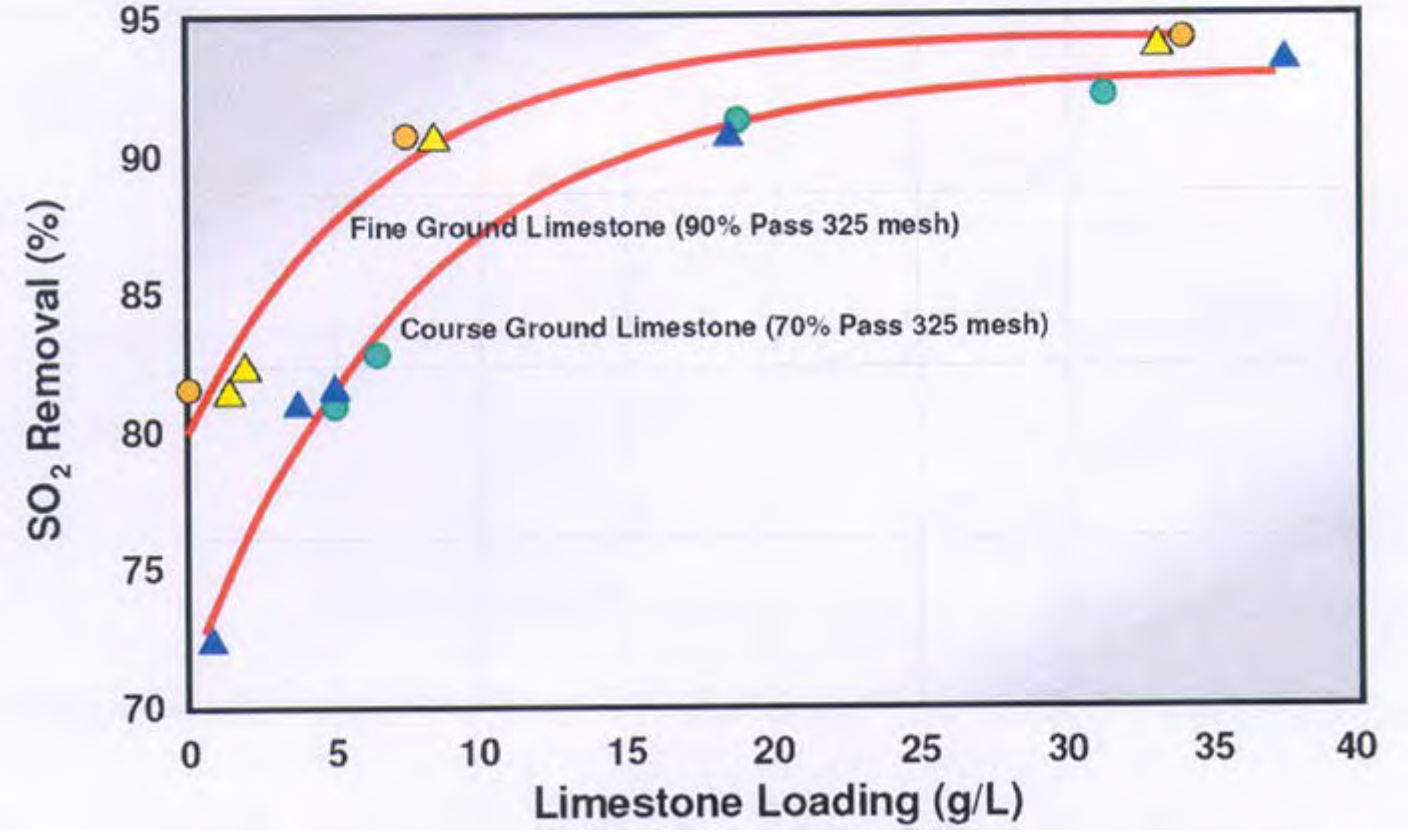
- Limestone Quality (hardness, reactivity, inerts) is also important, BUT supply is sometimes dictated by Availability or Economics.

