LO CAT®– The Green Solution to Sulfur Recovery

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AGENDA

- What is LO CAT?
- LO CAT Sulfur
- Green Aspects of LO CAT
- Sulfur in Agriculture
- LO CAT Sulfur in Agriculture

What is LO CAT?

Regenerative Desulfurization Process

LO CAT

Liquid Oxidation Catalyst

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What is LO CAT?

- Converts H_2S into elemental sulfur
- Aqueous–based, ambient temperature process
- Employs a proprietary, iron-based catalyst
- Can obtain 99.9+% removal, with turndowns approaching 100%
- Can treat any gas stream containing H_2S

How LO CAT Works

- **Overall Reaction**

$$H_2S\ (g) + \tfrac{1}{2}\ O_2\ (g) \xrightarrow[(Fe)]{} H_2O\ (g) + S^o$$

- **Important points**
  - Sulfur is formed as a solid
  - Reaction is not equilibrium limited
  - Iron is the catalyst

How LO CAT Works

- SULFIDE OXIDATION/IRON REDUCTION
- Absorption of H_2S (slow)

$$H_2S\ (g) + H_2O \longleftrightarrow H_2S\ (aq)$$

- Ionization of H_2S (fast)

$$H_2S\ (aq) \longrightarrow HS^- + H^+$$

- Sulfide Oxidation (fast)

$$HS^- + 2\ Fe^{+++} \longrightarrow 2\ Fe^{++} + H^+ + S^o$$

- Fe^{++} is inactive
- Sulfur is formed as a solid

How LO CAT Works

- IRON OXIDATION
- Absorption of oxygen (slow)

$$O_2\,(g) + H_2O \longleftrightarrow O_2\,(aq)$$

- Iron Oxidation (very fast)

