# REINHOLD ENVIRONMENTAL Ltd.


# 2011 APC Round Table
# & Expo Presentation

July 11-12, 2011, in Cleveland, OH / Hosted by FirstEnergy


# How Particle Size Affects $SO_2$ and $SO_3$ Removal Performance in a Dry Sorbent Injection System

**APC 2011**

**Presented By: Keith Day & Jon Norman**

# Current Particle Size Options for Trona

**Sorbent Supplier**

- **"Un-milled" – As Delivered**
  - 30 to 50 micron $D_{50}$
  - 300 micron high purity sodium sesquicarbonate
- **Pre-Milled**
  - 20 to 25 micron $D_{50}$

**On-Site**

- **Coarse In-Line Milled**
  - Approx. 20 micron $D_{50}$
- **Fine In-Line Milled** *(blow-through design)*
  - 10 to 14 micron $D_{50}$

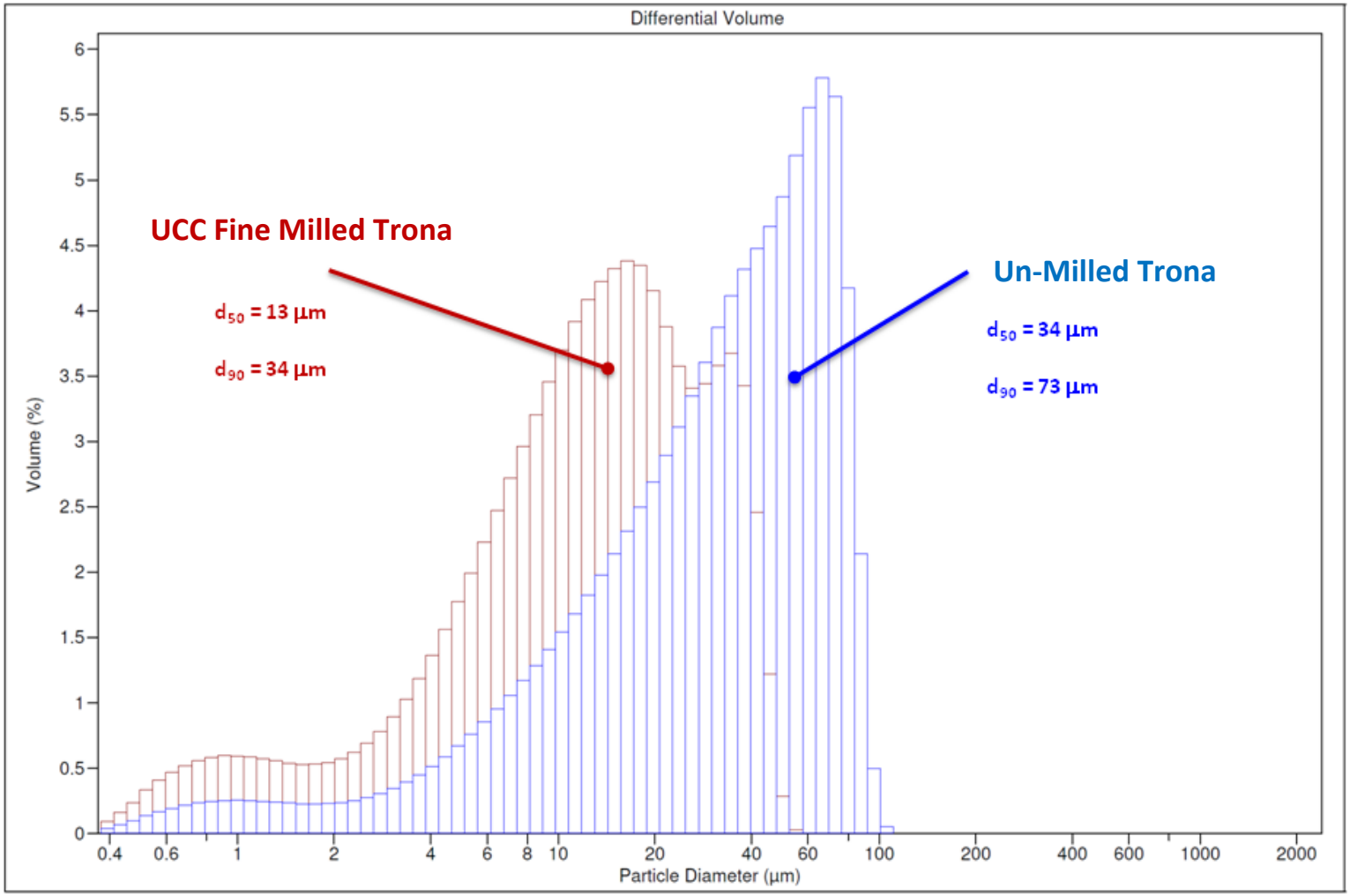
**Increased surface area**

**Increased number of particles**

**Increased dispersion with lighter, smaller particle**

UNITED CONVEYOR CORPORATION

# Trona Particle Size Analysis



# Current Particle Size Options for Sodium Bicarbonate

- **"Un-Milled" – As Delivered**
  - 50 to 150+ micron $D_{50}$
  - Not usable for DSI in unmilled state
- **Pre-Milled**
  - 20 to 25 micron $D_{50}$
- **In-Line Milled** *(blow-through design)*
  - 15 to 20 micron $D_{50}$
  - 40 to 50 micron $D_{90}$