Limestone Fineness

- Some of the FGD vendors have stated that one of the biggest causes of performance issues they find is improper limestone fineness in the limestone slurry feed to the absorber tower.

Effect of Limestone Grind

(Different Shaped Symbols Represent Different Limestone Tested)



Source: URS

There Are Two Things To Check First

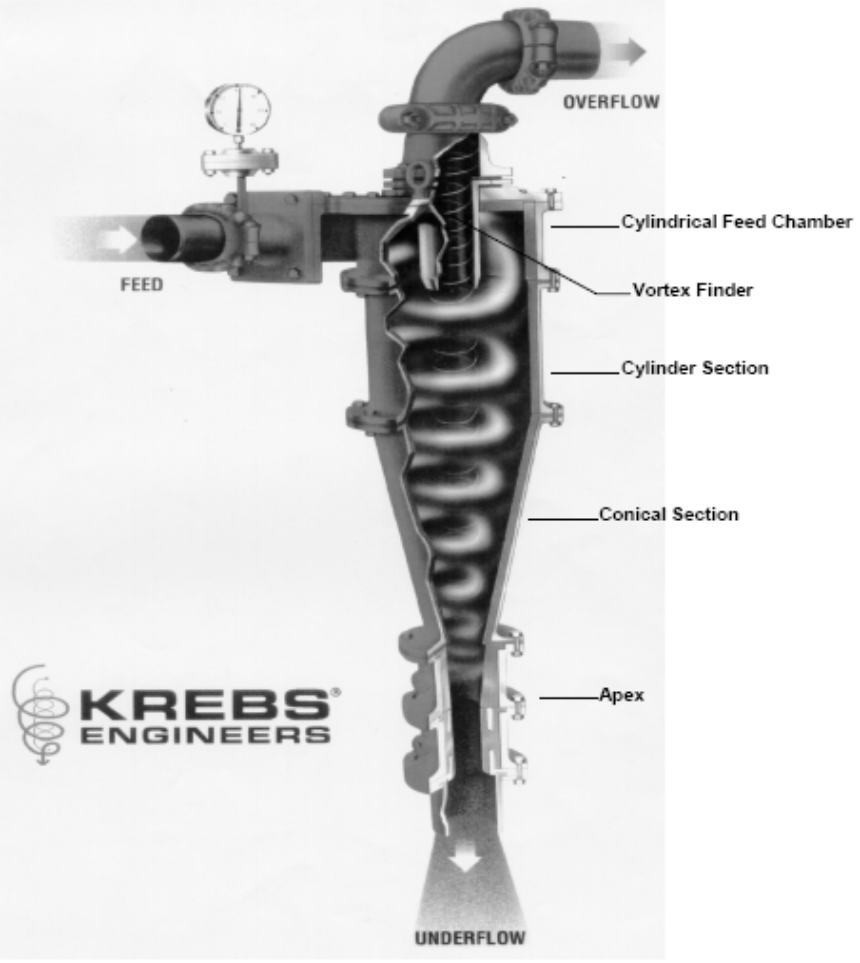
- Do the ball mill motor amps indicate that the mill has a full ball charge.

