



Li-Cycle[®]

LI - CYCLE HUB PROJECT

August 6, 2021

PRODUCTS & REAGENTS – DUST POTENTIAL – REVISED FOR SEQP



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- Review of dusting potential from products and reagents that will be used at Hub
- Three categories considered in this presentation:
 - **Wet feed/products/reagents**
 - **Dry products/reagents**
 - **Wet solid waste**



Wet Feed

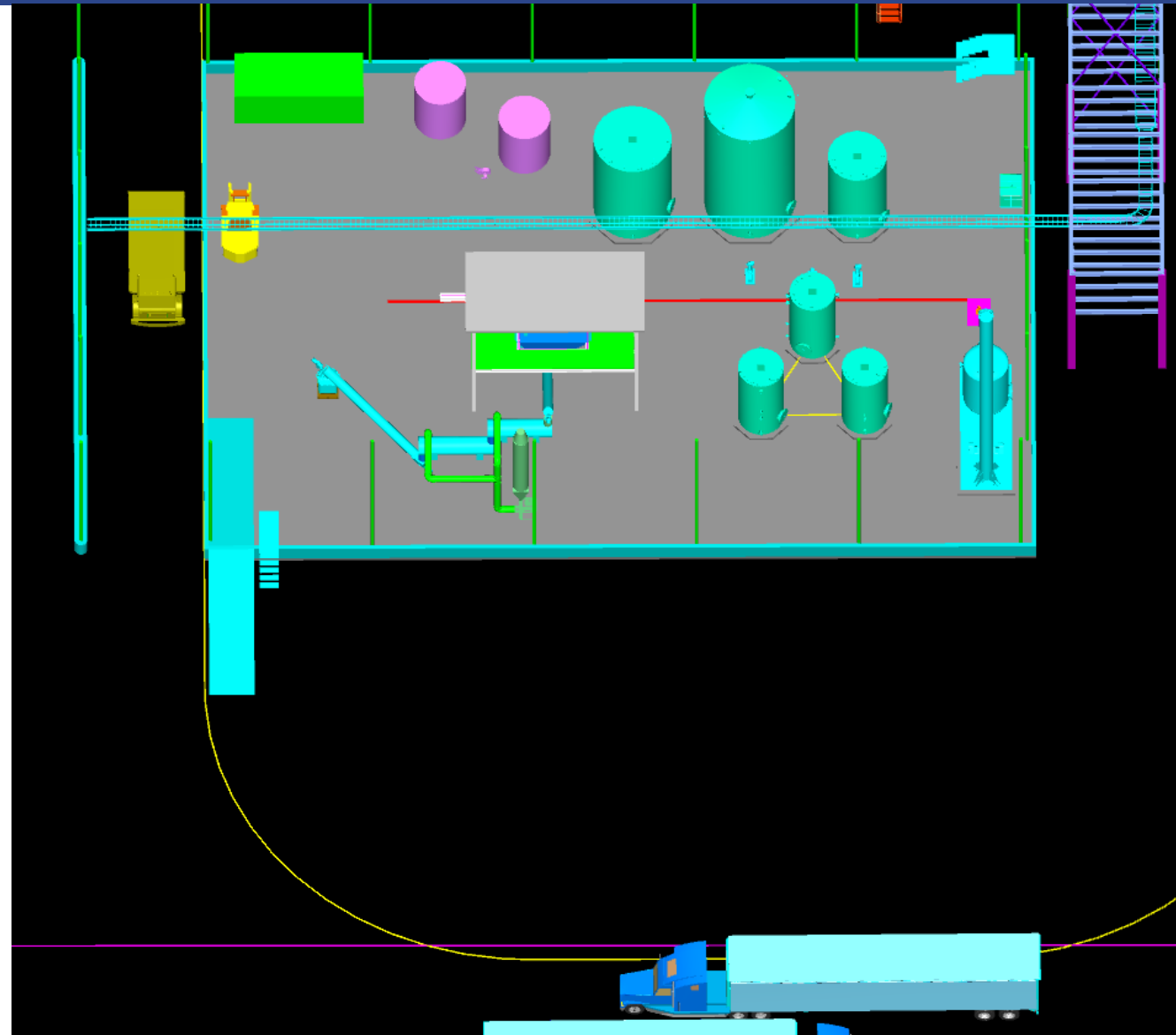
- Black mass concentrate

Wet Products

- Copper sulfide
- Gypsum
- Manganese carbonate

Dry Products

- Graphite concentrate
- Cobalt sulfate heptahydrate
- Nickel sulfate hexahydrate
- Anhydrous sodium sulfate
- Lithium carbonate





Wet Reagents

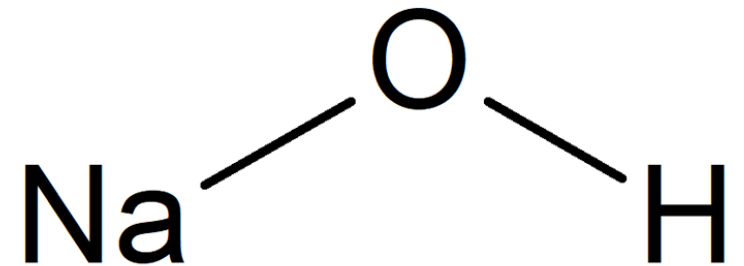
- Sulfuric acid
- Sodium hydroxide
- Hydrogen peroxide
- Solvent extraction diluent
- Solvent extraction extractants
- Solvent extraction modifiers
- Liquified oxygen
- Liquified carbon dioxide

Dry Reagents

- Sodium hydrosulfide hydrate
- Calcium oxide (Quicklime)
- Sodium carbonate (Soda Ash)