**Larger Particle Size SBC Requires Milling**

UCC Dry Sorbent Injection

# MILLING TECHNOLOGY OVERVIEW

UNITED CONVEYOR CORPORATION

# Comparison of Various Sorbent Mills

| Type | Pros | Cons |
|---|---|---|
| **Jet Mill** | Very fine, tight particle distribution (d50: 4-8 microns) | • High O&M for compressed air<br>• Relatively low capacity |
| **Air Classifying Mill** | Fine, tight particle distribution (d50: 8-10 microns) | • High capital and O&M<br>•Incompatible with DSI on a utility scale because not a blow through design, which is needed for numerous splits |
| **Pin Mills** | Longevity of pins<br>Capable of particle sizes < 15 micron (d50) | • Particle size vs. build up and Hp and heat<br>• Typical d50 >15 microns for above reasons<br>• Sensitive to air flow |
| **Turbine and Cutter** | Particle size vs. Build up and Hp (d50: 12-15 microns) | • Correct air flow balance important |

UCC Dry Sorbent Injection

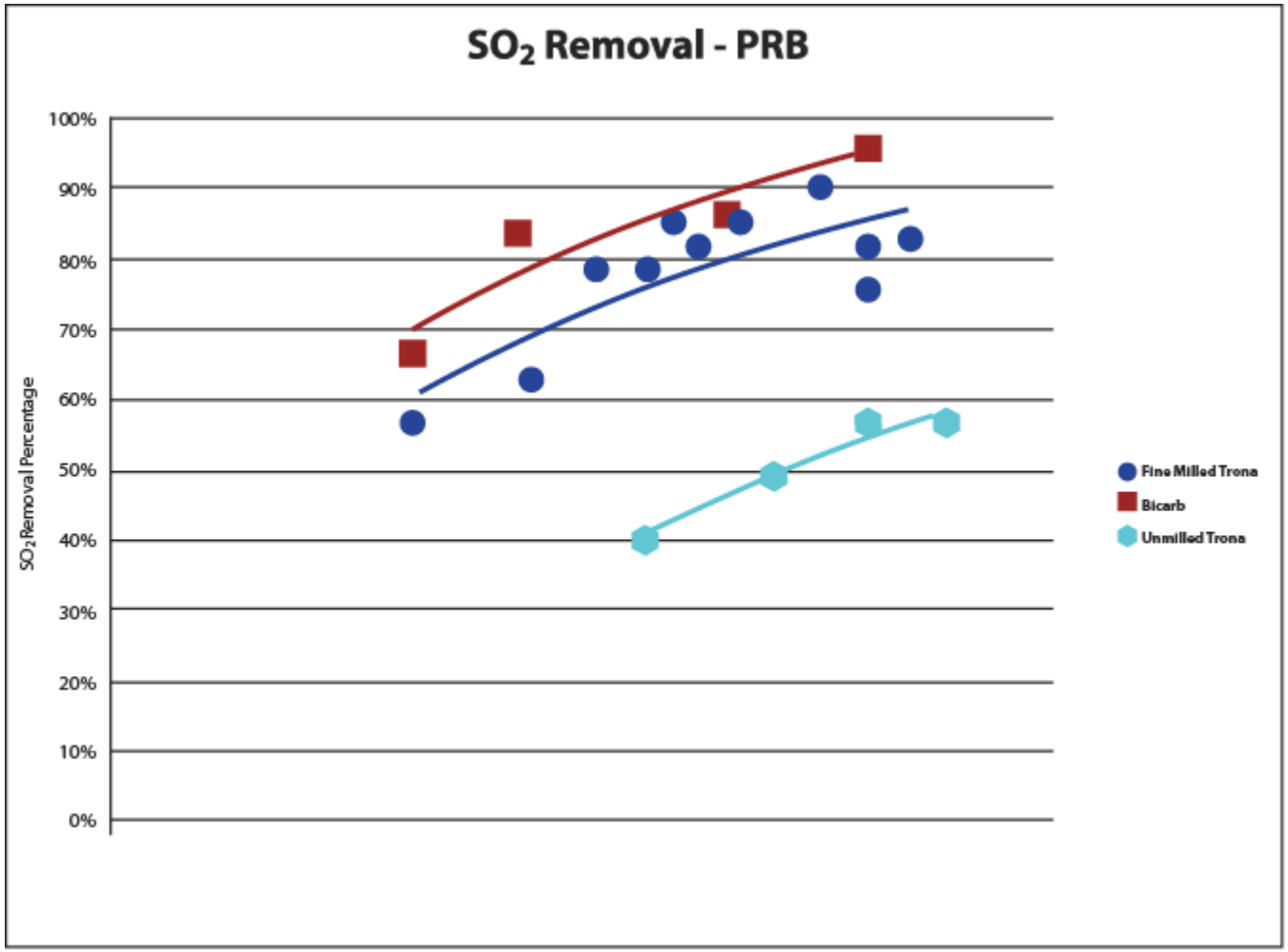
# EFFECT OF PARTICLE SIZE ON $SO_2$ REMOVAL