Normal Ball Level

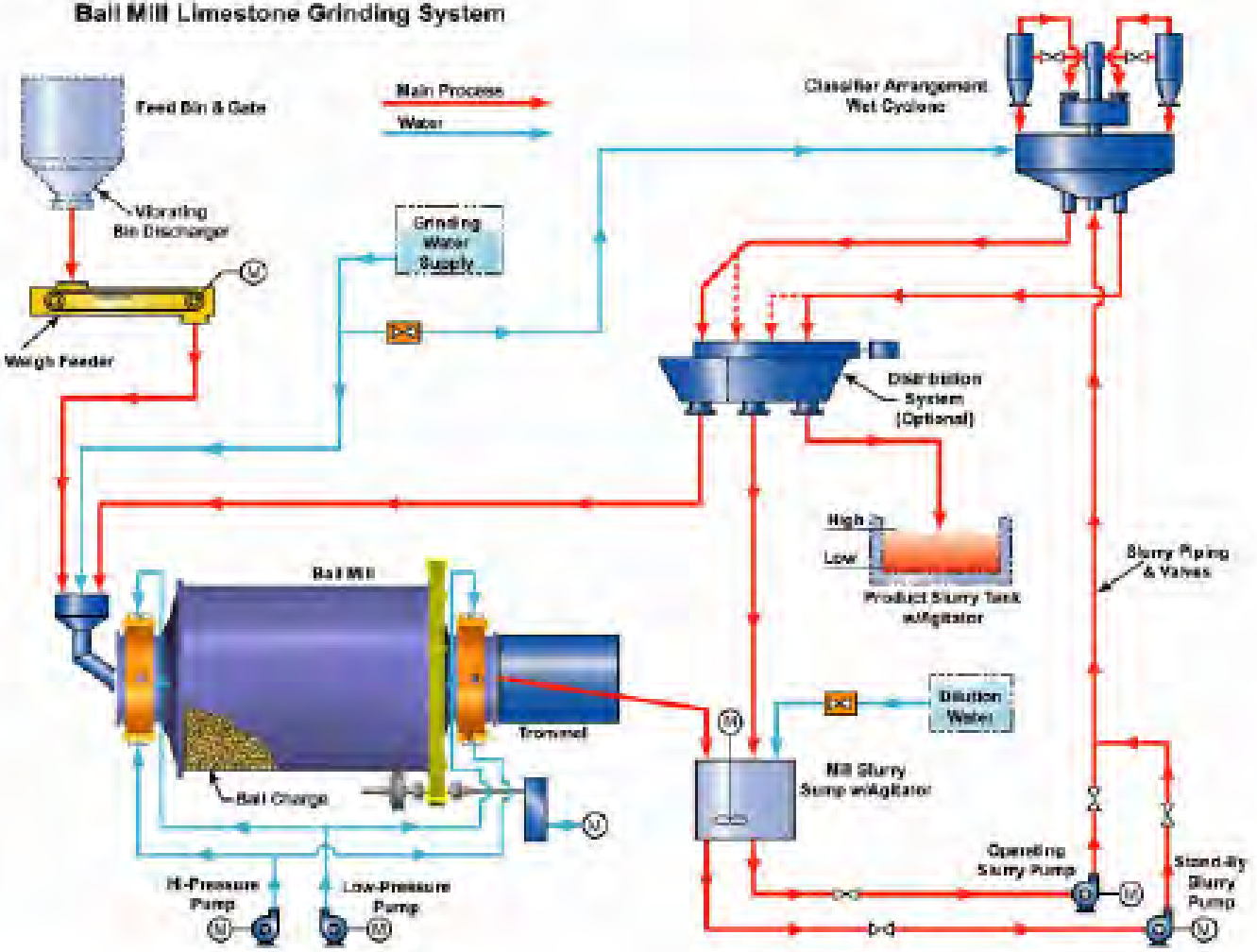
There Are Two Things To Check First

- Do the ball mill motor amps indicate that the mill has a full ball charge.
- Is there grit in a hydrocyclone overflow line that indicates hydrocyclone puggage.