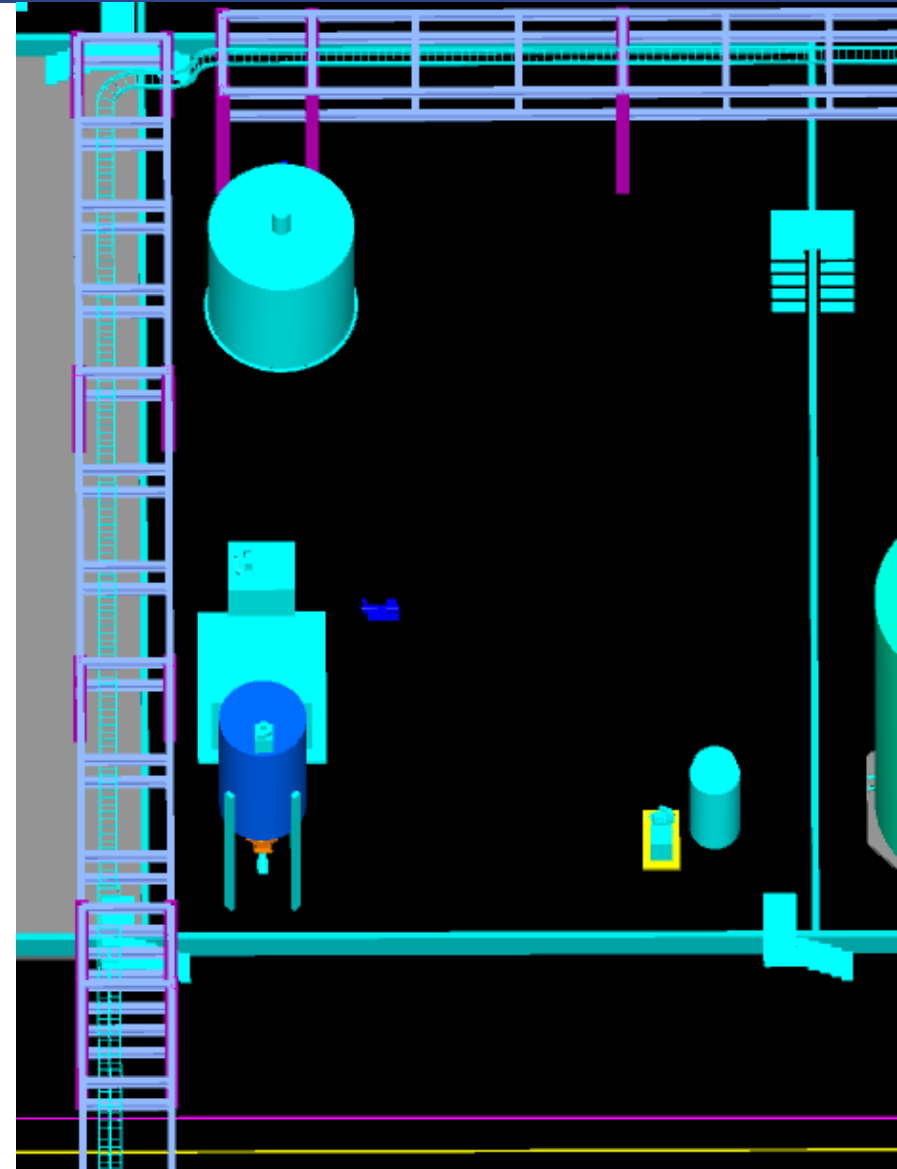
Wet Solid Waste

- Bleed Treatment residue





- This presentation will focus primarily on dry reagents and products due to their potential for dust generation.
 - Sodium hydrosulfide hydrate
 - Calcium oxide (quicklime)
 - Sodium carbonate (soda ash)
 - Cobalt sulfate heptahydrate
 - Nickel sulfate hexahydrate
 - Anhydrous sodium sulfate
 - Lithium carbonate
 - Graphite concentrate



DUST EXPLOSION



- Most organic and some inorganic dusts can be combustible and/or explosive
- Common examples include:
 - Grain
 - Starch
 - Flour
 - Sugar
 - Coal
 - Wood
 - Plastics
 - Rubbers
 - Pharmaceuticals
 - Some metals
- Over 80% of combustible dust events are fires that do not result in explosions





The key to preventing combustible dust fires and explosions is to control accumulation of fugitive dusts

Four conditions are required for a dust fire:

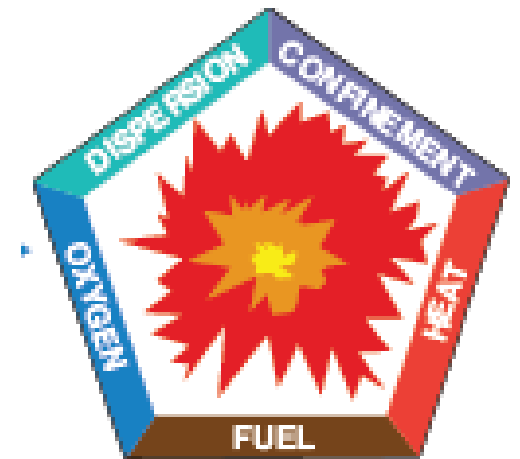
1. Dust particle must be **combustible**
2. Source of **ignition**
3. Dust must be **suspended** in air with sufficient concentration
4. **Oxygen** must be present

A fifth condition is required for a dust explosion:

5. Dust must be in a confined space



Fire Triangle



Explosion Pentagon



- Many dusts are confirmed carcinogens, for example:
 - Asbestos
 - Free crystalline silica
 - Hexavalent chromium
 - Arsenic (elemental and inorganic compounds)
 - Certain nickel-bearing dusts
- Soluble carcinogens may pose a risk to both lungs and other organs
- Dust particles that remain for a long time have increased potential to cause disease.

WHO/SDE/OEH/99.14

- Potentially carcinogenic dusts at Hub:
 - Nickel sulfate $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$
 - Cobalt sulfate $\text{CoSO}_4 \cdot 7\text{H}_2\text{O}$

Li-Cycle Mitigations

- A wet (hydrometallurgical) process
- Emission control devices (wet scrubbers)
- Large particle size
- Good housekeeping
- Training & procedures.
- Hygiene monitoring (as required)



- Non-combustible/Non-explosive/Non-carcinogenic:
 - Calcium oxide (quicklime),
 - Sodium carbonate (soda ash)
 - Anhydrous sodium sulfate
 - Lithium carbonate
- Combustible/Explosive:
 - Sodium hydrosulfide hydrate
 - Graphite concentrate
- Non-Combustible/Non-Explosive; but Potentially Carcinogenic:
 - Cobalt sulfate heptahydrate
 - Nickel sulfate hexahydrate