UNITED CONVEYOR CORPORATION

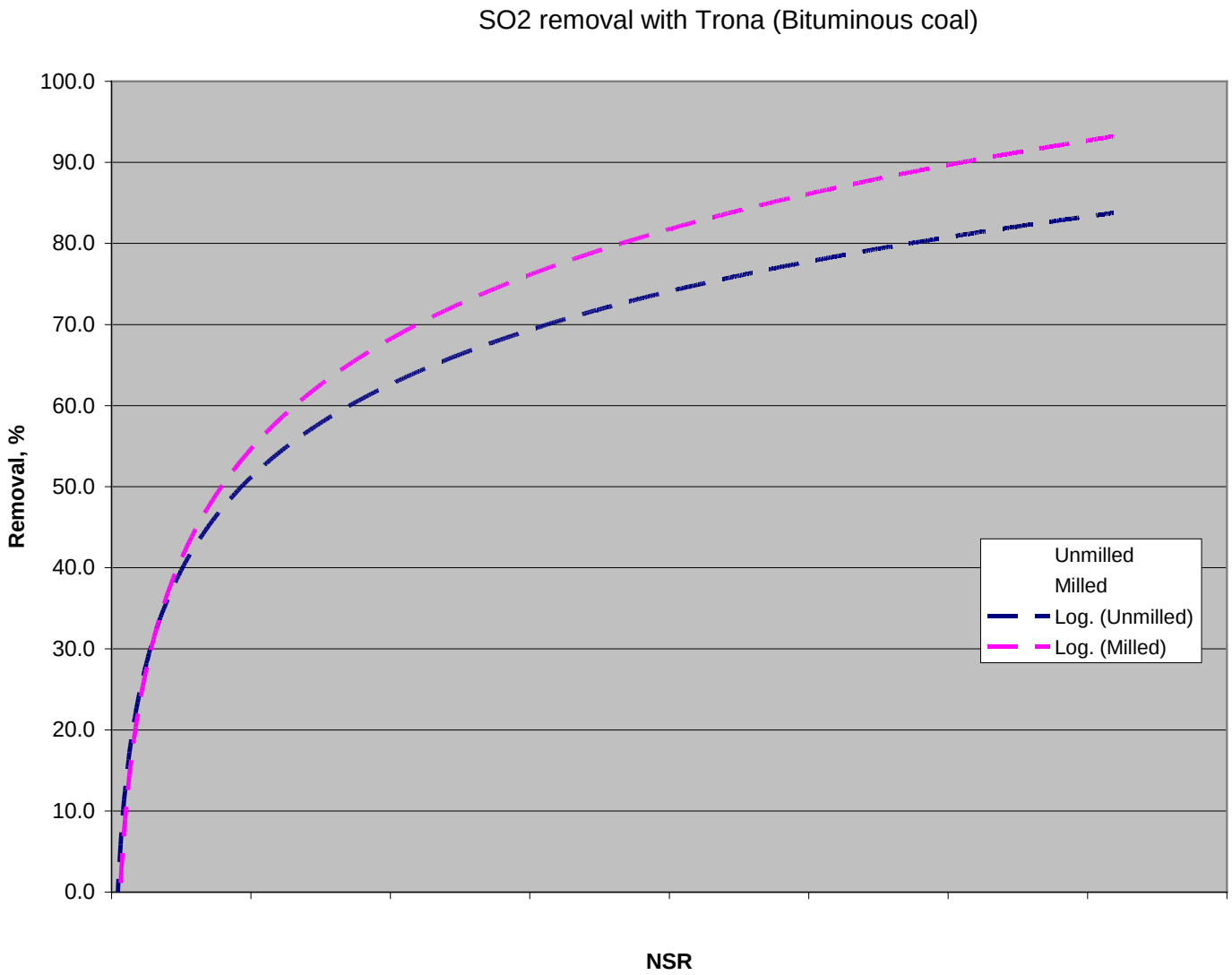
# $SO_2$ Removal Demonstration Test with Large Mill