CYCLONE CUTAWAY



Typical Flow Diagram for Ball Mill Limestone Grinding System



Ball Mill Design

P = T x W

P = Power Draw (kW) [Motor Size]

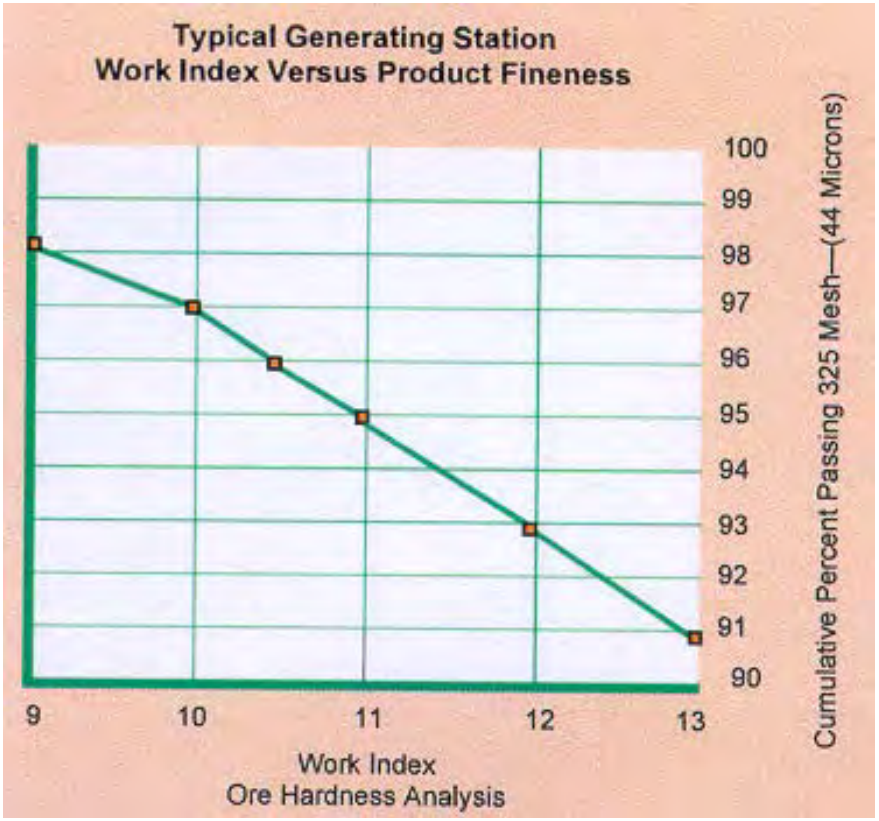
T = Limestone Feed Rate (ton/hour)

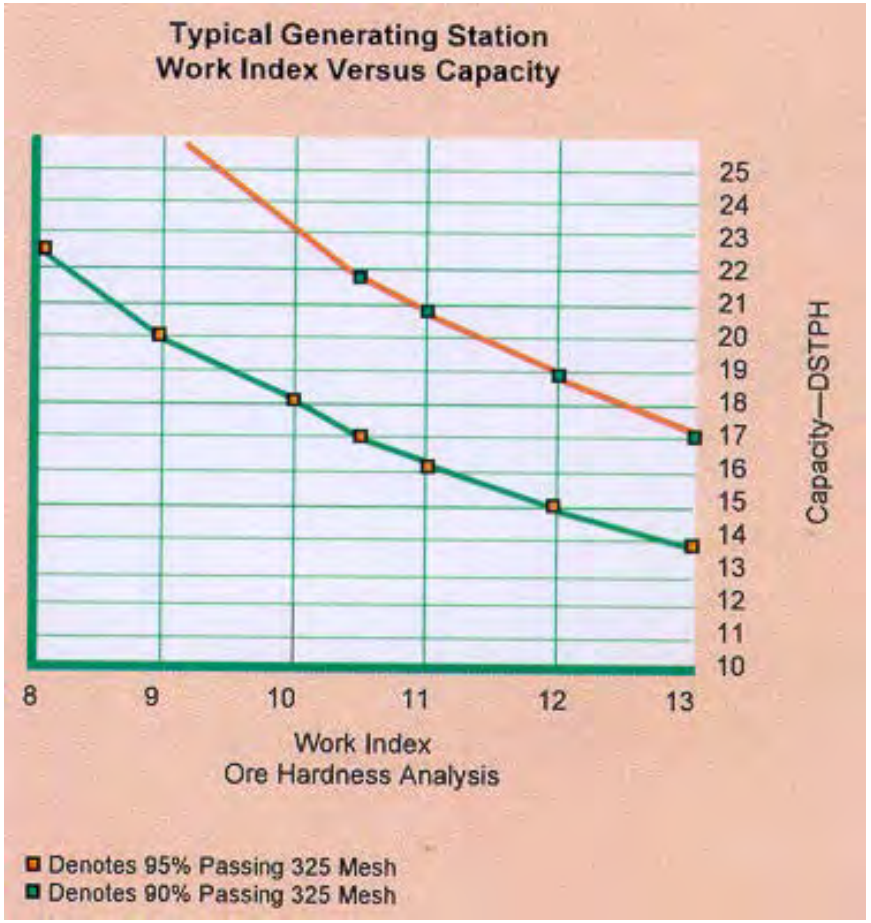
W = Work Input (kWh/ton)

