REDUCING SULFUR DIOXIDE EMISSIONS DOWNSTREAM OF AMINE UNITS WITH DRY SORBENT INJECTION

Jonathan Byers, Spartan Energy Partners LP

and Jon Norman, UCC Dry Sorbent Injection, LLC

Presented by:

Colby Meyer, Spartan Energy Partners LP

International Petroleum Environmental Conference Oct. 30 – Nov. 1, 2017
San Antonio, Texas

Presentation Overview

- Company Overview
- Why the Need for this Technology?
- Using DSI for SO_2 Removal - System Overview
- Summary

COMPANY OVERVIEW

UCC Dry Sorbent Injection Overview

- **UCC is a 97 year old global firm specializing in engineered material handling solutions for power and industrial customers**
- **Dry Sorbent Injection (DSI) Experience for Air Pollution Control**
  - Over 100 full-scale DSI tests and temporary systems
  - Almost 100 large, permanent systems total
  - Approximately one-half of the DSI systems used for SO_2 reduction

Spartan Energy Overview

- Spartan Energy is a provider of natural gas treating and processing equipment and services globally
- Spartan provides turnkey installation, commissioning, operations and maintenance services

Equipment	
Amine Plants and Facilities	Dehydration Units
Mechanical Refrigeration Units	Cooling Units
Condensate Stabilizers	JT Units
Natural Gas Compression	Natural Gas Gensets

WHY THE NEED FOR THIS TECHNOLOGY?

Why the Need for this Technology?

- Produced natural gas high in Hydrogen Sulfide (H_2S) can create significant issues for operators
- H_2S is typically removed from produced natural gas streams using two methods
  - Scavenger: a liquid or solid media that removes H_2S
  - Amine Treating: a regenerative solvent that removes H_2S and CO_2
- Scavenger and Amine Treating each have their own benefits and disadvantages
- The biggest issue with amine treating of high H_2S gas is the disposal of H_2S rich acid gas

Disposal of H_2S

- H_2S emitted from Amine Unit Regeneration System
  - Oxidation into SO_2 (Flare or Thermal Oxidizer)
  - Acid Gas Injection
  - Claus or Liquid Redox Process

H_2S Disposal Considerations

H2S emitted from Amine Unit Regeneration System

	Oxidation into SO_2 (Flare or Thermal Oxidizer)	Acid Gas Injection	Claus or Liquid Redox Process
Capital Cost	Low	High	Moderate to High
Operating Cost	Low	Moderate	Moderate to Low
Regulatory Burden	Low to High	Very High	Moderate

DSI Used to Reduce Regulator Burden

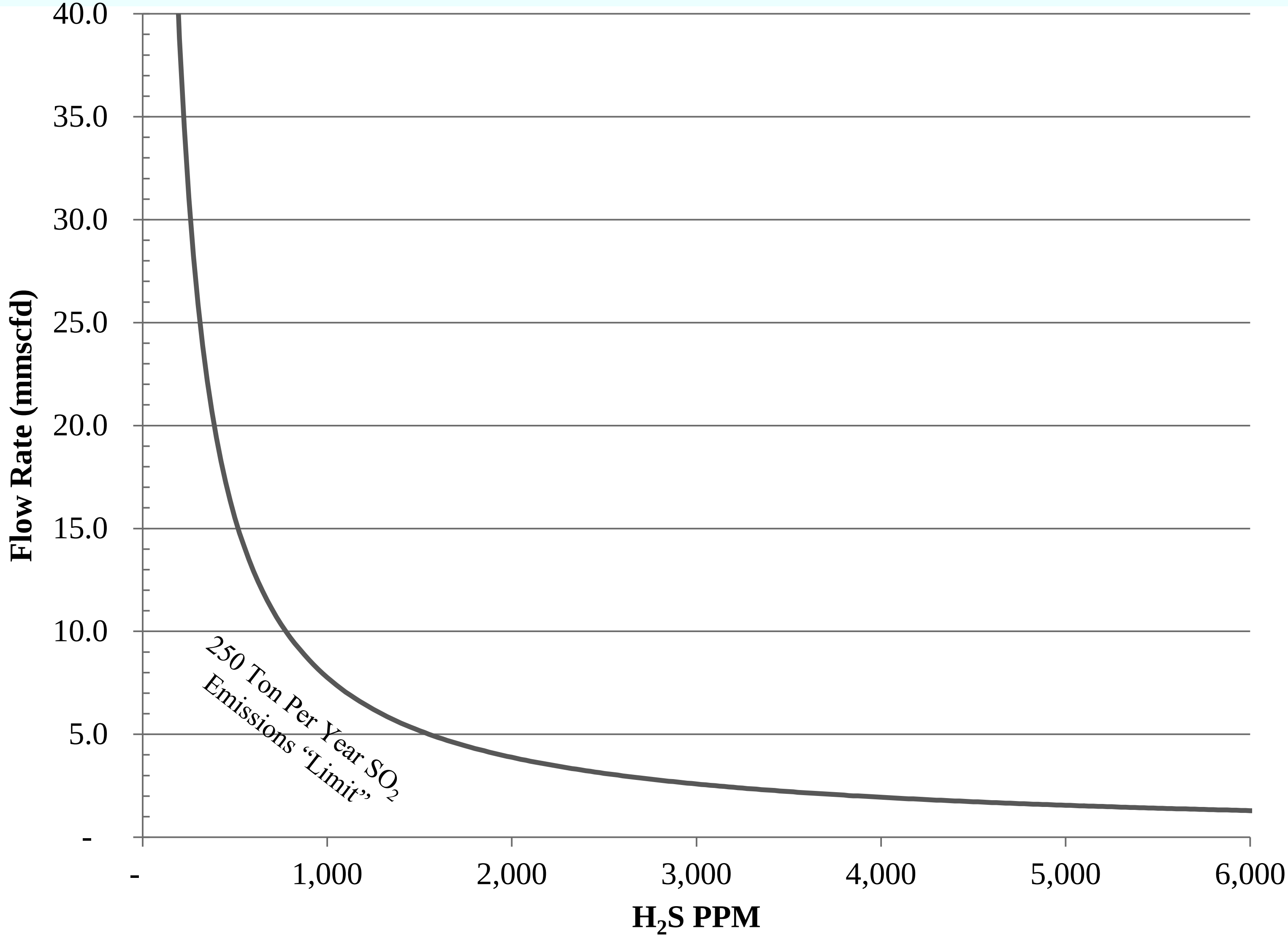
Dry Sorbent Injection Overview

- Dry Sorbent Injection is a process of injecting a sorbent into a waste gas stream to remove pollutants
- It was commercialized over the last 25 years as a way for power plants to minimize SO_2 and other pollutants
- It is used extensively in power plants, waste incinerators, and other industrial processes
- Spartan and UCC developed a modular DSI system that can be used in the oil and gas industry to reduce pollutant emissions downstream of an amine unit.
- Spartan / UCC process is Patent Pending