UNITED CONVEYOR CORPORATION

# $SO_2$ Removal Data – Trona/Bicarb, PRB, ESP



# $SO_2$ Removal Data – Eastern Bituminous




UNI CORPORATION

# $SO_2$ Economics – Eastern Bituminous Coal

## *Unmilled Trona vs. Fine Milled Trona*

| Unit (MW) | Sulfur lb/mmbtu | $SO_2$ Reduction (% Removal) | Unmilled (ton/hr) | Fine Milled (ton/hr) | Annual Savings ($180/ton trona) |
|---|---|---|---|---|---|
| 50 | 1.6 | 60% | 2.4 | 1.7 | $ 993,384 |
| 100 | 1.6 | 60% | 4.8 | 3.4 | $1,986,768 |
| 150 | 1.6 | 60% | 7.2 | 5.1 | $2,980,152 |

30% more unmilled sorbent vs. Fine Milled

## *Coarse Grind (~20micron) vs. Fine Milled Trona*

| Unit (MW) | Sulfur lb/mmbtu | $SO_2$ Reduction (% Removal) | Unmilled (ton/hr) | Fine Milled (ton/hr) | Annual Savings ($180/ton trona) |
|---|---|---|---|---|---|
| 50 | 1.6 | 60% | 2.0 | 1.7 | $ 425,736 |
| 100 | 1.6 | 60% | 4.0 | 3.4 | $ 851,472 |
| 150 | 1.6 | 60% | 6.0 | 5.1 | $1,277,208 |

15% more Coarse sorbent vs. Fine Milled

UNITED CONVEYOR CORPORATION

Based on Actual Test Data

# $SO_2$ Economics - PRB

## *Unmilled Trona vs. UCC Fine Milled Trona*

| Unit (MW) | Sulfur lb/mmbtu | $SO_2$ Reduction (% Removal) | Unmilled (ton/hr) | Fine Milled (ton/hr) | Annual Savings ($180/ton trona) |
|---|---|---|---|---|---|
| 100 | 0.8 | 60% | 1.5 | 1.1 | $ 638,604 |
| 250 | 0.8 | 60% | 3.8 | 2.7 | $1,617,797 |
| 500 | 0.8 | 60% | 7.5 | 5.3 | $3,193,020 |

30% more Unmilled sorbent vs. Fine Milled

## *Coarse Grind (~20micron) vs. Fine Milled Trona*

| Unit (MW) | Sulfur lb/mmbtu | $SO_2$ Reduction (% Removal) | Unmilled (ton/hr) | Fine Milled (ton/hr) | Annual Savings ($180/ton trona) |
|---|---|---|---|---|---|
| 100 | 0.8 | 60% | 1.3 | 1.1 | $ 319,302 |
| 250 | 0.8 | 60% | 3.2 | 2.7 | $752,134 |
| 500 | 0.8 | 60% | 6.4 | 5.3 | $1,525,554 |