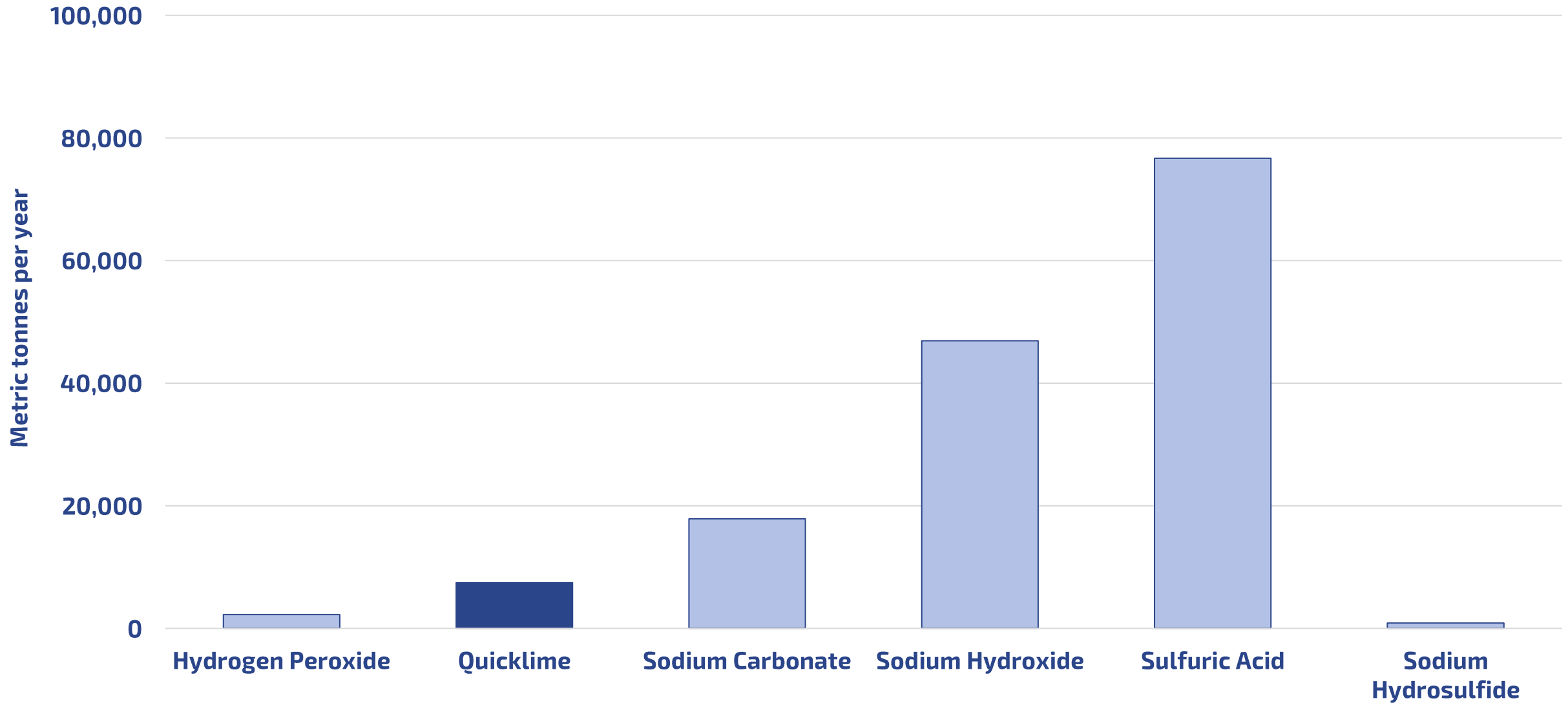


**N O N - C O M B U S T I B L E ,
N O N - E X P L O S I V E ,
N O N - C A R C I N O G E N I C**



CALCIUM OXIDE (QUICKLIME)

REAGENT USAGE (Average)





Physical Properties

- Molecular form: CaO
- White solid powder or pebble
- Relative density: 3.2
- PSD: TBC



Potential to Generate Dust?

- Yes, delivered in powdered form
- Not flammable or combustible
- Not listed in NFPA 499, 2013 Ed.

Dust Mitigations

- Pneumatic rail car unloading
- Silo with dust filter
- Screw conveying to process (not pneumatic)



CALCIUM OXIDE (QUICKLIME)



CALCIUM OXIDE (QUICKLIME)

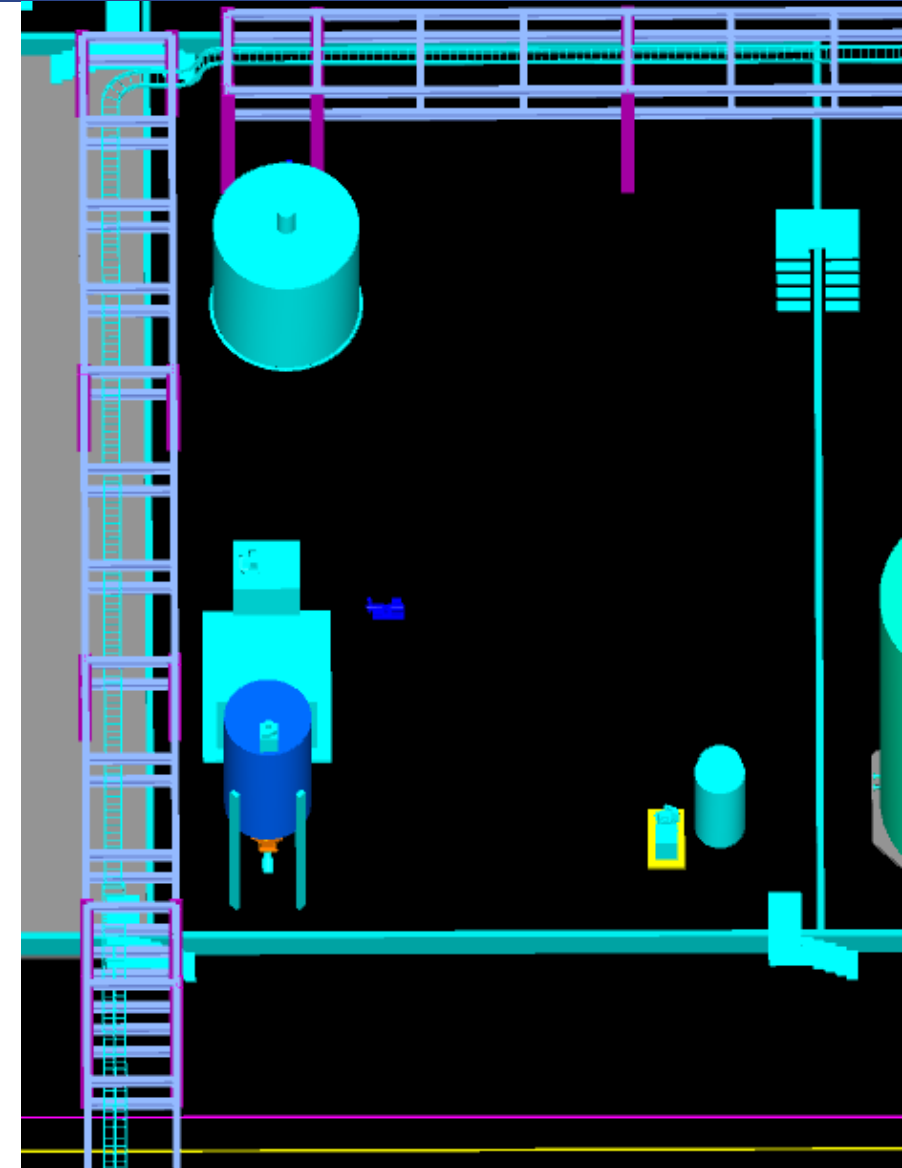


Bulk Delivery

- Rail delivery: 100 tons each car
- Hopper car
- Roughly 1.8 railcars per week
- Unloaded by a contained/enclosed pneumatic conveying system