Evolution of DSI

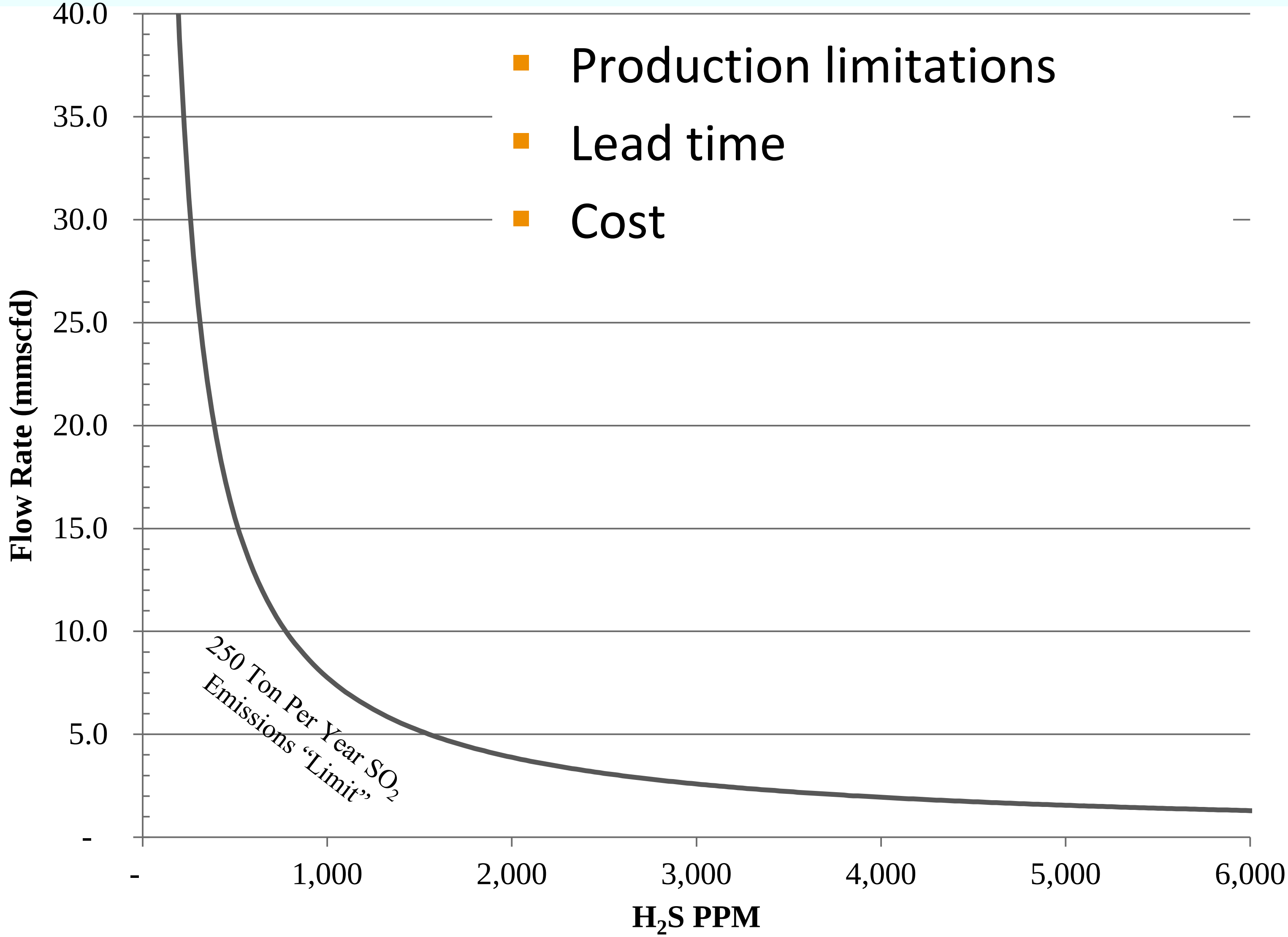
- UCC developed test units for power plants to demonstrate DSI at power plants
- The units are modular, trailer-mounted systems that are used to feed sorbent into power plant flue gas
- With additional components that Spartan and UCC developed for amine systems, the DSI system can be set up on a site in a few weeks
- Using DSI, SO_2 pollution can be reduced by up to 90%

Production Limits at NSR Permit Threshold

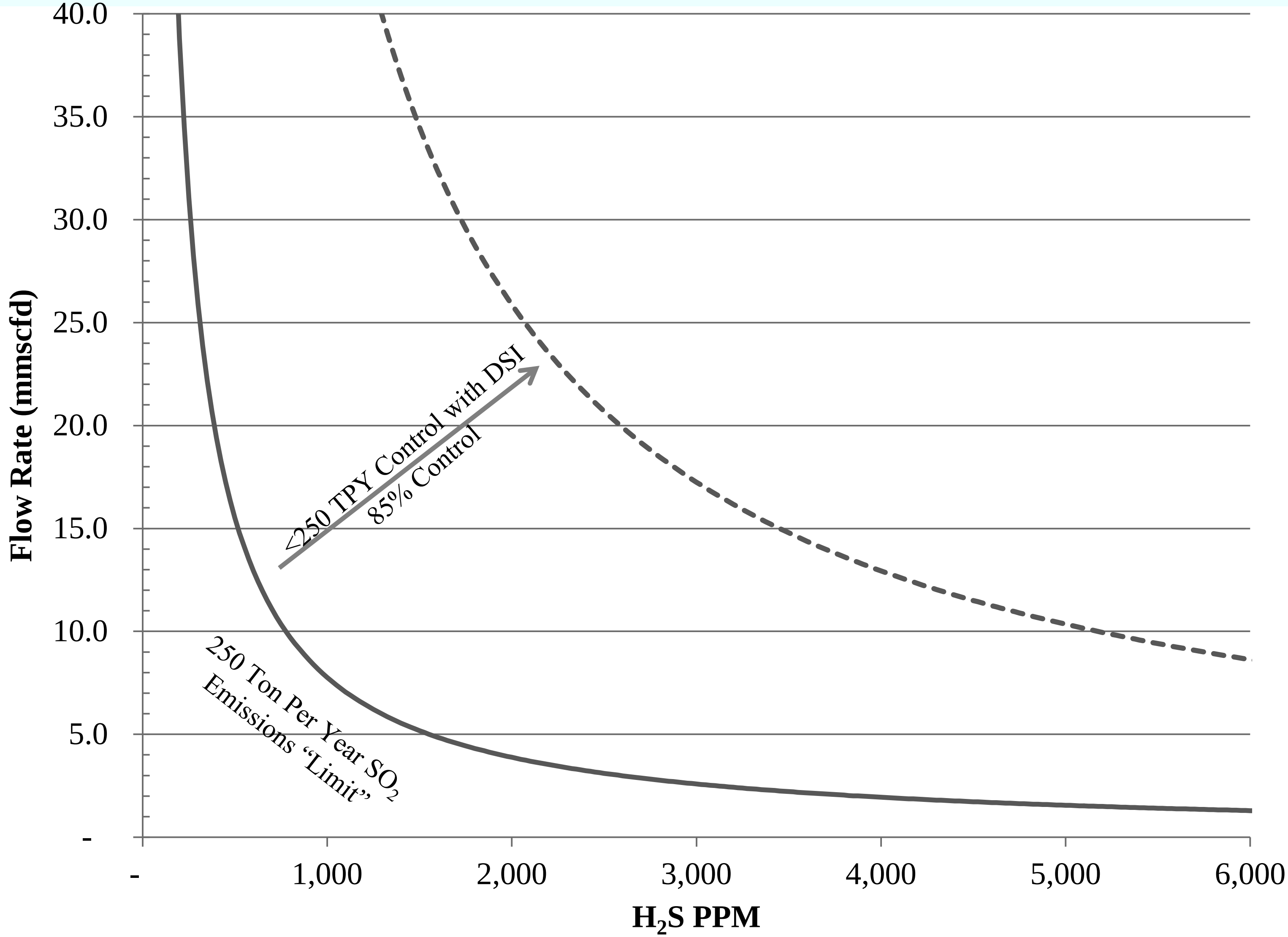


Production Limits at NSR Permit Threshold

- Production limitations
- Lead time
- Cost



Production Limits at NSR Permit Limit with DSI



Spartan® Selection of a Sulfur Removal Technology

- Selection of a Sulfur Removal Process requires evaluation of several variables
  - Concentration of H_2S in produced gas
  - Concentration of CO_2 in produced gas
  - Total gas flow and production curve
  - Anticipated life of production facilities and future drilling plans
  - Availability of existing infrastructure for treatment and disposal of H_2S
  - Operational/Complexity considerations