15% more Coarse sorbent vs. Fine Milled

UNITED CONVEYOR CORPORATION

Based on Actual Test Data

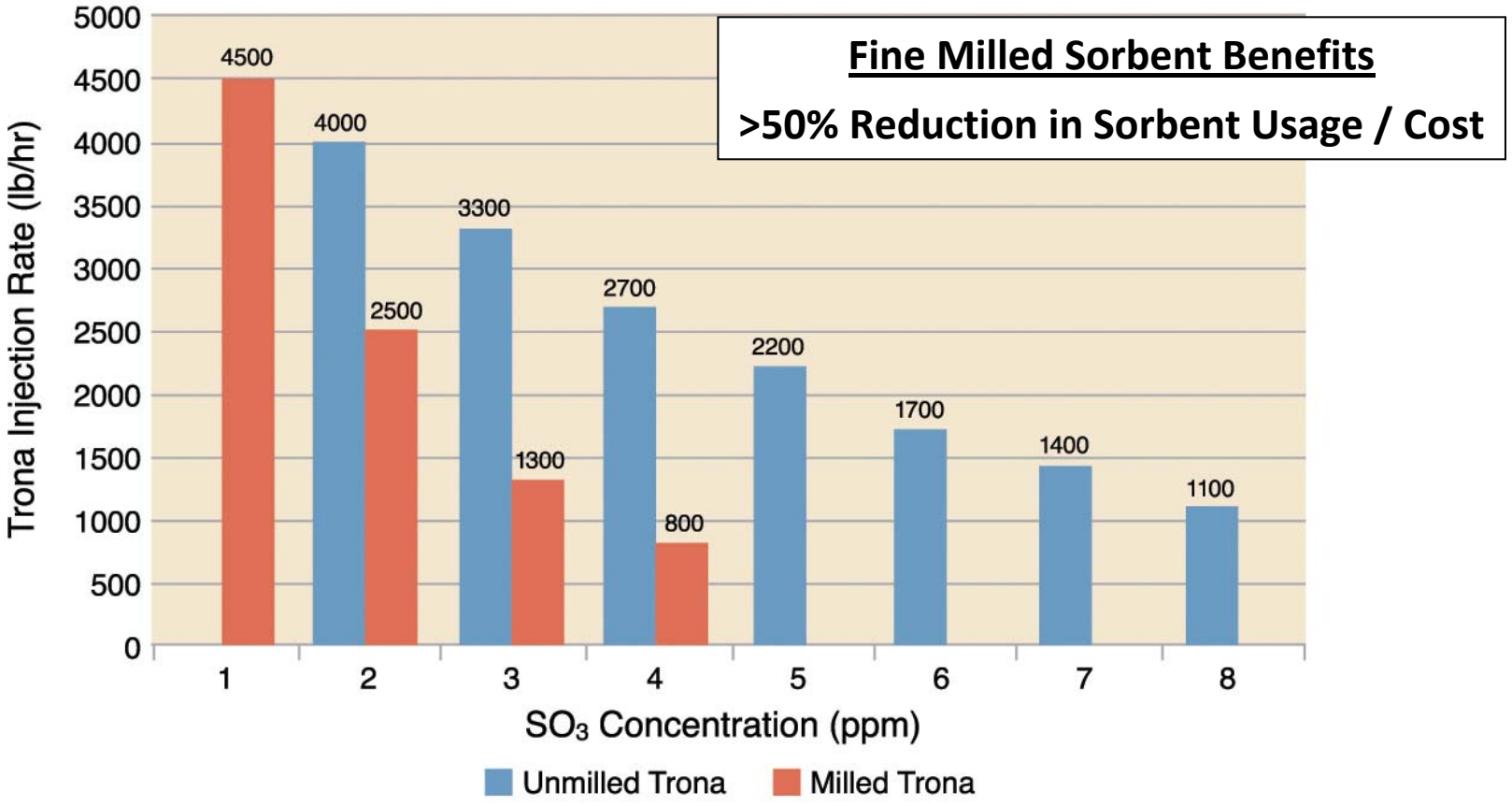
UCC Dry Sorbent Injection

# EFFECT OF PARTICLE SIZE ON $SO_3$ REMOVAL

UNITED CONVEYOR CORPORATION

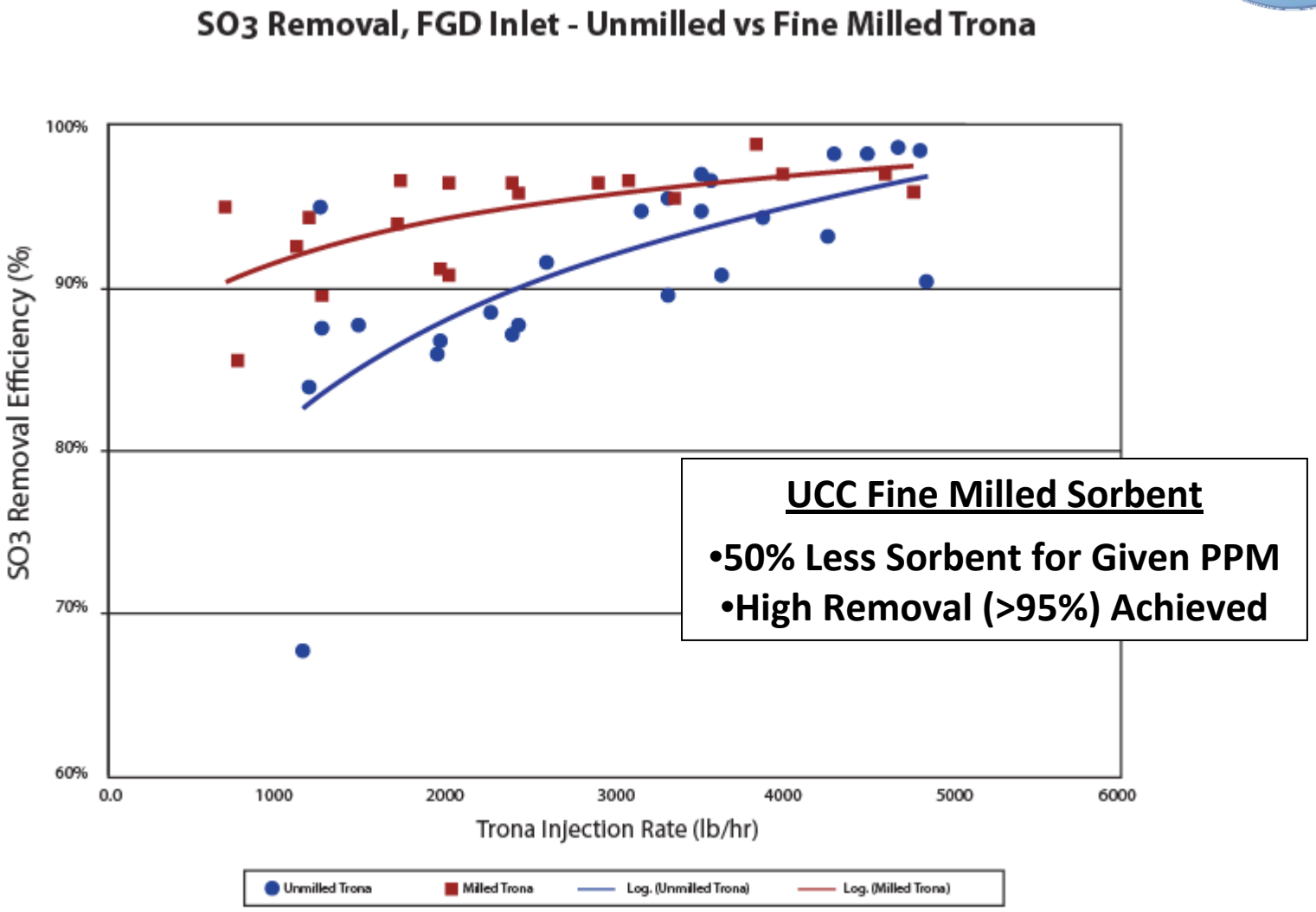
# In-Line Milling for $SO_3$ Removal

## $SO_3$ Concentration – Unmilled vs UCC Fine Milled Trona




Actual Test Data

# Fine Milled vs. Unmilled Trona for $SO_3$ Removal



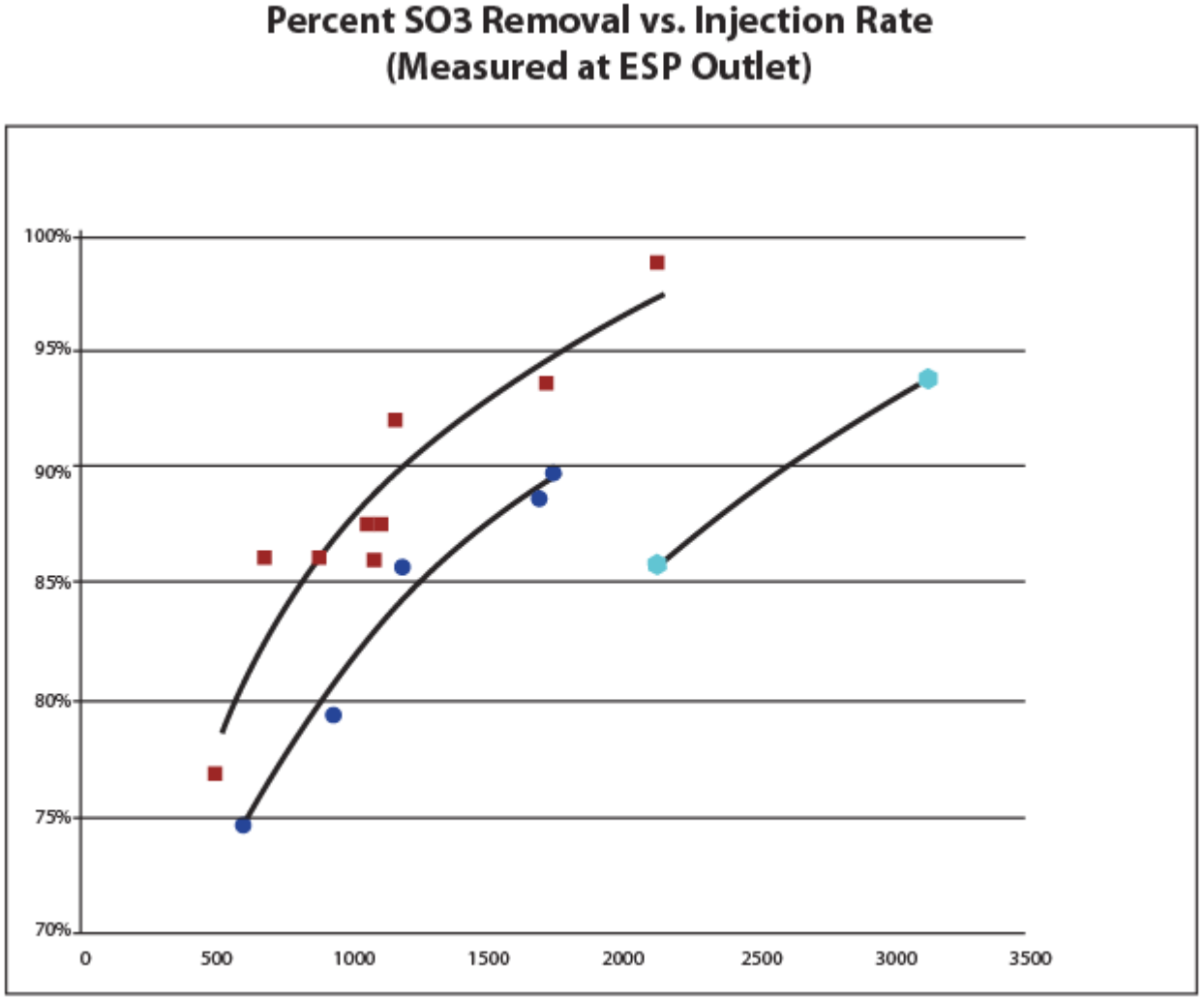