$$\tfrac{1}{2}\,O_2 + 2Fe^{++} + H_2O \longrightarrow 2Fe^{+++} + 2OH^-$$

How LO CAT Works

OVERALL REACTION

$$H_2S\ (g) + H_2O \leftrightarrow H_2S\ (aq)$$

$$H_2S\ (aq) \rightarrow HS^- + H^+$$

$$HS^- + 2\ Fe^{+++} \rightarrow 2\ Fe^{++} + H^+ + S^o$$

$$O_2\ (g) + H_2O \leftrightarrow O_2\ (aq)$$

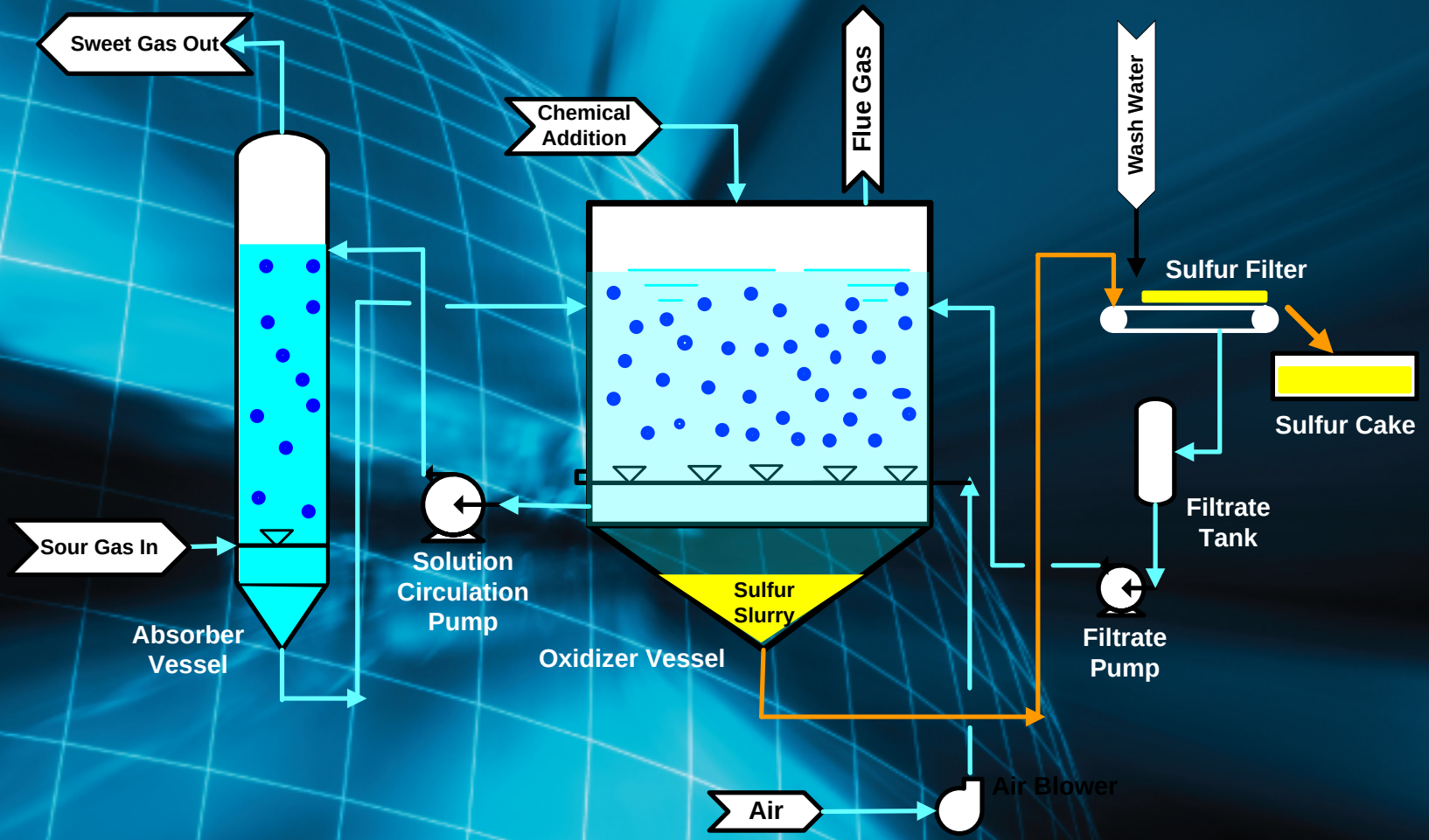
$$\tfrac{1}{2}\ O_2 + 2Fe^{++} + H_2O \rightarrow 2\ Fe^{+++} + 2OH^-$$

$$H_2S\ (g) + \tfrac{1}{2}\ O_2\ (g) \xrightarrow{(Fe)} H_2O\ (g) + S^o$$

Process Configurations

- **Direct Treatment Processing Scheme**
  - Employed when treating combustible gas streams – fuel gas, natural gas, associated gas, etc.
  - Product streams which cannot be contaminated with air or CO_2
- **AutoCirculation Processing Scheme**
  - Employed when processing non-combustible gas streams – acid gas, SWS gas