Traditional Sulfur Removal and Disposal

Solution	Scavenger	Liquid Redox	Sulfur Recovery Unit	Acid Gas Injection
Summary	Liquid or Solid media used to remove H_2S from process gas	Removal of H_2S using a reduction/oxidation reaction using a catalyst	Recovers H_2S as elemental sulfur through the Claus Reaction	Injection of H_2S and other acid gases into a non-producing formation to prevent emission into atmosphere

DSI
Sorbent injection to remove SO_2 from an acid gas stream

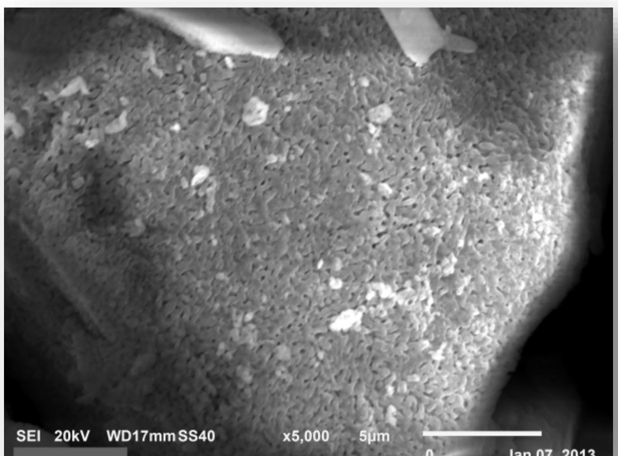
All Options have Benefits and Drawbacks

Solution	Scavenger	DSI	Liquid Redox	Sulfur Recovery Unit	Acid Gas Injection
Sulfur Removal "Sweet Spot"	<0.5 TPD	0.3-2 TPD	<15 TPD	>10 TPD	High Volumes
High H2S in gas	☒	☑	☑	☑	☑
Removal of CO2	Amine Required	Amine Required	Amine Required	Amine Required	Amine Required
Anticipated Life of Production	Short-Long Term	Short-Medium Term	Long Term	Long Term	Long Term
Availability of Existing Infrastructure	Limited Infrastructure Needed	Temporary Equipment	New Facility	New Facility	Great if Available
Operational Complexity	Minimal Complexity	Minimal Complexity	Moderate Complexity	High Complexity	High Complexity
Cost Considerations	Low Capital /High Variable	Low Capital/ Moderate Variable	Moderate Capital / Low Variable	High Capital / Low Variable	High Capital / Low Variable

USING DSI FOR SO_2 REMOVAL

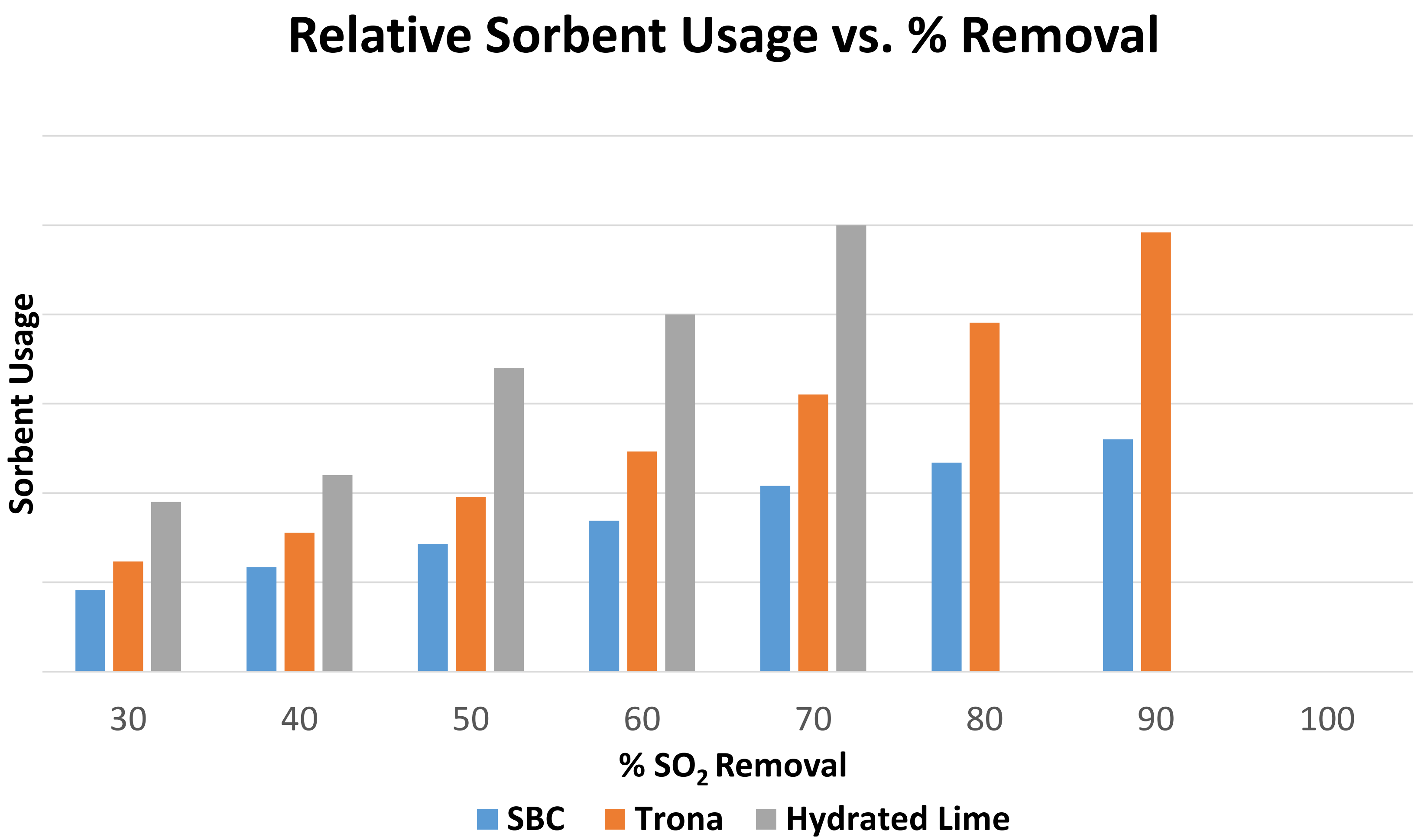
SO_2 Removal – Sorbent Choice

- **Trona**
  - Use when:
    - Moderate SO_2 removal needed (approx. 80% or less)
    - Must be milled
    - Optimum temperature is 275F to 1000F