**UCC Fine Milled Sorbent**

- **50% Less Sorbent for Given PPM**
- **High Removal (>95%) Achieved**

UNITED CONVEYOR CORPORATION

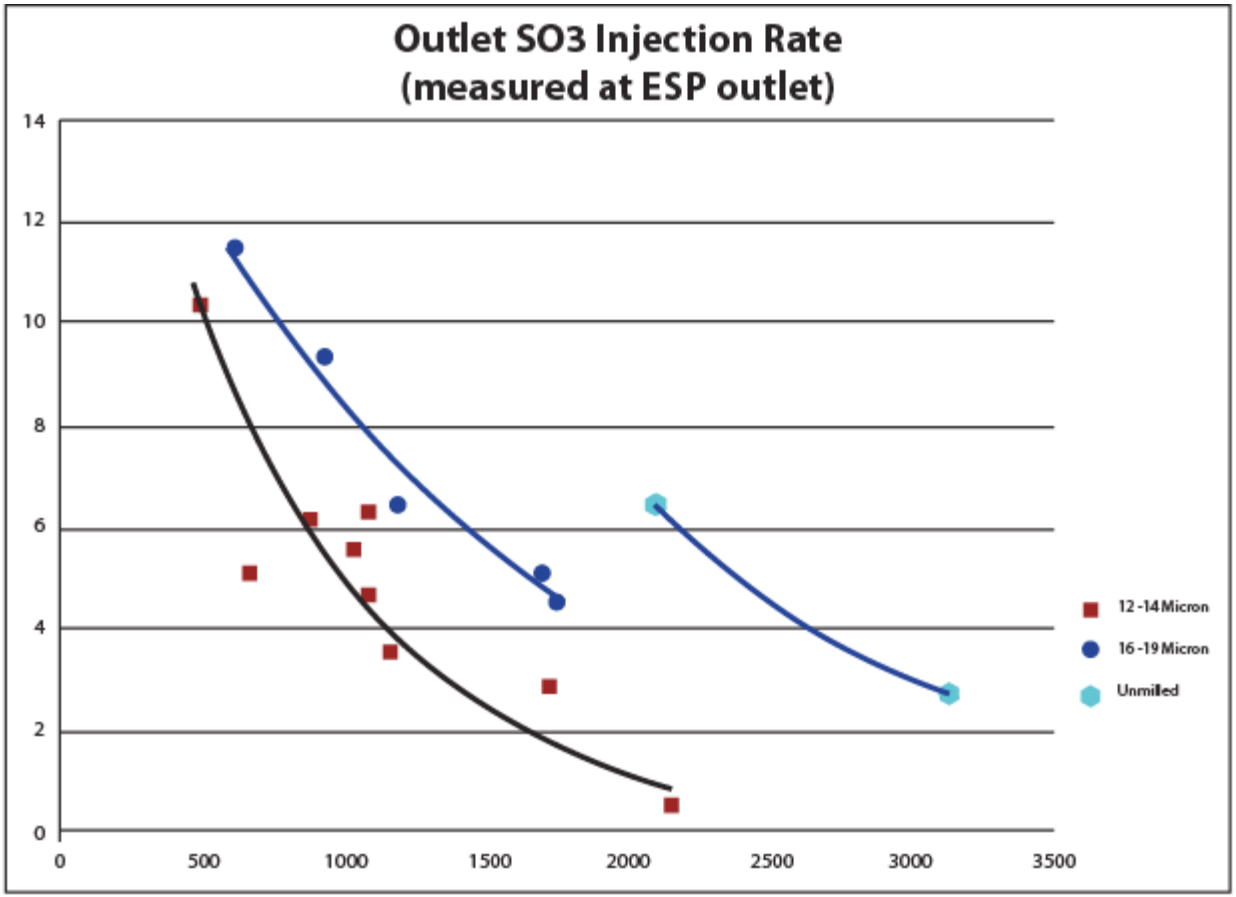
Actual Test Data

# Effect of Particle Size on $SO_3$ Removal (%)



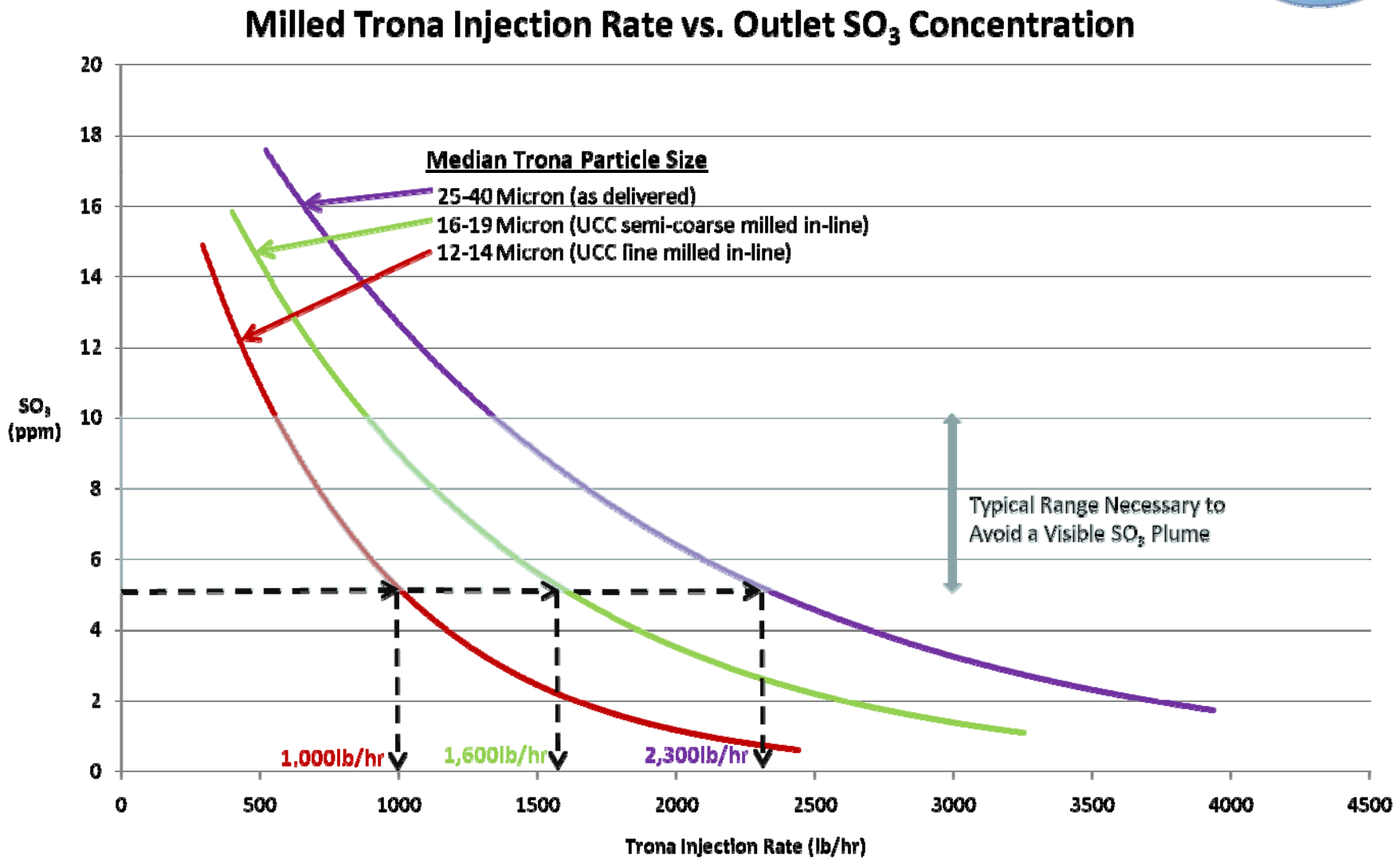

Percent Removal Graph - United Conveyor Corporation - Confidential

# Effect of Particle Size on $SO_3$ Removal (ppm)




Outlet SO3 vs. Injection Rate - United Conveyor Corporation - Confidential