Direct Treatment



Process Flow Diagram - Direct Treatment LO CAT® Design

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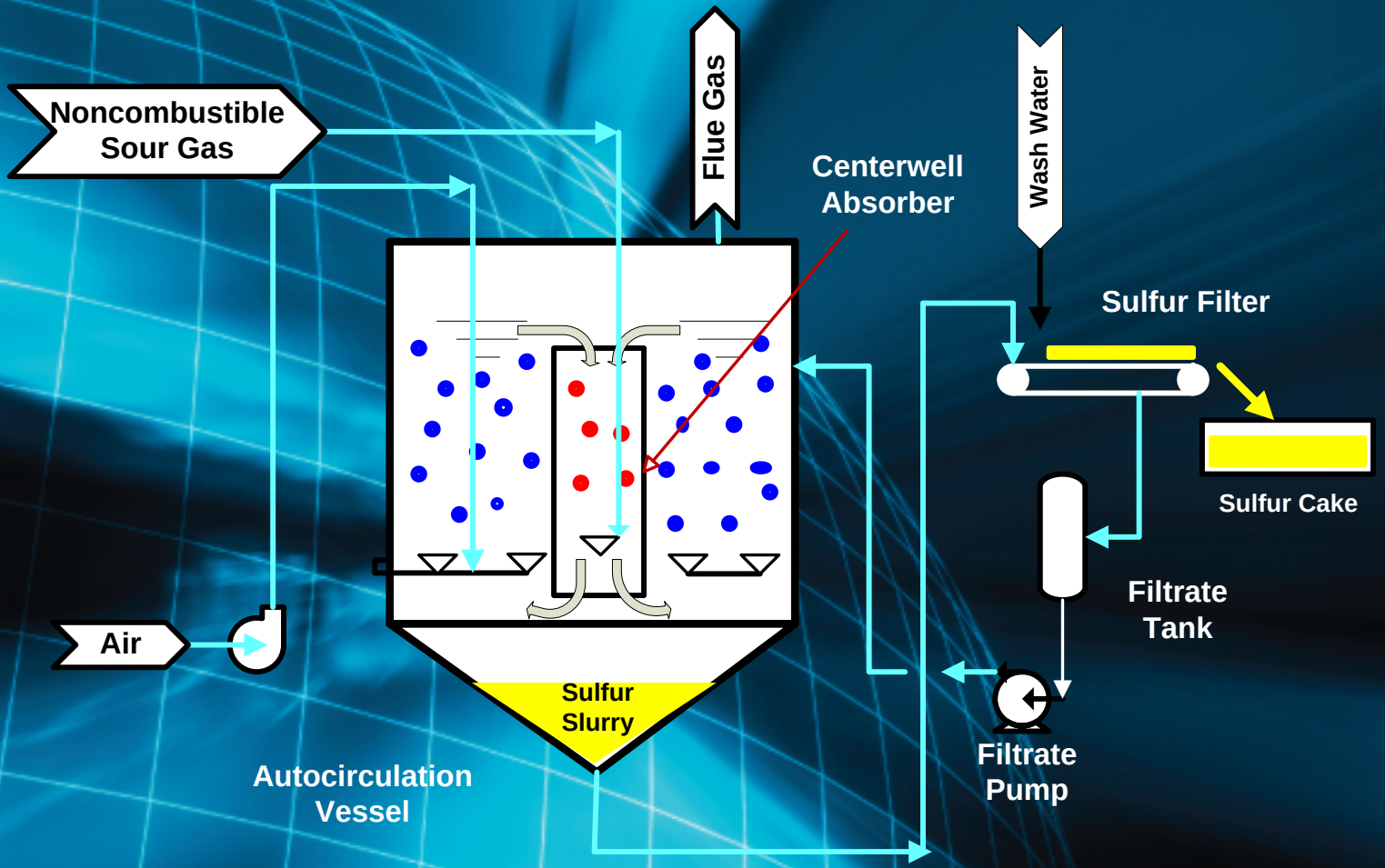
AutoCirculation Scheme



Process Flow Diagram – Autocirculation LO CAT® Design

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Chemical Additives

- Chemical additives have 5 basic functions
  - Replenishment of chelate loss due to degradation
  - Replenishment of chelated iron due to physical losses through processing
  - Control of biological activity
  - Surfactant to improve sulfur settling
  - Alkaline material to control pH @ ~ 8.5

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LO CAT Sulfur

LO CAT Sulfur

- Produced as a solid
- No dissolved H_2S
- Methods of removal
  - Bag filter - 35% sulfur cake (simple gravity filtration)
  - Vacuum belt filter - 65% sulfur cake
  - Pressure filter - 80+% sulfur cake
  - Melter – 99.9% sulfur

Merichem's Belt Filter

Merichem Proprietary LO CAT® Sulfur Filter System

LO CAT Sulfur Product

Sulfur cake produced with Merichem Proprietary LO CAT® Sulfur Filter

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Sulfur Cake Analysis

Sulfur	~ 65 wt.%
Water	~32.5 wt.%
$S_2O_3^=$	~ 1.2 wt.%
Fe	~ 85 ppm
Carbonates	~ 1.2 wt.%
Organics	~ 85 ppm
H_2S	ZERO!