Bulk Storage

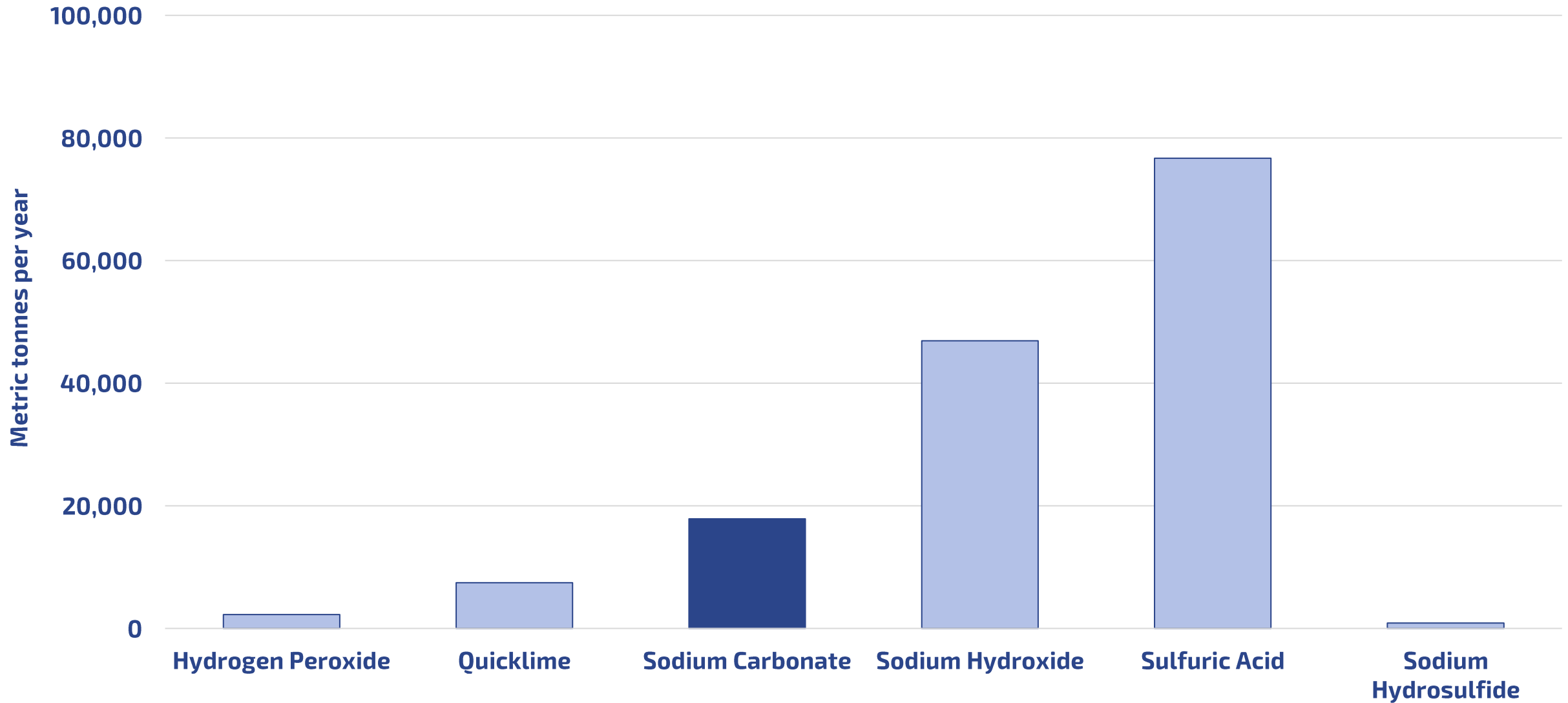
- One (1) bulk storage silo
- Larger of 150 tonnes or 7 days
- Storage silo equipped with dust control





SODIUM CARBONATE (SODA ASH)

REAGENT USAGE (Ave)





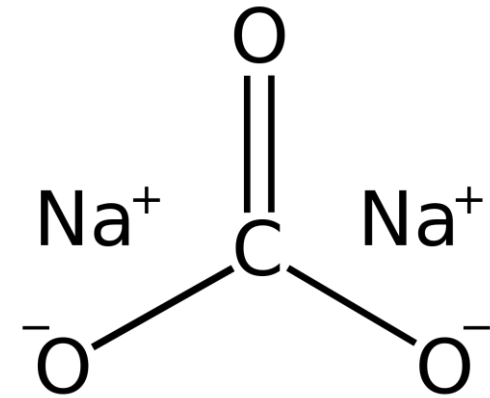
Physical Properties

- Molecular form: Na_2CO_3
- White solid powder
- Relative density: 3.2
- PSD: 85% @ 150 micron



Potential to Generate Dust?

- Yes, delivered in powdered form
- Not flammable or combustible
- Dried with direct flame
- Not listed in NFPA 499, 2013 Ed.



Dust Mitigations

- Pneumatic rail car unloading
- Silo with dust filter
- Screw conveying to process (not pneumatic)

SODIUM CARBONATE (SODA ASH)

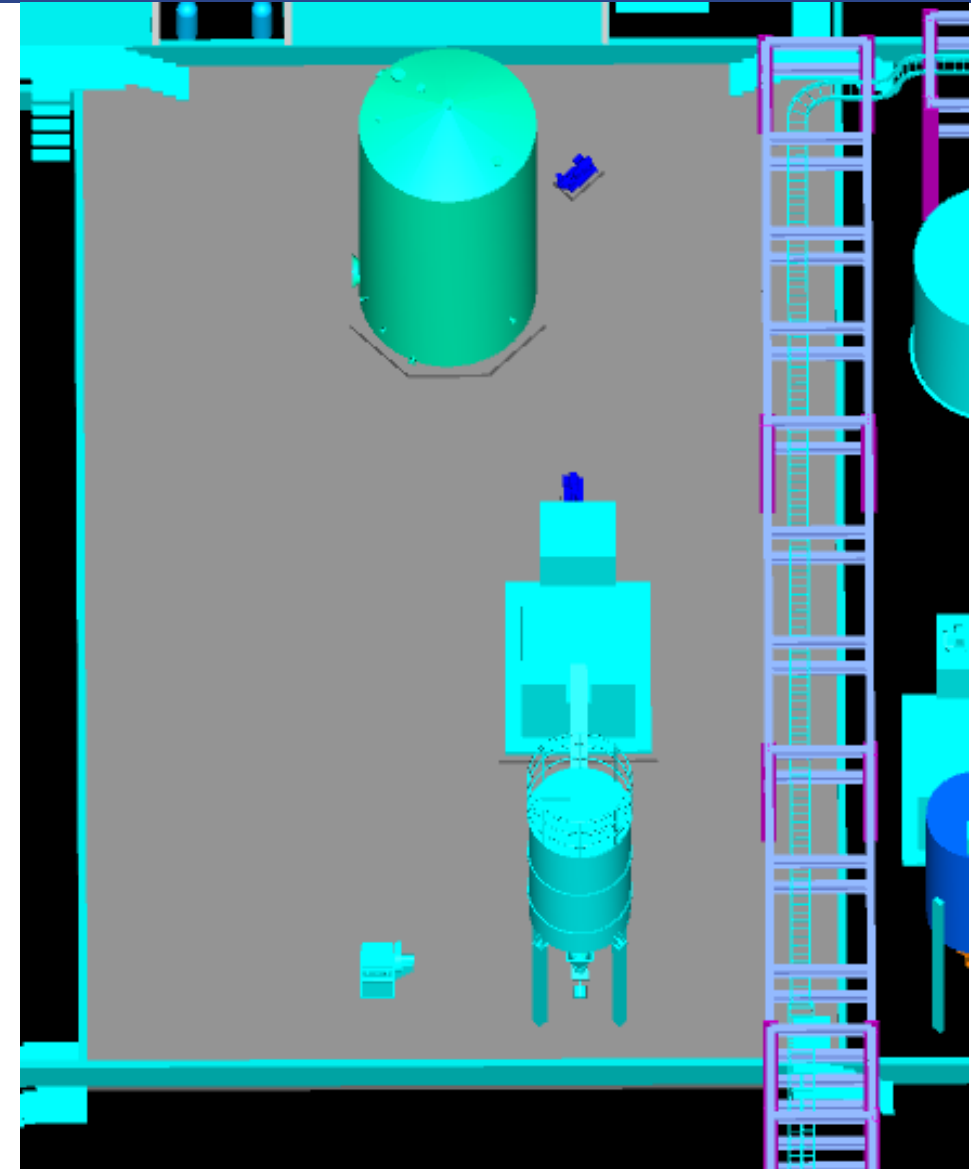


Bulk Delivery

- Rail delivery: 100 tons each car
- Hopper car
- Roughly 4.5 railcars per week
- Unloaded by enclosed pneumatic conveying system