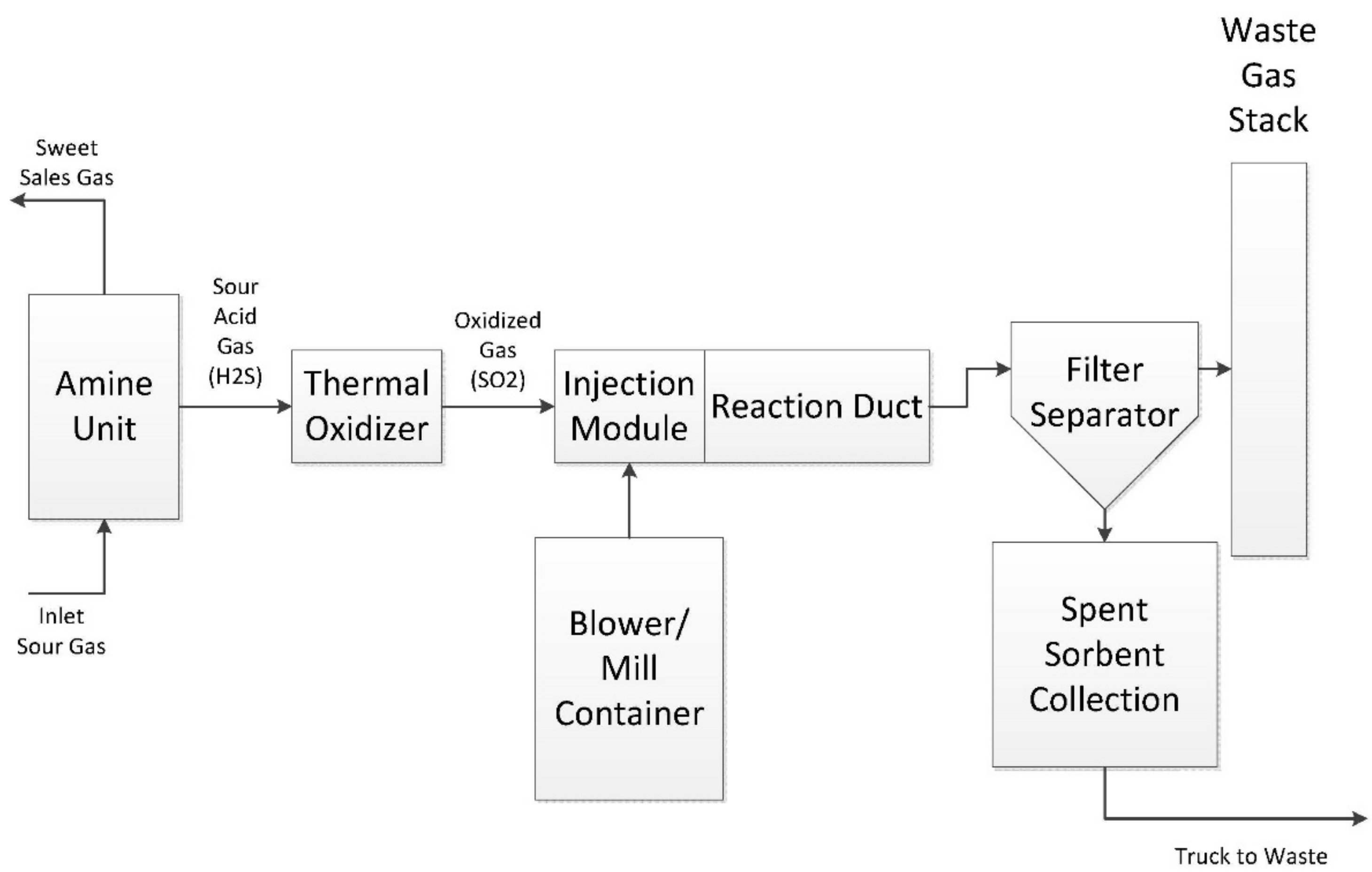
- **Sodium Bicarbonate**
  - Use when:
    - High removals needed (> 80%)
    - Want to minimize waste loading
    - Optimum temperature is 275°F to 650°F
- **Hydrated Lime**
  - Use when:
    - Lower removals needed (<60%)
    - Optimum temperature is 600 to 1100°F
    - Highest usage/waste generation