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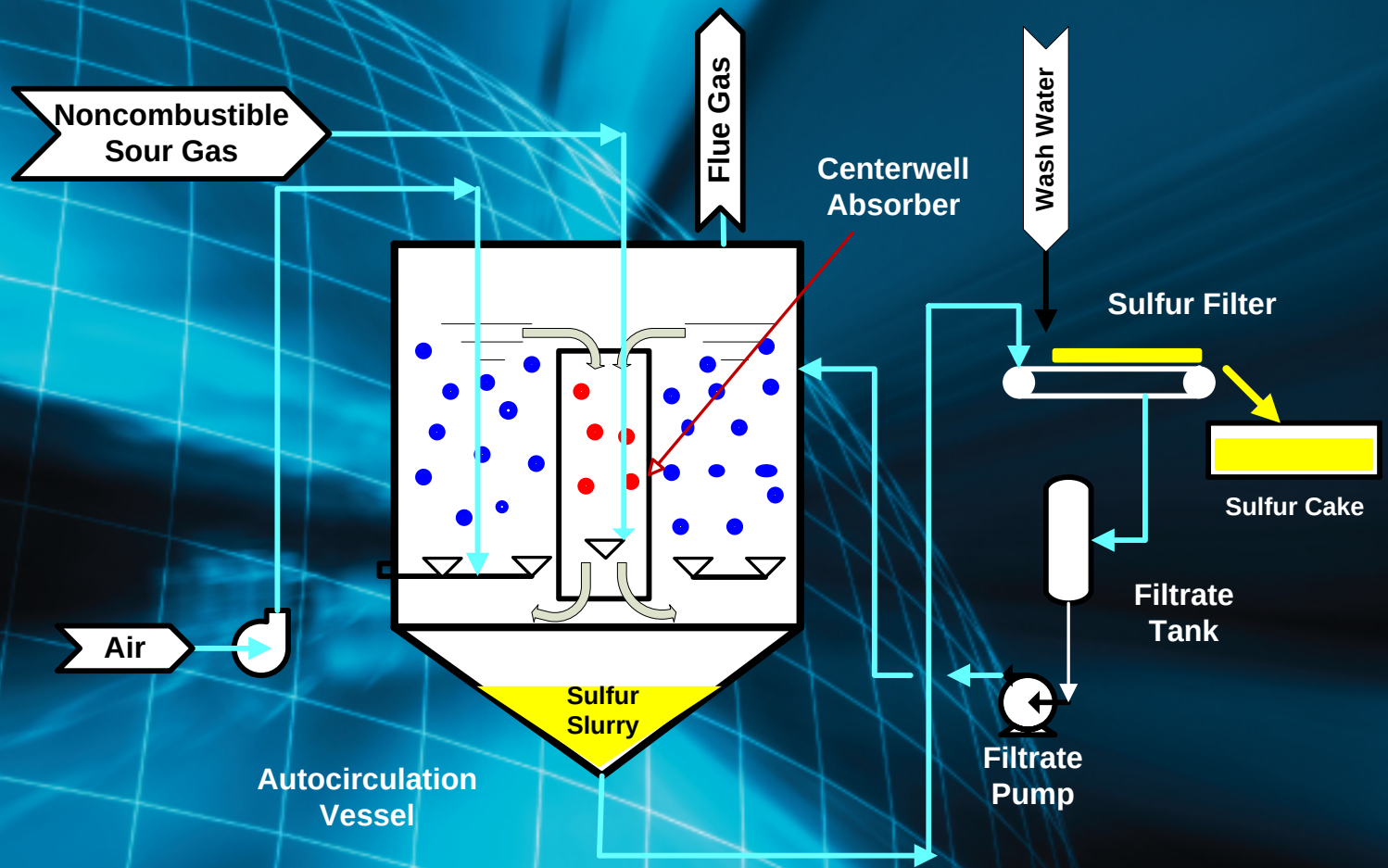
Green Aspects of LO CAT

What Goes into LO CAT?