Work Input

$$W = \frac{10\ W_i}{\sqrt{D_P}} - \frac{10\ W_i}{\sqrt{D_F}}$$

W_i = Bond Work Index (kWh/ton)
D_P = Diameter of 80% of Product (microns)
D_F = Diameter of 80% of Feed (microns)





Source: METSO

Mist Eliminators

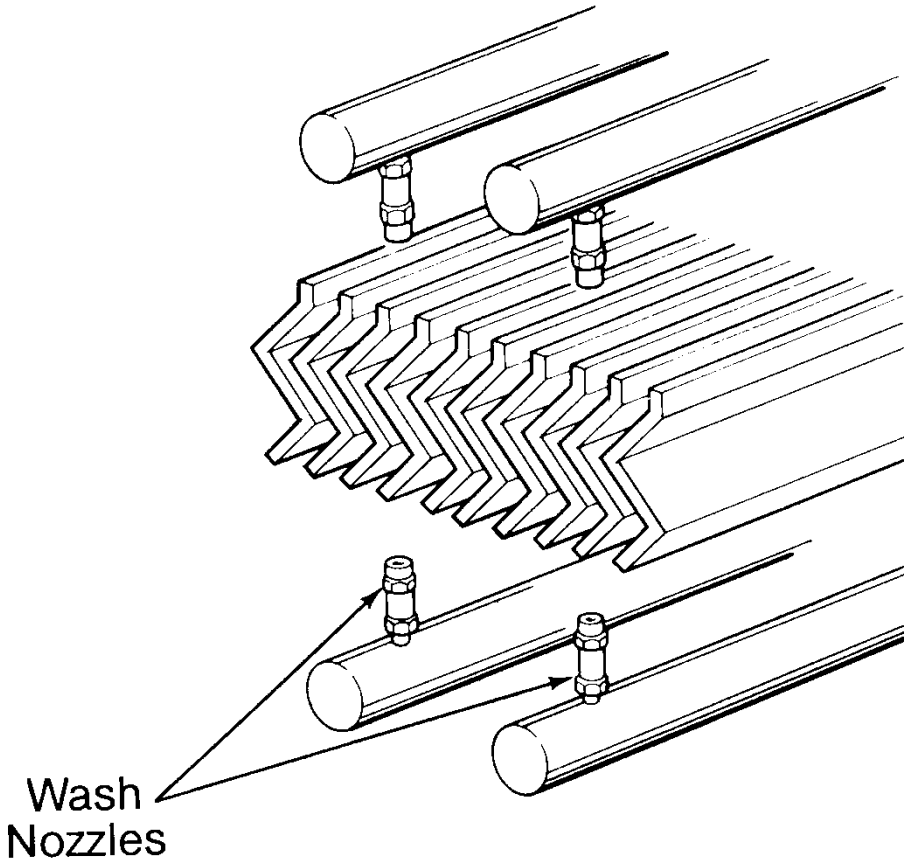
Achilles' Heel??