SO_2 Removal – Sorbent Comparison

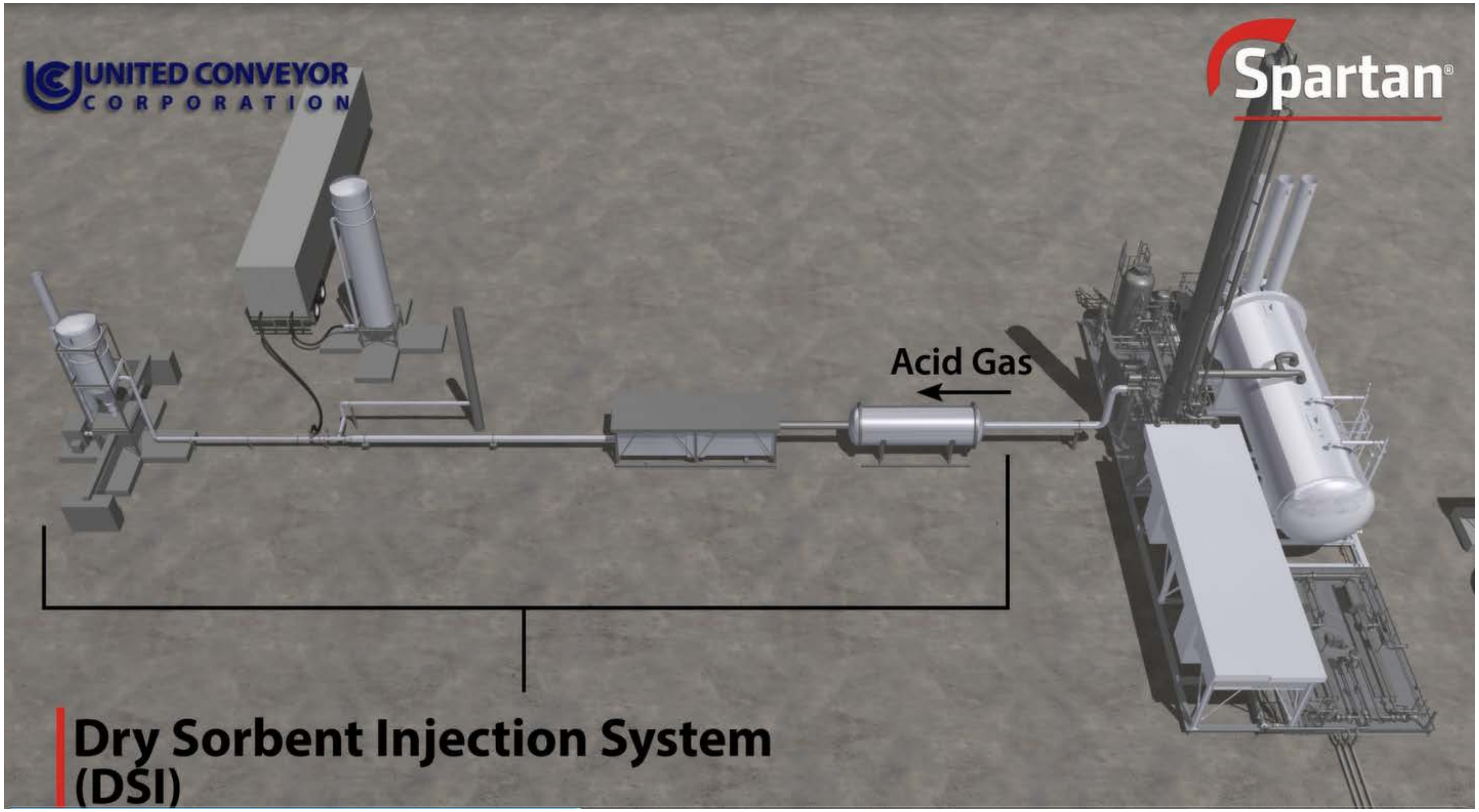


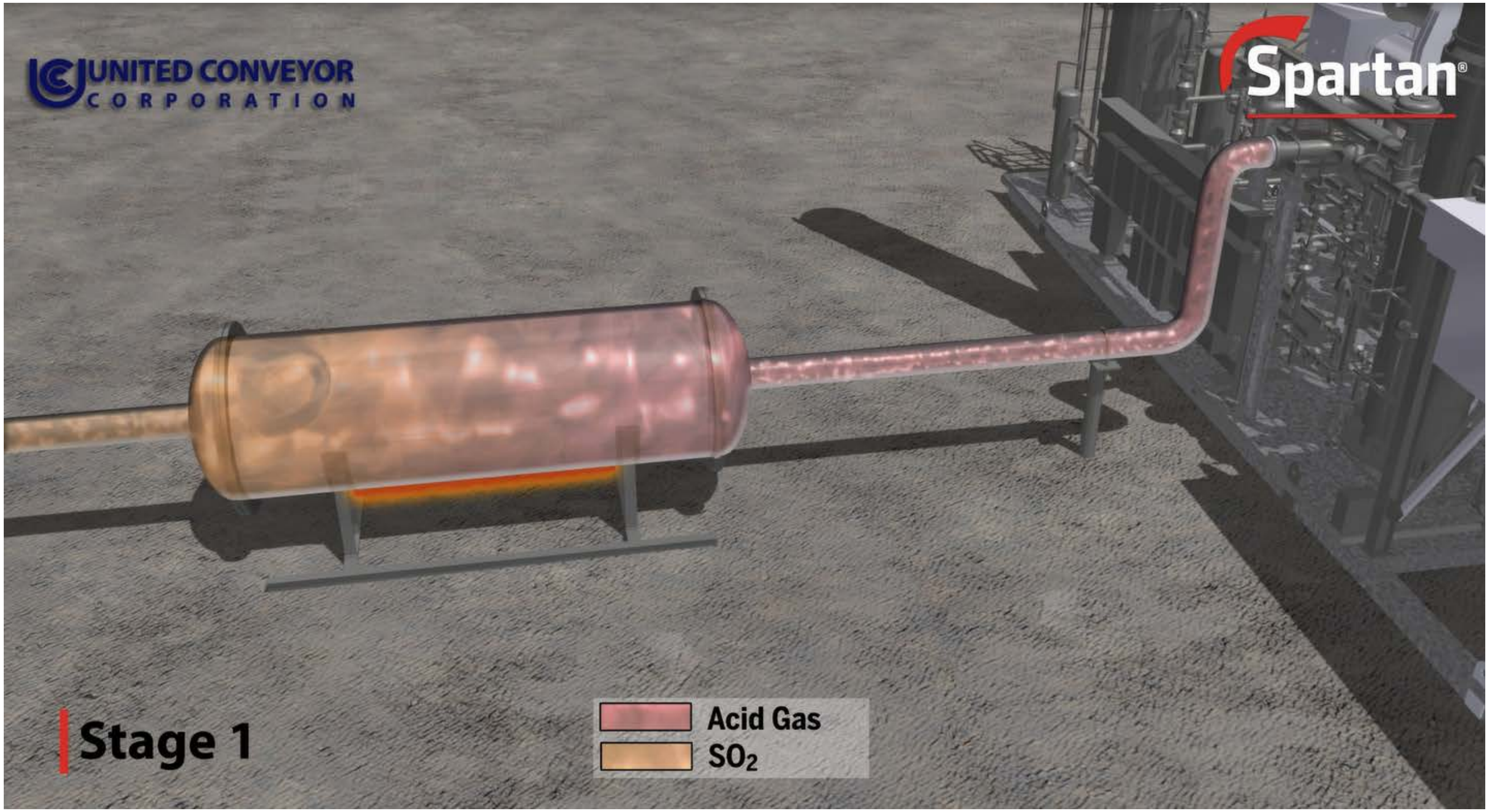
SYSTEM OVERVIEW

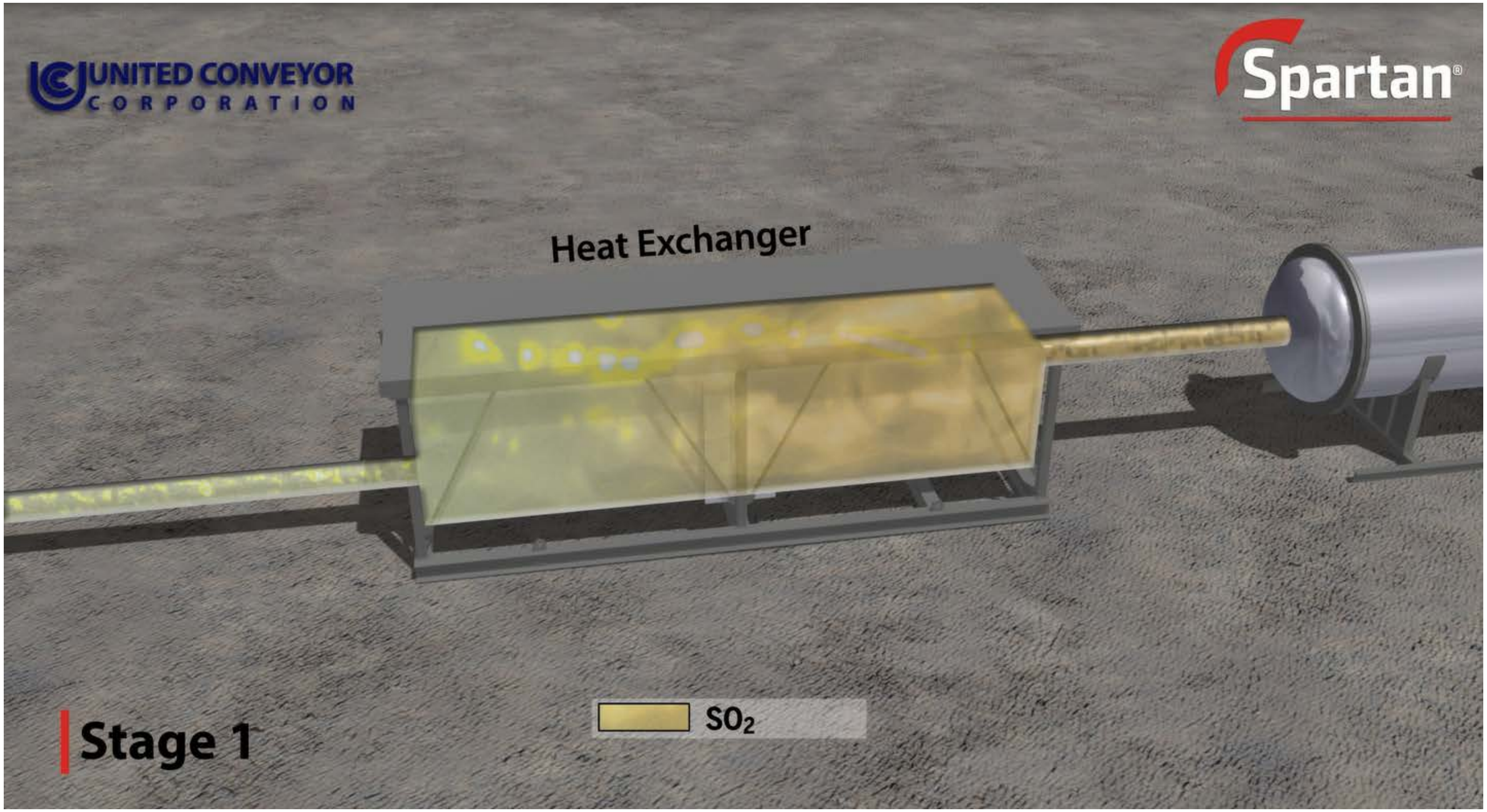
Description of Amine Process with DSI

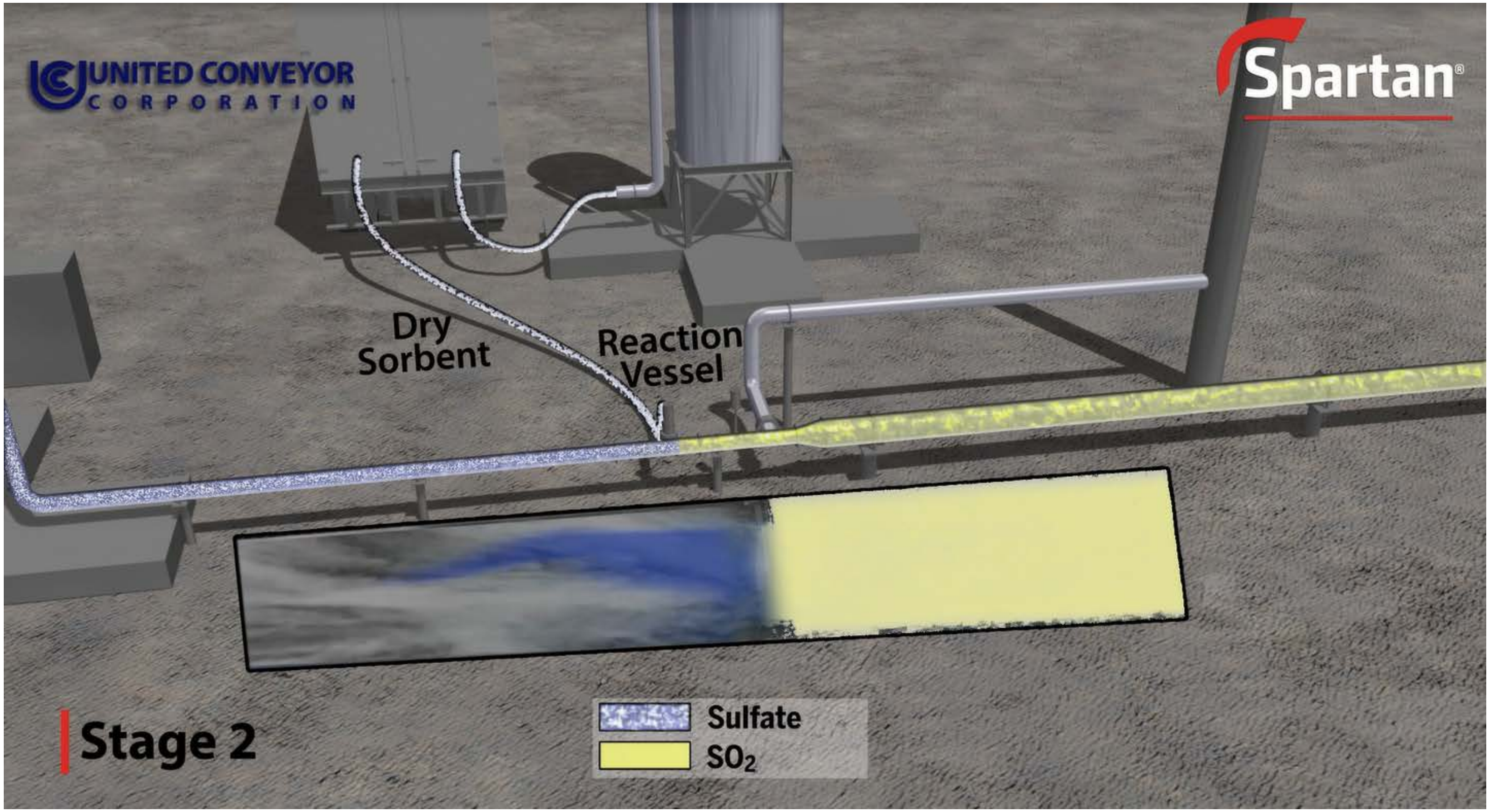