Bulk Storage

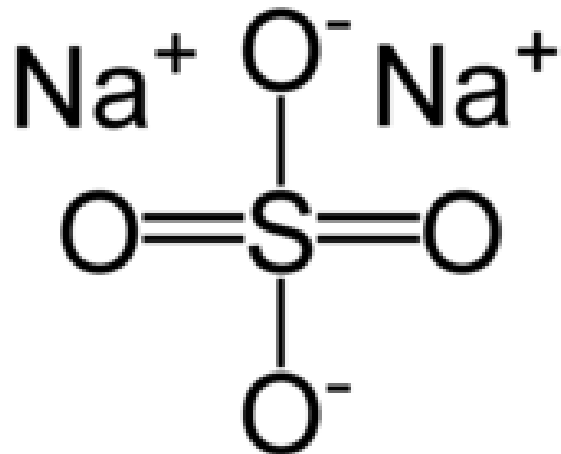
- One (1) bulk storage silo
- Larger of 300 tonnes or 5 days





Physical Properties

- Molecular form: Na_2SO_4
- Solid crystalline material, white
- SG: 2.0
- PSD: 0.2 mm to 1.2 mm



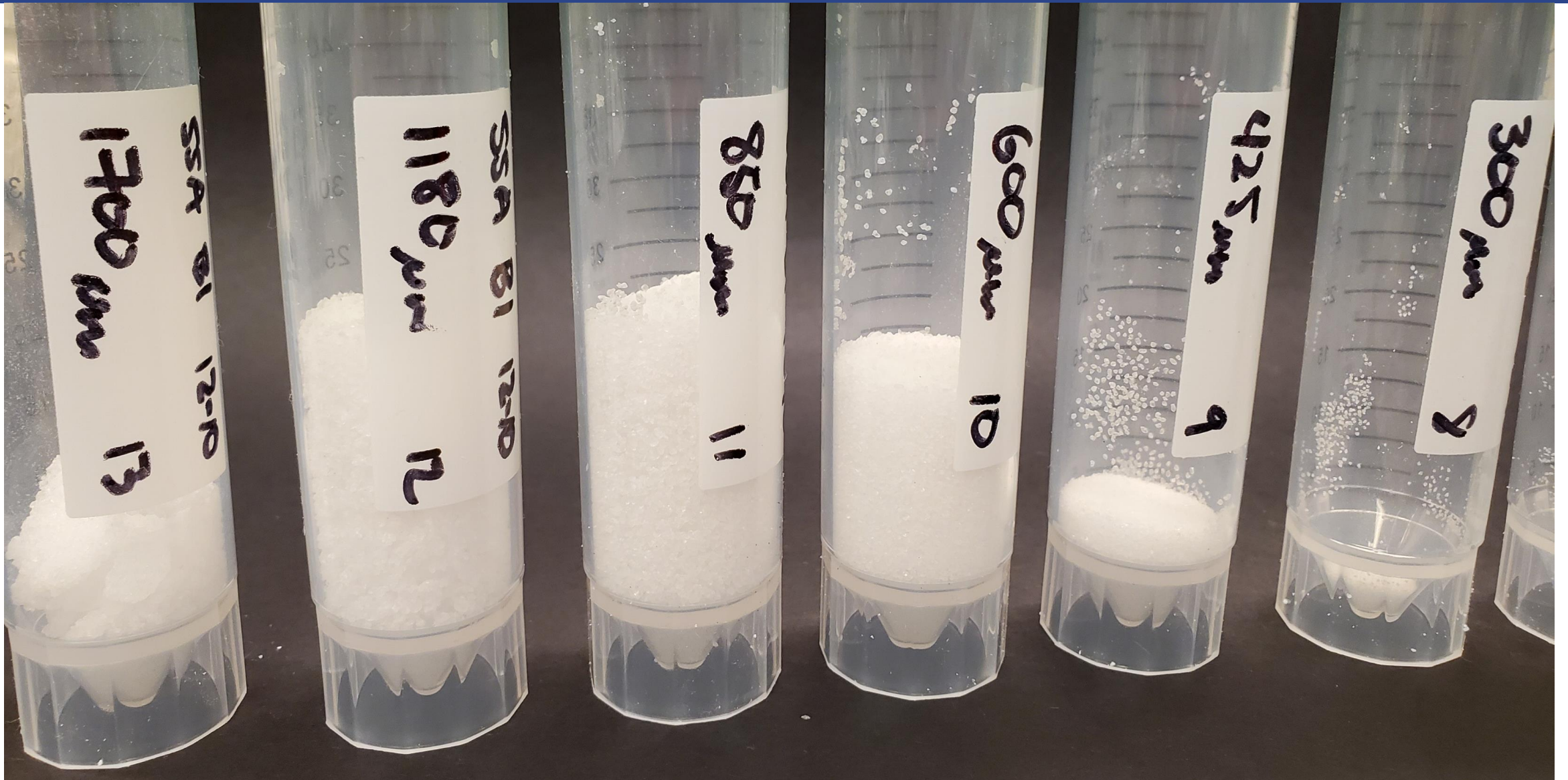
Potential to Generate Dust?

- Yes, but unlikely
- Not flammable or combustible
- Not listed in NFPA 499, 2013 Ed.

Dust Mitigations

- Large PSD
- Loading equipment contained
- Screw conveyed and pneumatic conveyed
- Control devices utilized, as required (baghouse on dryer, filter on silos)

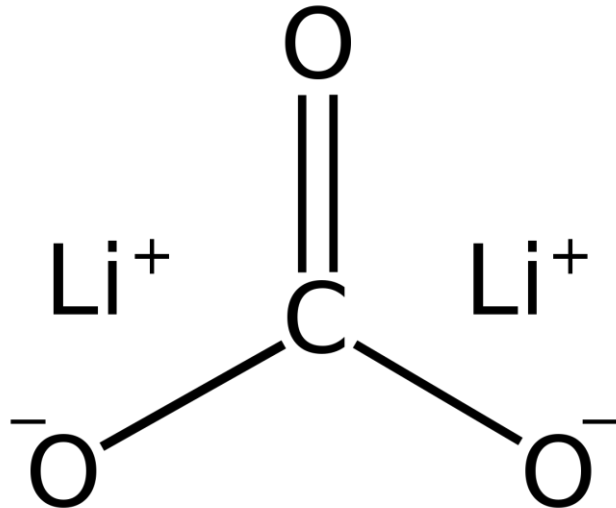
ANHYDROUS SODIUM SULFATE





Physical Properties

- Molecular form: Li_2CO_3
- Solid crystalline material, white
- SG: 2.0
- PSD: 25 micron to 200 micron