- With the current design of a large single FGD tower with no bypass, I feel that the mist eliminators may pose one of the biggest risks for a forced outage of the unit.

The Problem – Scale Formation

The Solution

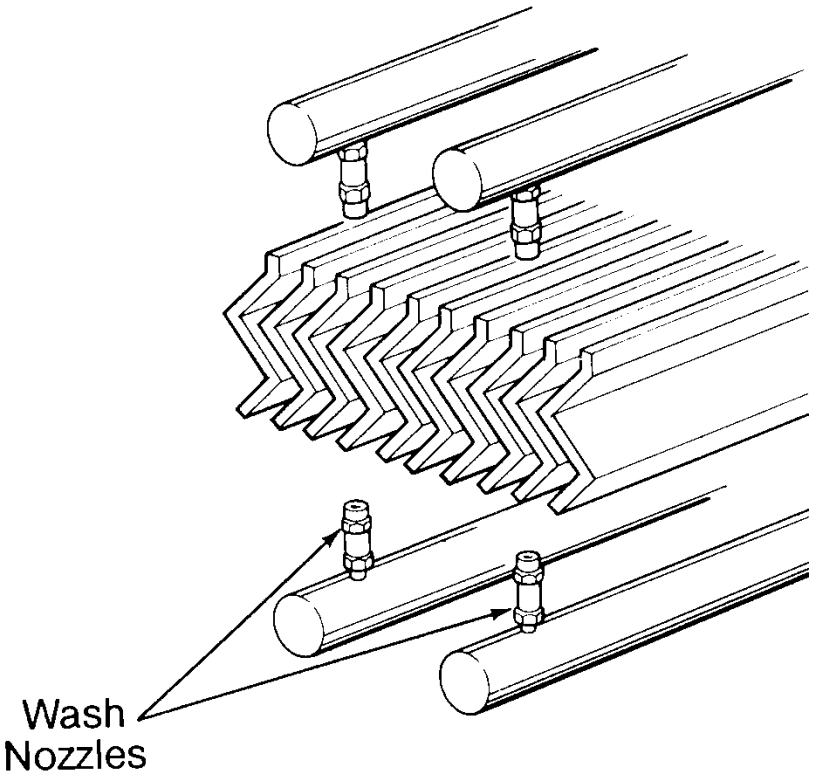
- All FGD vendors supply a mist eliminator wash system as part of their design.



The Only Effective Mist Eliminator Wash System

What You Really Have

- A “keep the blades wet and the liquid collecting on them diluted below calcium saturation so scale doesn’t form” system.



What That Really Means

- You must constantly be in a proactive mode of keeping scale from forming on the blades rather than being in a reactive mode of trying to wash it off after it forms because you can’t wash all of it off with the system you have.

What That Means

- The wash water needs to be as fresh (unsaturated with calcium) as possible.
- Each blade needs to be washed as often as possible.
- An “in-situ forced oxidized” tower has less problems.
- Adding a scale inhibitor to the wash water may need to be considered.

ME Wash Water

- Use as much “service water” or other fresh water as the water balance will allow.
- Add “process water” only as needed to maintain the level in the ME Wash Water Tank.