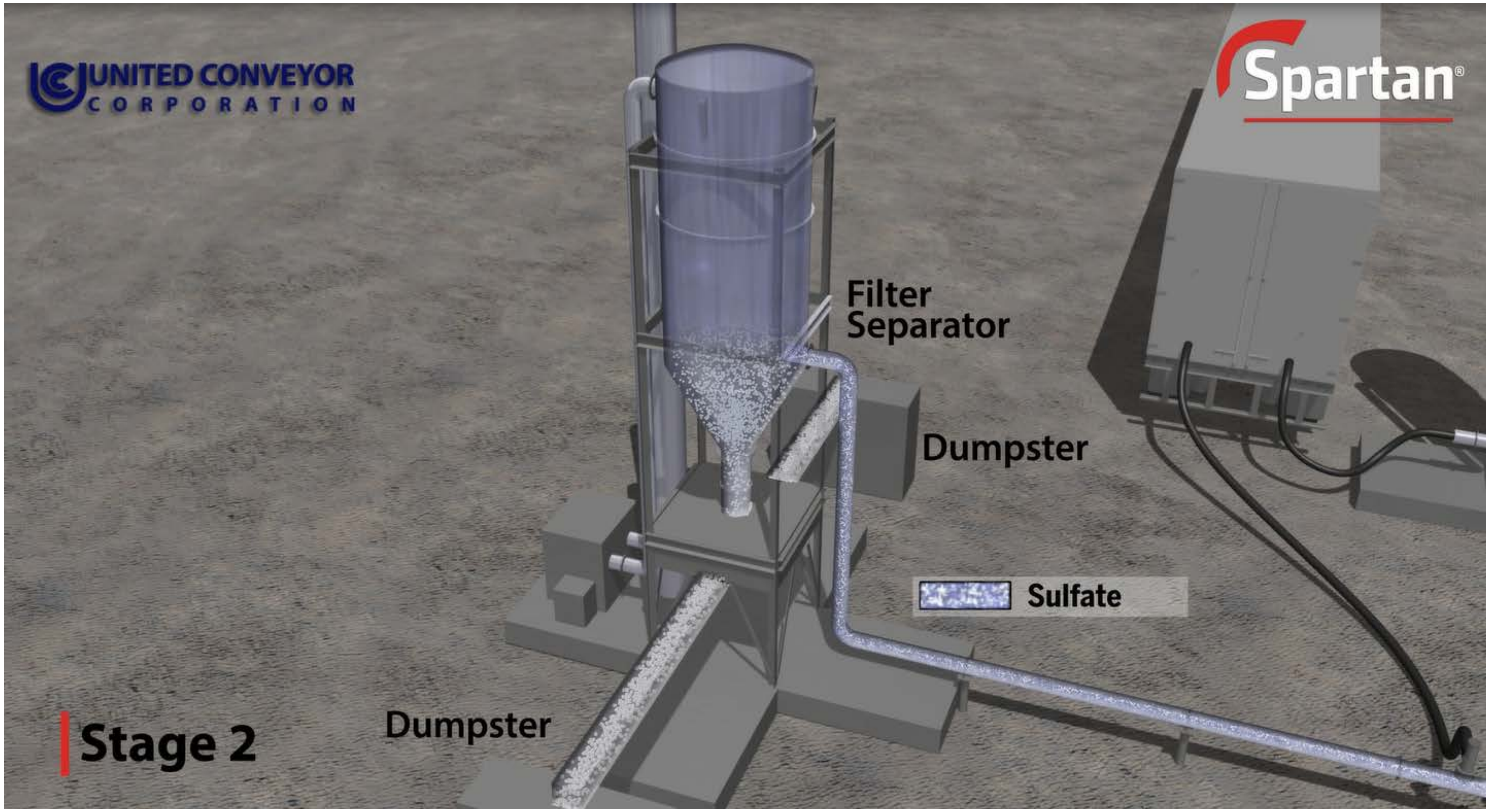
Dry Sorbent Injection System




UNITED CONVEYOR
CORPORATION
Spartan
Stage 1
Acid Gas
SO2


UNITED CONVEYOR
CORPORATION
Spartan®
Heat Exchanger
SO2
Stage 1


UNITED CONVEYOR
CORPORATION
Spartan®
Dry
Sorbent
Reaction
Vessel
Sulfate
SO2
Stage 2