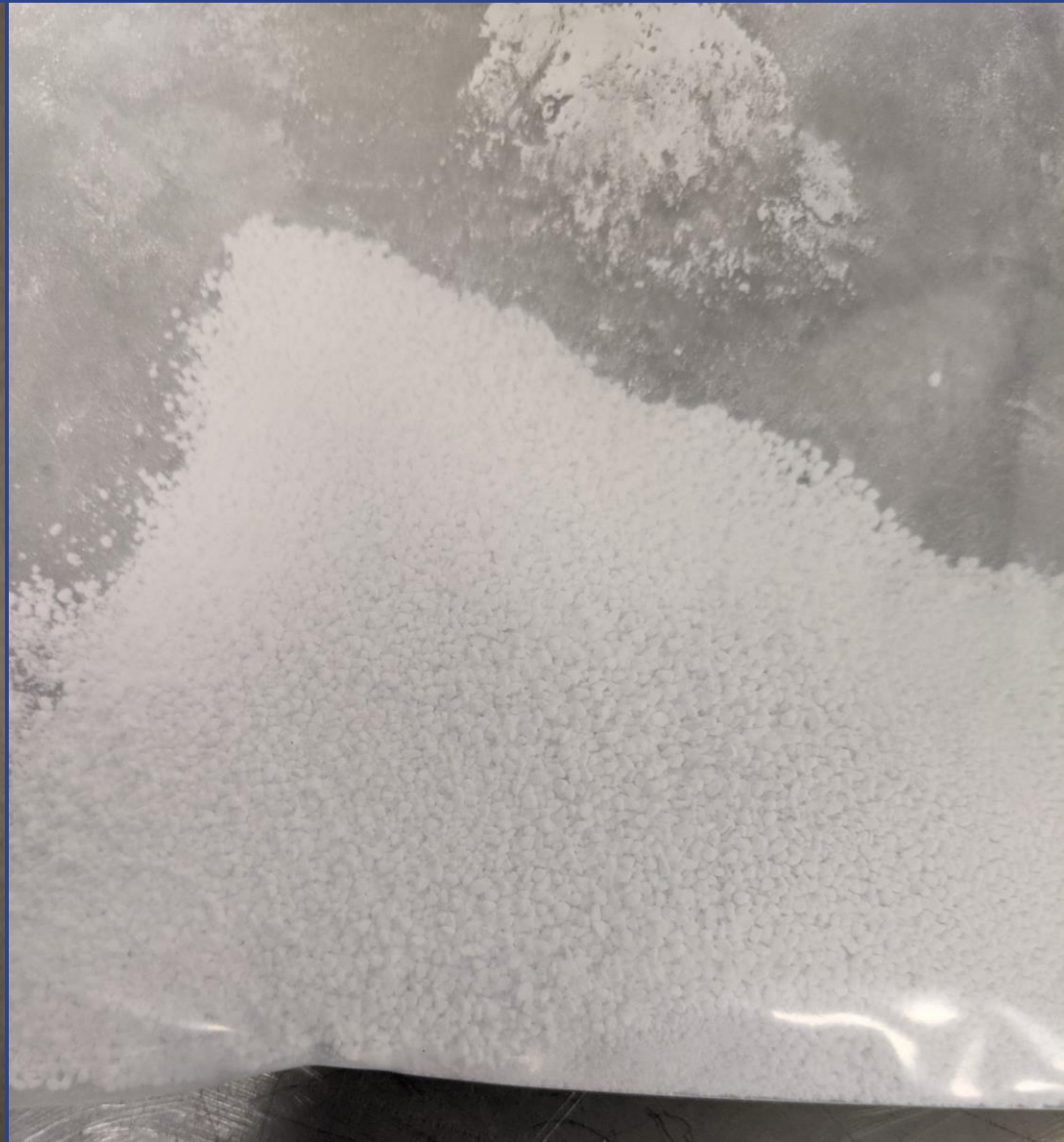
Potential to Generate Dust?

- Yes
- Not flammable or combustible
- Not listed in NFPA 499, 2013 Ed.

Dust Mitigations

- Bulk bag loading equipment contained
- Roll compaction to increase PSD of ~40% of product
- Screw conveying (not pneumatic)
- All equipment connected to control device

LITHIUM CARBONATE





COMBUSTIBLE, EXPLOSIVE



GRAPHITE CONCENTRATE



Physical Properties

- Molecular form: C-C
- Black solid powder
- Relative density: 3.2
- PSD: 85% @ 15 micron



Potential to Generate Dust?

- Yes, in powdered form
- Will be dried in a steam dryer to low moisture content
- Combustible at high temperatures when finely dispersed in air.
- Autoignition point: 572°F

Dust Mitigations

- Steam dryer installed outdoors
- Fully contained conveyor
- All equipment connected to control device (baghouse)
- Bagging plant in separate building room



Li-Cycle Mitigation

Emissions Control Device

- Bag filter (also known as a “baghouse”)
- Removes particulate matter by passing air stream through fabric bags
- All equipment associated with drying and bagging graphite concentrate will be connected to the bag filter
- The bag filter fan will “pull” air containing dust from the equipment through the filter bags
- This ensures all potential dust are captured before discharging clean air to the environment
- No ignition sources inside bag filter (prior to dust being extracted from air)





Graphite powder is used in fire extinguishers

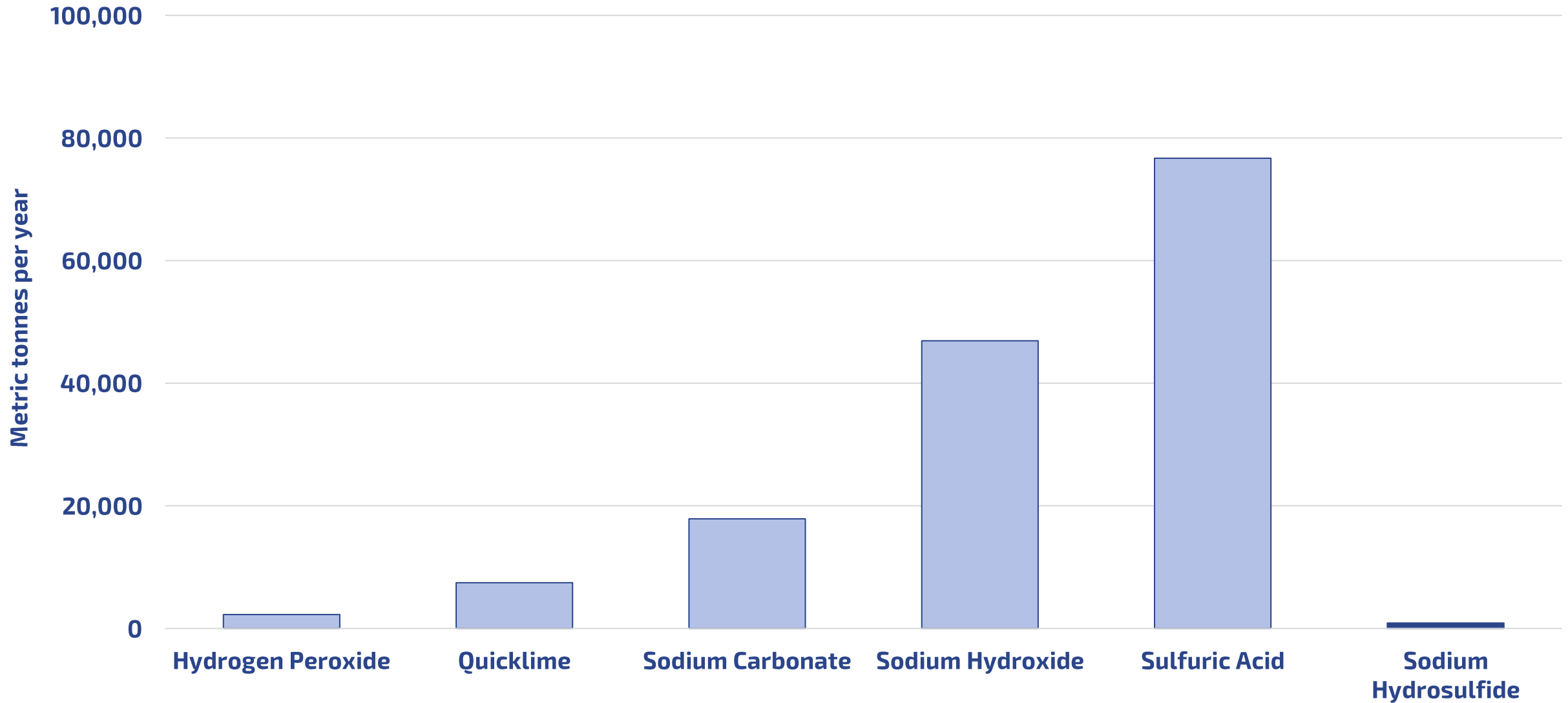
- Class D fires - combustible of metals, such as aluminum, titanium, magnesium, lithium, zirconium, sodium, and potassium.
- Class D fire extinguishers use **dry graphite powder** or granular sodium chloride.
- These extinguishers work by smothering the fire and eliminating the oxygen element.
- Very specific conditions are required (i.e., high temperature and fine dispersion) for graphite powder dust to combust.