- Sour Gas Streams
  - H_2S is converted into innocuous elemental sulfur
- Chemicals
  - Caustic is neutralized in the process
  - Chelates are biodegradable
  - Biocide is a birth control pill for bugs

Small Carbon Foot Print



Autocirculation LO CAT® System

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H_2S Removal Efficiencies

- Efficiencies > 99.9% achievable in one step
- Flue gas from AC systems contain <5 ppm H_2S
- Incineration of flue gas is not required – no SO_2 emissions
- Conversion of sulfide ions is very fast (<1 sec) – no dissolved sulfide ions

Effluent Streams

- Conventional Unit
  - Oxidizer Flue Gas: Saturated air stream with ~ 18% O_2 and some CO_2 if present in feed gas – NO H_2S!
- Autocirculation Unit
  - Flue gas: saturated gas stream of air and CO_2 with < 5 ppm H_2S & no SO_2
- 65 wt.% Sulfur Cake
- Liquid Streams: NONE!

Safety

- Ambient temperature operation
  - No burner
  - No hot surfaces
- Mild alkaline solution
  - pH's in the low 8's
  - No spent caustic streams

Sulfur in Agriculture

Sulfur in Agriculture

- Sulfur performs three important functions in agriculture
  - As a soil conditioner for pH adjustment
  - As a nutrient
  - As a fungicide
- Often referred to as the fourth macronutrient (P, K & N_2)
  - Component of protein, which is essential for chlorophyll formation

Sulfur as a Soil Conditioner

- Sulfur is converted to $SO_4^=$ by microbial action, which lowers the pH of the soil
- Ability of plants to consume nutrients is dependent on soil pH.
- The plant uptake of macronutrients and most micronutrients is optimized at pH's between 6.5 & 7.0

Macronutrients

- Nitrogen: Essential for chlorophyll formation
- Phosphorus: Root formation, early growth & photosynthesis
- Potassium: Resistance to disease, quality size of crops