UNITED CONVEYOR
CORPORATION
Spartan®
Filter
Separator
Dumpster
Sulfate
Stage 2
Dumpster

Silo and Blower/Mill Trailer

Semi-Mobile System, Sorbent Storage Silo

- **50 ton capacity (2000 ft^3)**

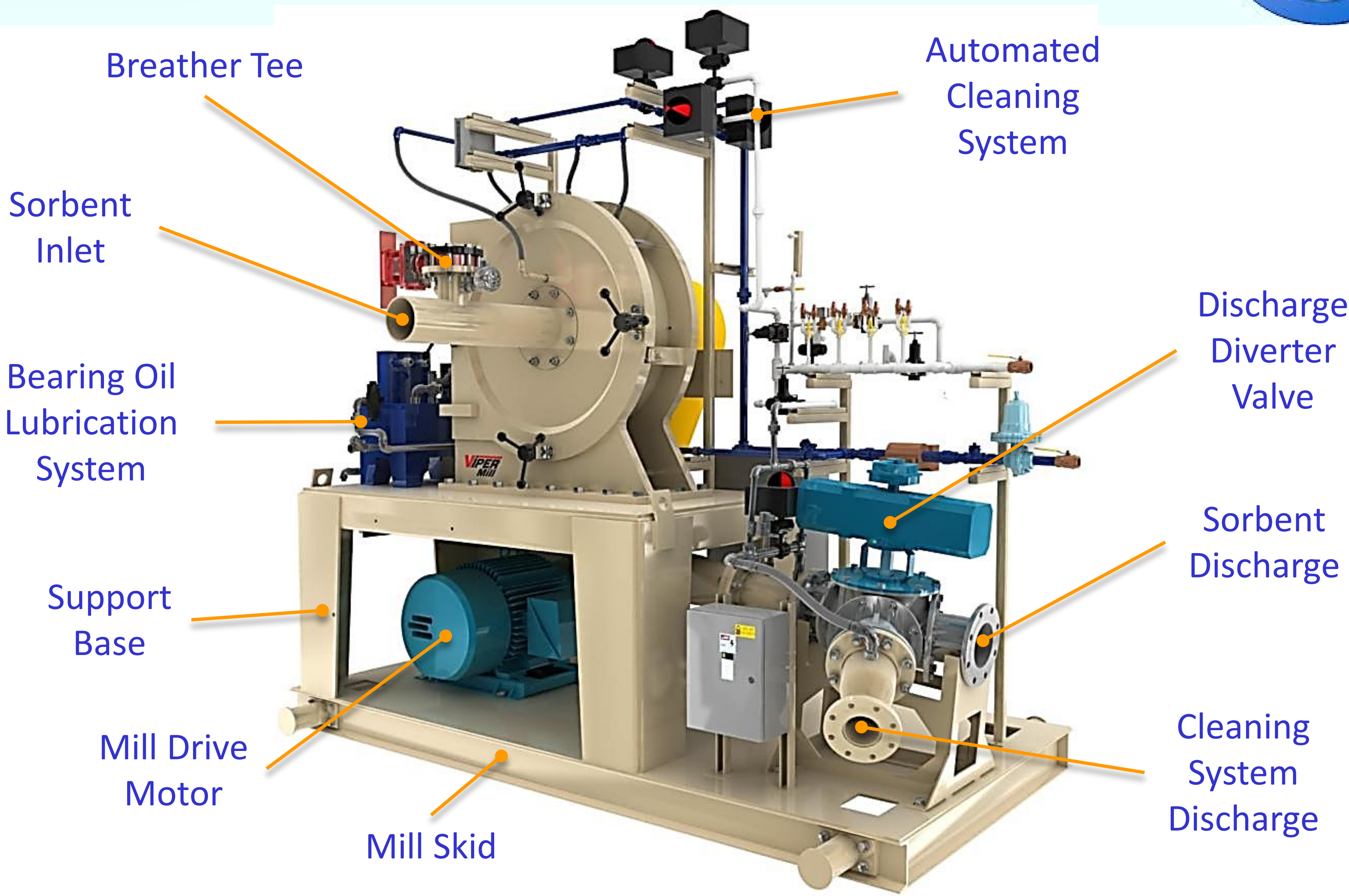
Blower/Mill Trailer

UCC VIPER® Mill

- **Greatest opportunity for increased performance is to reduce particle size**
  - Increased surface area for reaction
  - Increased number of particles/collisions
  - Increased dispersion