SODIUM
HYDROSULFIDE
HYDRATE

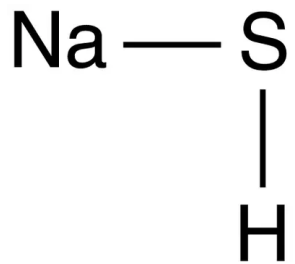
REAGENT USAGE (Ave)





Physical Properties

- Molecular form: $\text{NaHS} \cdot 2\text{H}_2\text{O}$
- Solid (flake) material, yellow
- Relative density: 1.8
- PSD: *See next slide*



Potential to Generate Dust?

- Yes, but unlikely
- Dust / powder can form explosive mixtures with air
- Not listed in NFPA 499, 2013 Ed.

Dust Mitigations

- Dedicated storage area for sodium hydrosulfide hydrate bulk bags
- Flaked product (large PSD) shipped in bulk bags
- Bulk bag unloading equipment
- All equipment connected to control device (wet scrubber)

SODIUM HYDROSULFIDE HYDRATE



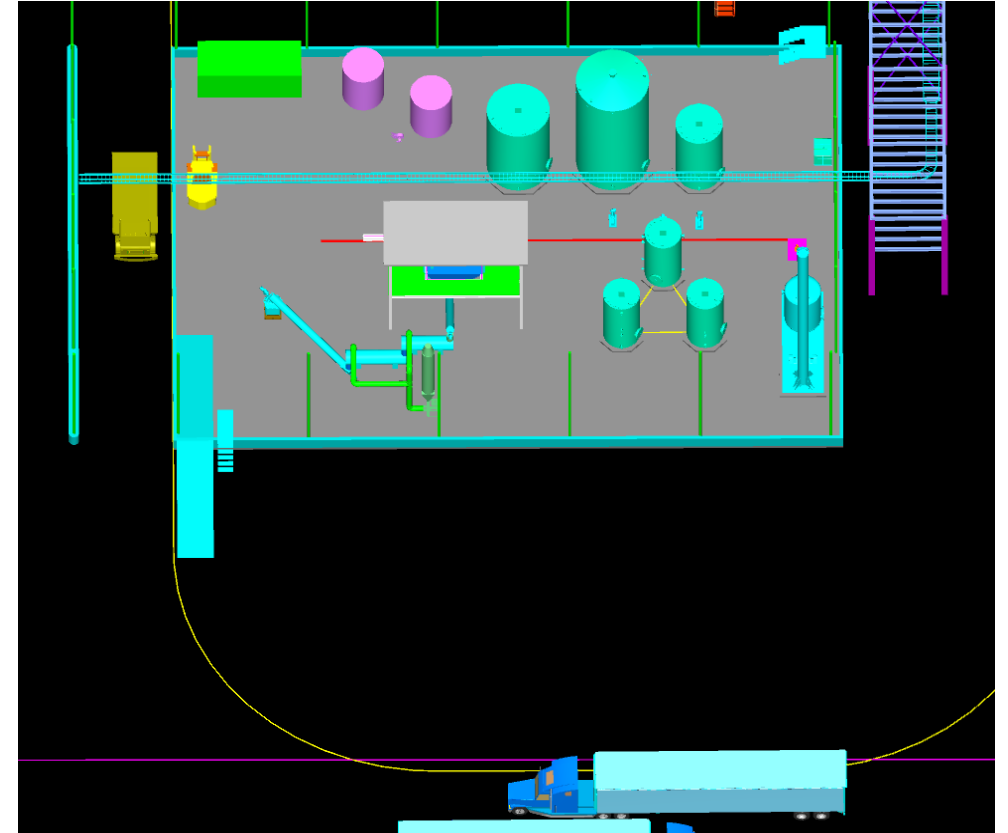


Bulk Delivery

- Truck delivery: 1 ton bags (~24 bags per ISO container)
- Roughly ½ truck per week
- Fully contained bag breaking system
- **All equipment connected to emissions control device (i.e., caustic scrubber)**

Bulk Storage

- Batch tank
- 30 hrs (maximum 3,500 gallons)
- No incompatible chemicals stored in, or passing through, sodium hydrosulfide area.
- Equipment will be constructed in secondary containment.