# Effect of Particle Size on $SO_3$ Removal




UNITED CONVEYOR CORPORATION

# $SO_3$ Removal Economics

## *Unmilled Trona vs. Fine Milled Trona*

| Unit (MW) | $SO_3$ PPM | $SO_3$ Reduction (% Removal) | Unmilled (ton/hr) | Milled (ton/hr) | Annual Savings ($180/ton trona) |
|---|---|---|---|---|---|
| 700 | 25 | 90% | 0.7 | 0.4 | $ 425,736 |
| 700 | 35 | 90% | 1.0 | 0.5 | $ 709,560 |
| 700 | 50 | 90% | 1.3 | 0.6 | $ 922,428 |

## *Coarse Grind vs. Fine Milled Trona*

| Unit (MW) | $SO_3$ PPM | $SO_3$ Reduction (% Removal) | Coarse (ton/hr) | Milled (ton/hr) | Annual Savings ($180/ton trona) |
|---|---|---|---|---|---|
| 700 | 25 | 90% | 0.5 | 0.4 | $ 141,912 |
| 700 | 35 | 90% | 0.6 | 0.5 | $ 184,486 |
| 700 | 50 | 90% | 0.9 | 0.6 | $ 390,258 |

# www.ductinjection.com
# www.unitedconveyor.com

# UCC Dry Sorbent Injection

How Particle Size Affects $SO_2$ and $SO_3$ Removal Performance in a Dry Sorbent Injection System


UNITED CONVEYOR CORPORATION