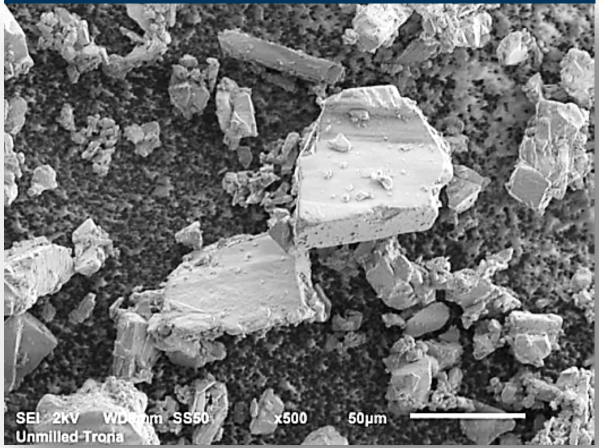
UCC VIPER® Mill
(Two Sizes)
2 tph
7 tph

Milling Technology
VIPER® Mill Skid Layout



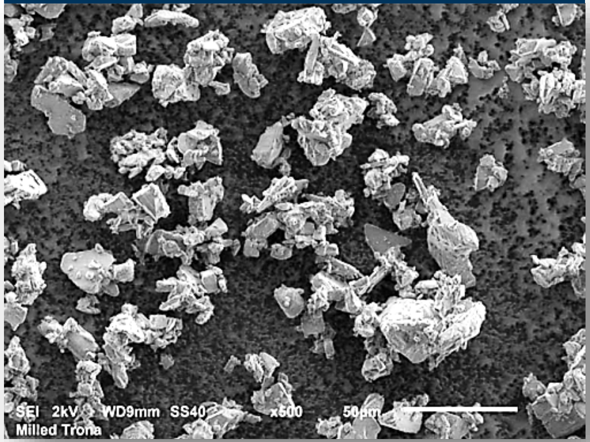
VIPER® Mill

Unmilled Trona



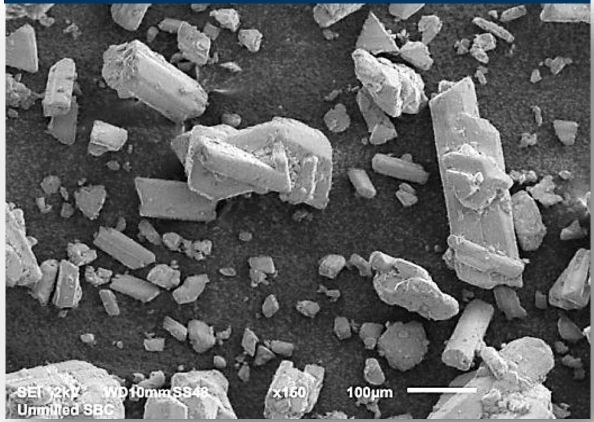
25-40 µm

Milled Trona



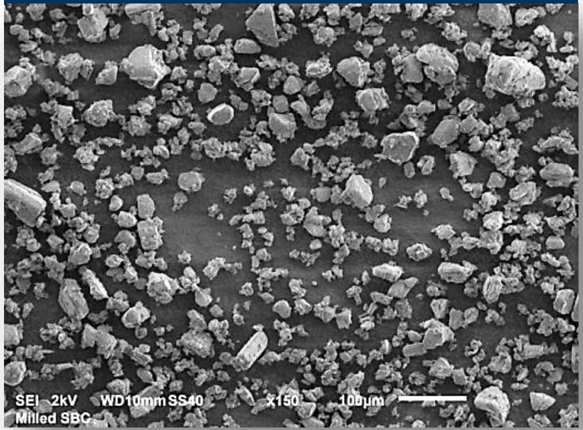
12-15 µm

Unmilled SBC



150-180 µm

Milled SBC

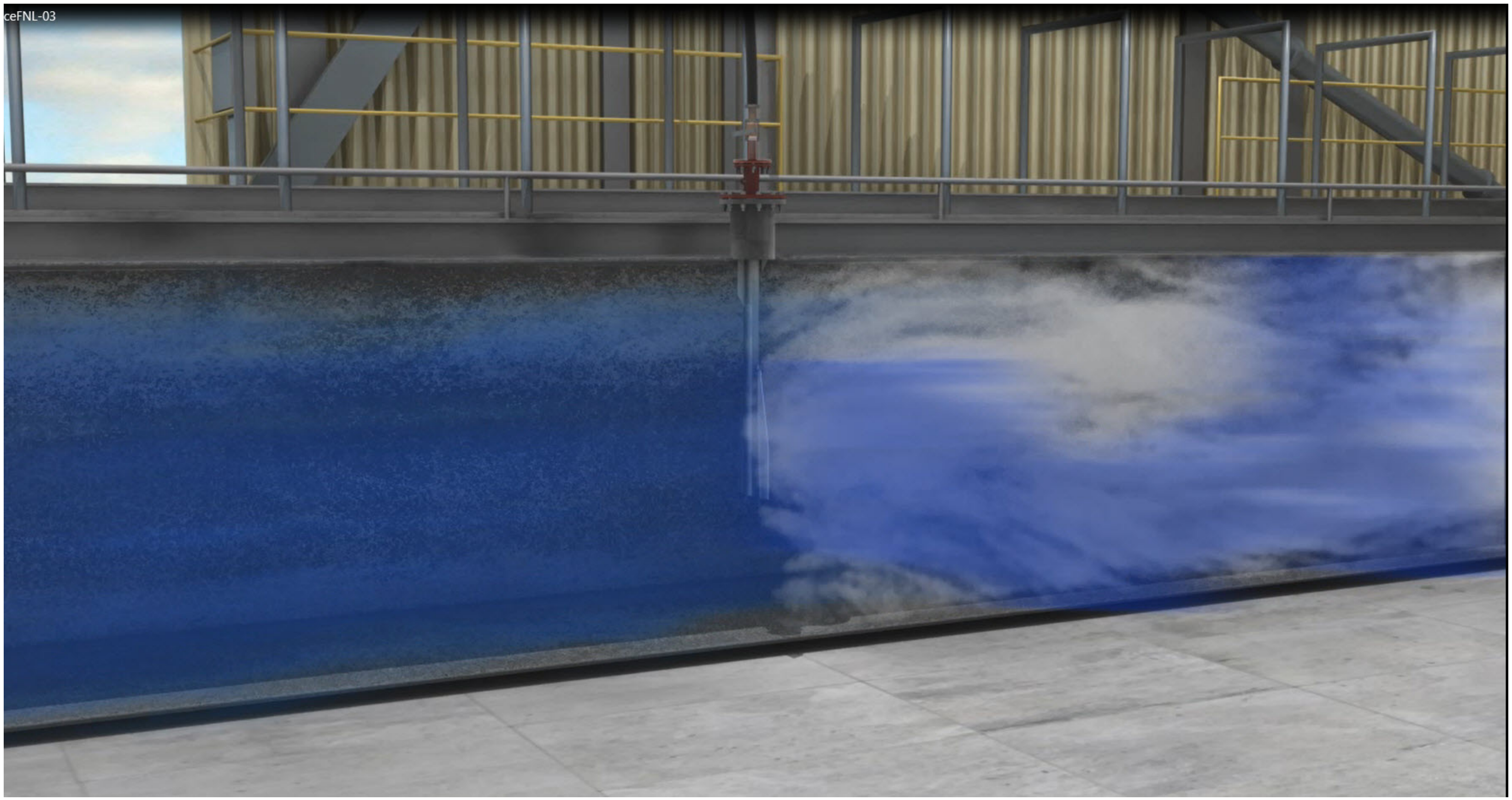


15-19 µm

DSI System Design

- **Splitters/Lances**
  - Splitter design critical for performance and reliability (auto purge system shown)
  - Lances designed for optimum dispersion (COBRA™ Lances shown)

COBRA Lance

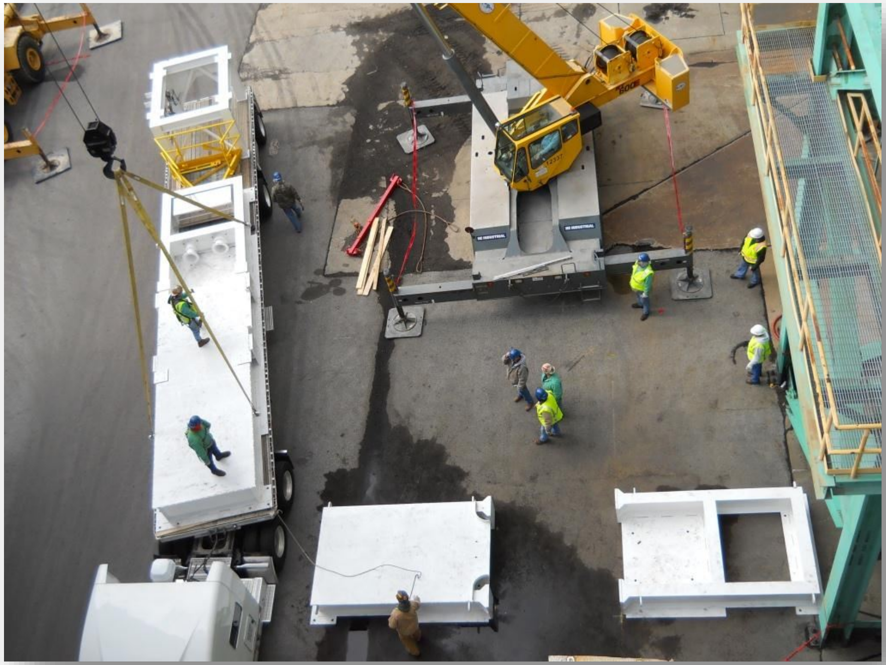


Spartan® Filter Separator and Waste Handling

- Collects spent sorbent
- byproduct directed into two “dumpsters” using screw feeders
- Byproduct disposal is non-hazardous

Installation - Equipment Arrival

Installation - Silo Preparation



Installation - Silo Set Up

SUMMARY

Summary

- **Factors to consider when choosing sulfur removal technology:**
  - CO_2 and H_2S amount in gas
  - Gas flow and anticipated life of production facilities
  - Existing infrastructure and operational/complexity considerations
- **Reducing SO_2 emissions downstream of amine units with DSI**
  - Economical solution for applications ranging from 500-4000 lbs/day of sulfur, particularly when amine treating is also required.
  - Mobile equipment allows for quick set-up and operation
  - Enables higher gas production while maintaining permit limits
  - Dry system – eliminates water and wastewater concerns
  - Proven equipment

Questions?

For More Information

Jon Norman, PE

Manager, DSI Sales and Technology

UCC Dry Sorbent Injection, LLC

P: 315-440-3244

jonnorman@unitedconveyor.com

Jonathan Byers

VP, Corporate Development

Spartan Energy Partners LP

P: 281-466-3313

jon.byers@spartanep.com

Colby Meyer

Engineer

Spartan Energy Partners LP

P: 281-466-3317

colby.meyer@spartanep.com