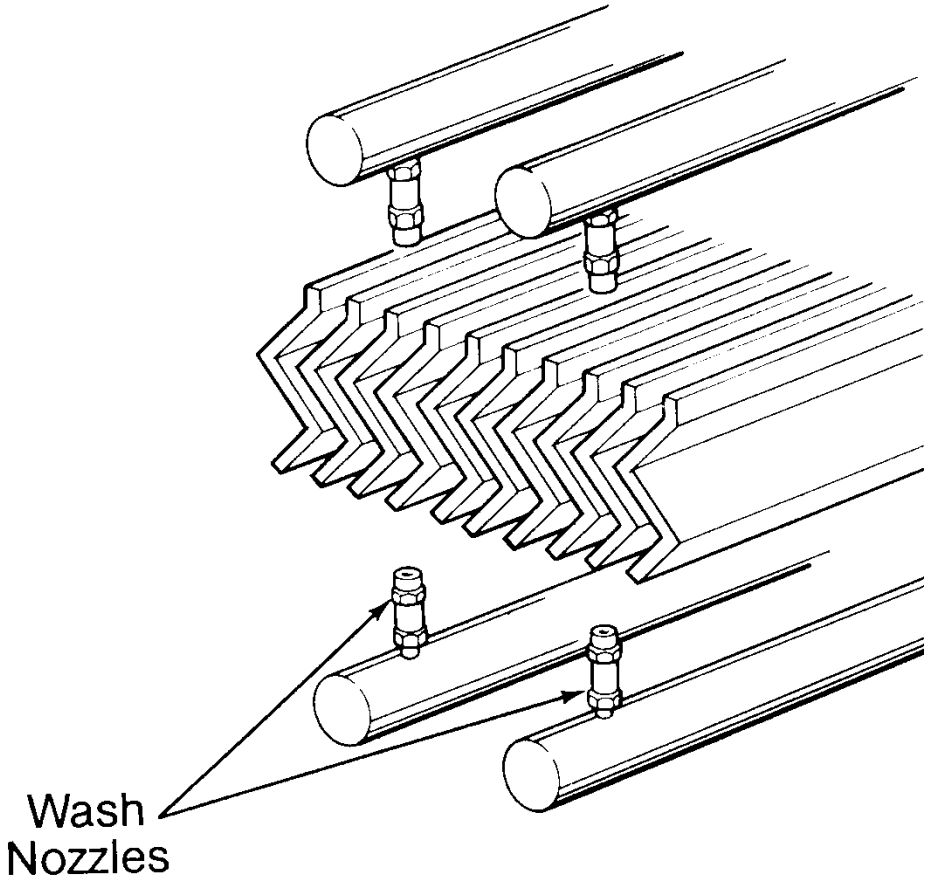
Wash Cycles

- Most designs only wash one portion of one side of a mist eliminator at a time.
- If possible, always be washing something.

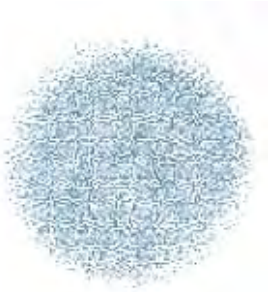
Wash Cycles

- If the water balance will only allow you to wash each section for 8 minutes every hour:
  - **It is better to wash for 1 minute every 8 minutes**
  - **Than to wash for 2 minutes every 15 minutes**
  - **Than to wash for 4 minutes every 30 minutes**
  - **Than to wash for 8 minutes every 60 minutes**