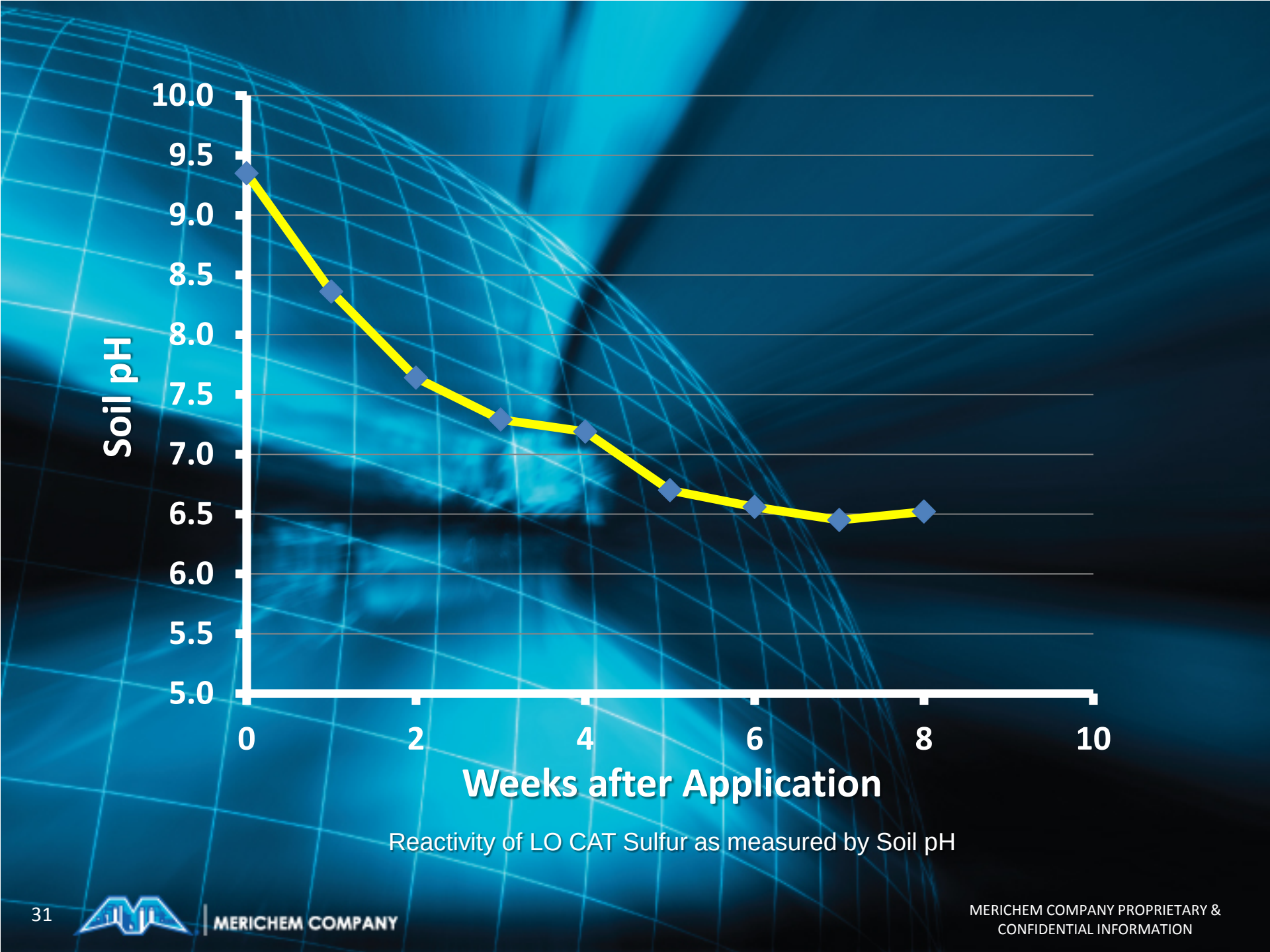
LO CAT Sulfur in Agriculture

LO CAT Sulfur in Agriculture

- LO CAT sulfur cake is composed of small (8 – 45 µ) particles
- Contains ~35 % moisture – no dusting problems
- Porous particles – large internal & external surface areas

LO CAT Sulfur in Agriculture

- Rate of microbial conversion to $SO_4^=$ - directly proportional to particle surface area
- Claus sulfur takes 1 to 3 years to be completely converted to $SO_4^=$
- LO CAT sulfur is completely converted to $SO_4^=$ in ~45 days



Reactivity of LO CAT Sulfur as measured by Soil pH

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Disclaimer

- For any liquid–based sulfur recovery system generating solid sulfur, toxic or hazardous compounds in the inlet gas stream, such as hydrogen cyanide, aromatics, etc., may contaminate the sulfur product. Consequently, before employing any solid sulfur product as a soil additive, it is imperative that the material be analyzed for possible contamination.

LO CAT®
The Green Solution to Sulfur Recovery

- AutoCirculation design has a small carbon footprint
- No liquid waste streams requiring treatment & disposal
- Sulfur cake has no dissolved H_2S requiring removal
- LO CAT achieves very high removal efficiencies (>99.9%)
- LO CAT sulfur cake has been employed as an excellent soil conditioner, fertilizer and fungicide