SODIUM HYDROSULFIDE HYDRATE

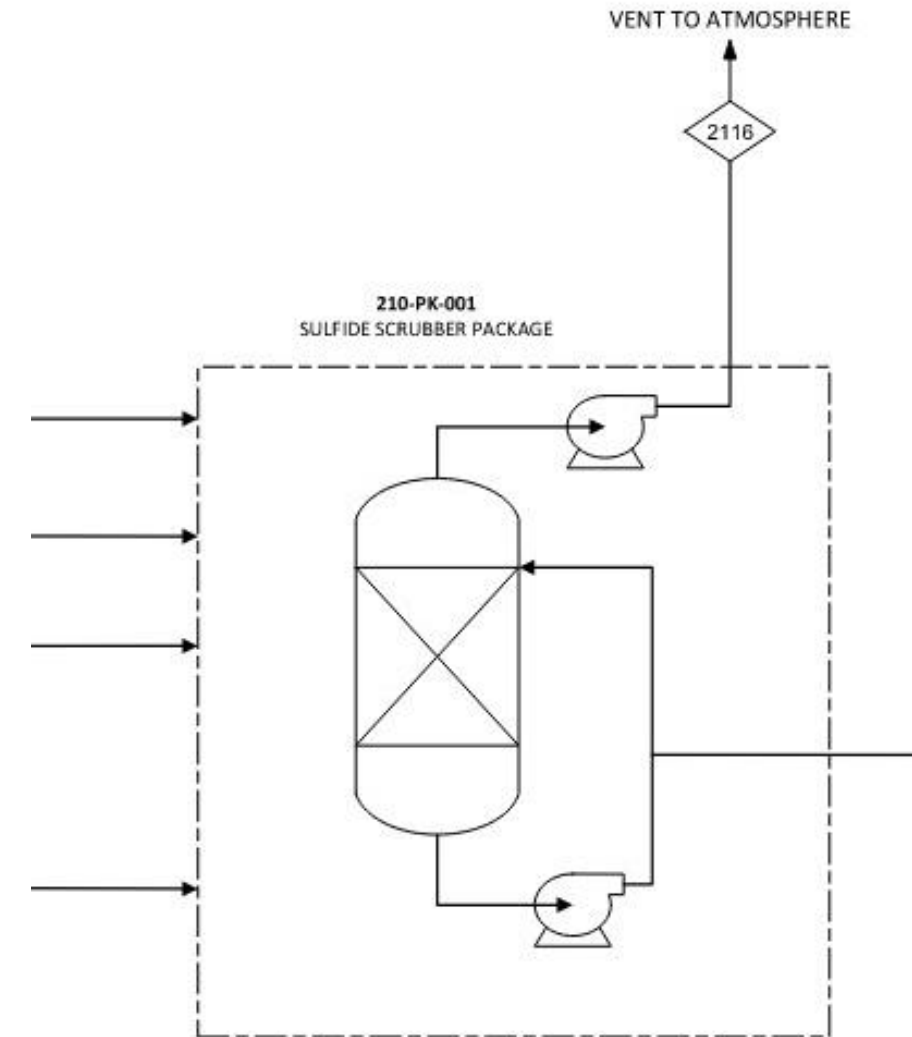




Li-Cycle Mitigation

Emissions Control Device

- Packed bed / venturi scrubber (i.e., wet scrubber)
- All equipment that has a gas headspace will be connected to the wet scrubber in the sodium hydrosulfide area
- Tanks and equipment will operating under a slight negative pressure
- The wet scrubber fan will “pull” gas and dust from tanks and equipment
- This ensures all gases and potential dust are treated / neutralized by the wet scrubber system





NON-COMBUSTIBLE,
NON-EXPLOSIVE,
POTENTIALLY CARCINOGENIC



Physical Properties

- Molecular form: $\text{CoSO}_4 \cdot 7\text{H}_2\text{O}$
- Solid crystalline material, red
- Relative density: 1.95
- PSD: 0.2 mm to 2 mm



Potential to Generate Dust?

- Yes, but unlikely
- Not flammable or combustible
- Not listed in NFPA 499, 2013 Ed.
- Possibly carcinogenic to humans

Dust Mitigations

- Large particle size
- Bulk bag loading equipment contained
- Screw conveying (not pneumatic)
- All equipment connected to control device (wet scrubber)



Physical Properties

- Molecular form: $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$
- Solid crystalline material, green
- SG: 2.0
- PSD: 0.2 mm to 2 mm



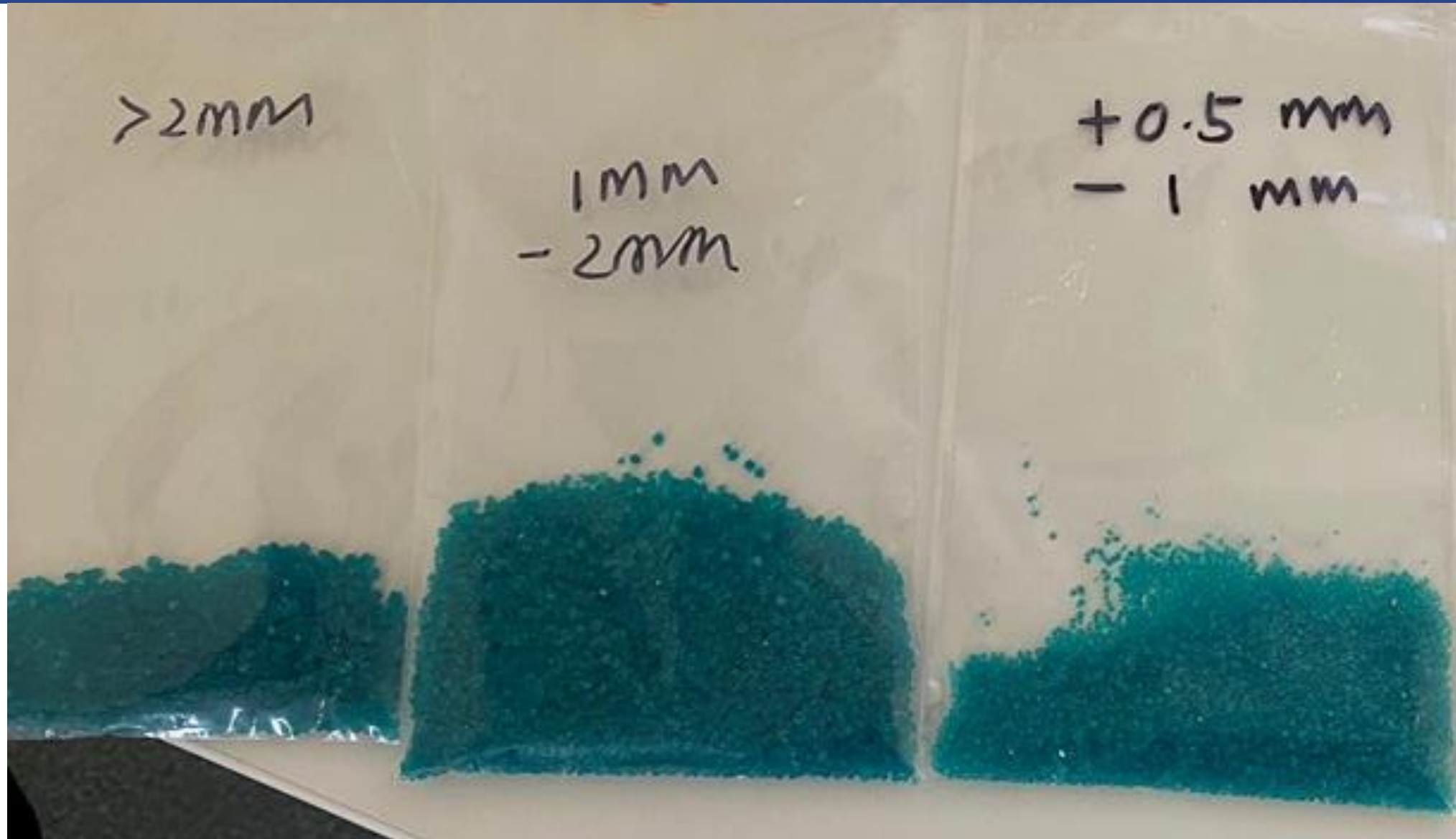
Potential to Generate Dust?

- Yes, but unlikely
- Not flammable or combustible
- Not listed in NFPA 499, 2013 Ed.
- Human carcinogen. May cause cancer by inhalation.

Dust Mitigations

- Large particle size
- Bulk bag loading equipment contained
- Screw conveying (not pneumatic)
- All equipment connected to control device (wet scrubber)

NICKEL SULFATE HEXAHYDRATE





NON-DUSTING PRODUCTS



Products shipped as wet cakes

- Copper sulfide
- Gypsum
- Manganese carbonate

Solid waste shipped wet

- Bleed treatment residual
- Minimum 1% moisture expected

Potential to Generate Dust?

- No, all products contain minimum 12% wt water
- Bleed treatment residual will contain minimum 1% wt moisture