Wash Nozzle Considerations

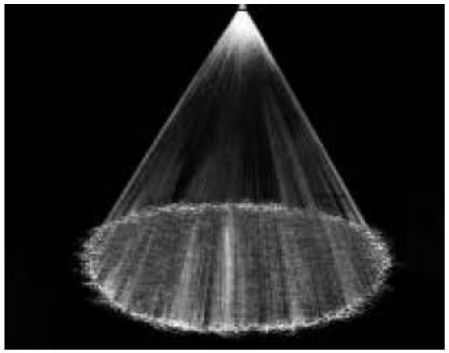


Wash Nozzle Pattern

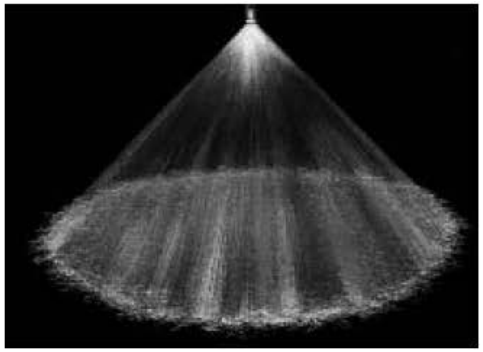


Spray Pattern Angle

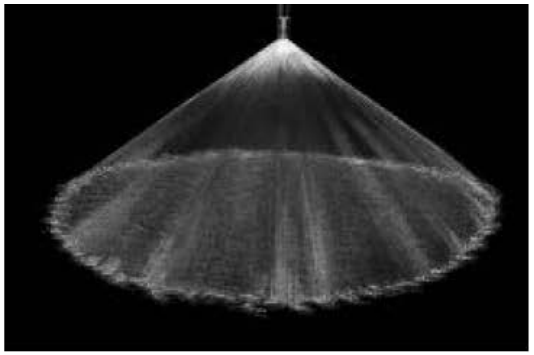
Full Cone 30° (NN)



Full Cone 60° (N)



Full Cone 90° (M)



Full Cone 120° (W)

APS Side by Side Comparison

Figure 2. Test Installation at APS's Cholla Station, Unit 2: Materials (left to right) Polysulfone, FRP, Stainless Steel, Polypropylene

Source: KOCH-Glitsch

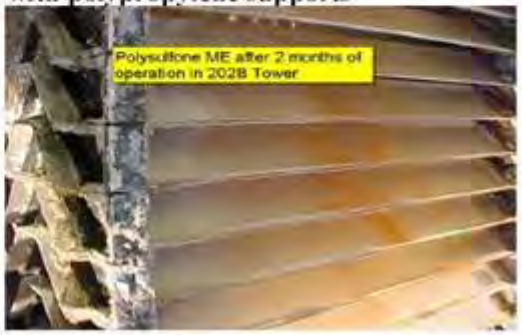
APS Side by Side Comparison

Figure 3. Polypropylene mist eliminator

Figure 5. Stainless steel mist eliminator

Figure 4. FRP mist eliminator from

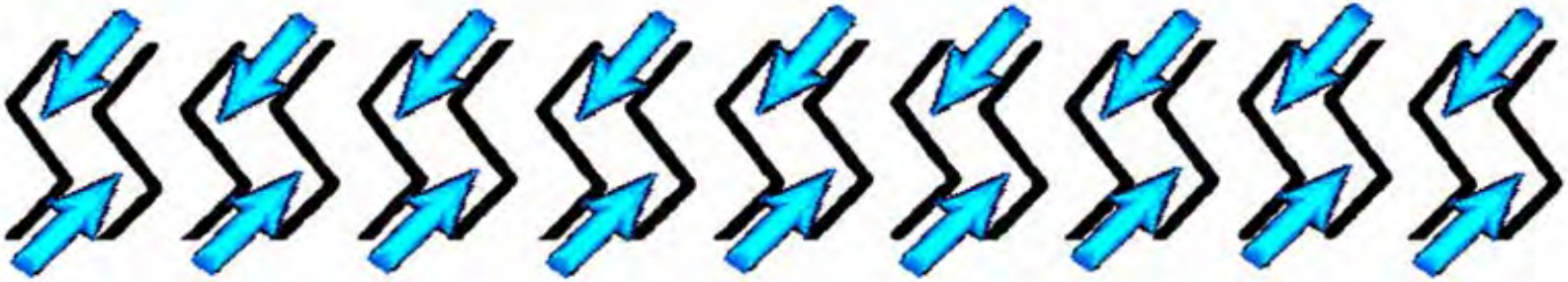
Figure 6. Polysulfone mist eliminator with polypropylene supports



Source: KOCH-Glitsch

Cleaning Effectiveness

3-Pass Mist Eliminator



2-Pass Mist Eliminator

Preventing Damage During Manual High Pressure Washing

- Don’t use any more nozzle pressure than necessary to remove the deposit.
- A fan pattern nozzle does less cutting of the blade than a straight pattern nozzle.
- Keep the nozzle several inches from the blade.
- Keep the nozzle as parallel as possible with the blades.

Questions