Nevada Mining Association/ NIOSH Silica Dust Control Workshop for Metal/Nonmetal Mining

Elko, Nevada

Dust Control in Mineral Processing Operations

Tuesday, Sept. 28, 2010

Andrew B. Cecala
Senior Research (Mining) Engineer

CDC Workplace Safety and Health

National Institute for Occupational Safety and Health NIOSH

1977 Federal Mine Safety and Health Act

Sec 3. “Congress declares that (a) the first priority and concern of all in the coal or other mining industry must be the health and safety of it’s most precious resource - - the miner;”

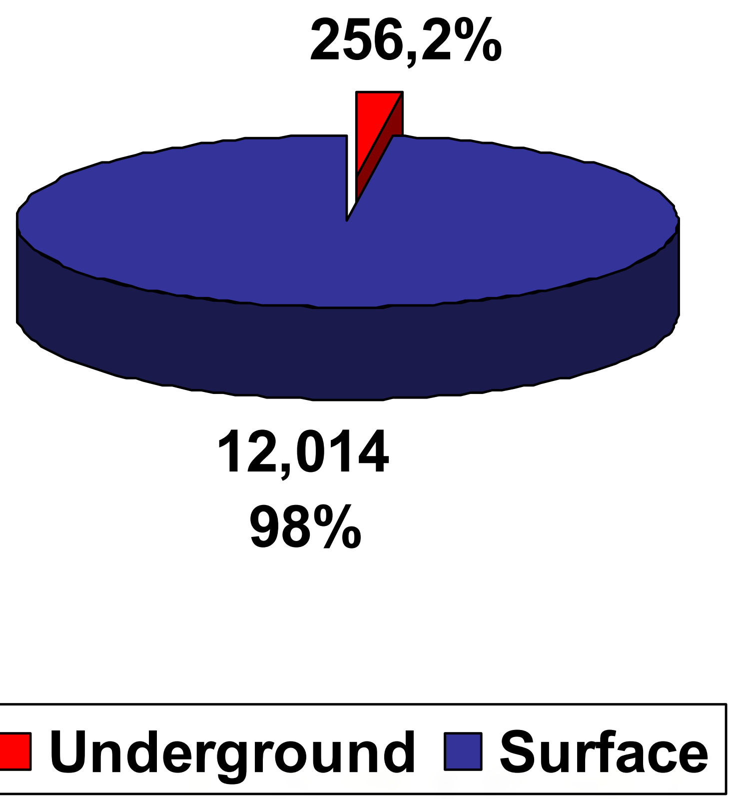
100 YEARS NIOSH Mining Research 1910 2010 Promises made ★ Promises kept

Engineering Control Technology

Reducing workers exposure to silica/other respirable dust in underground and surface metal/nonmetal operations.

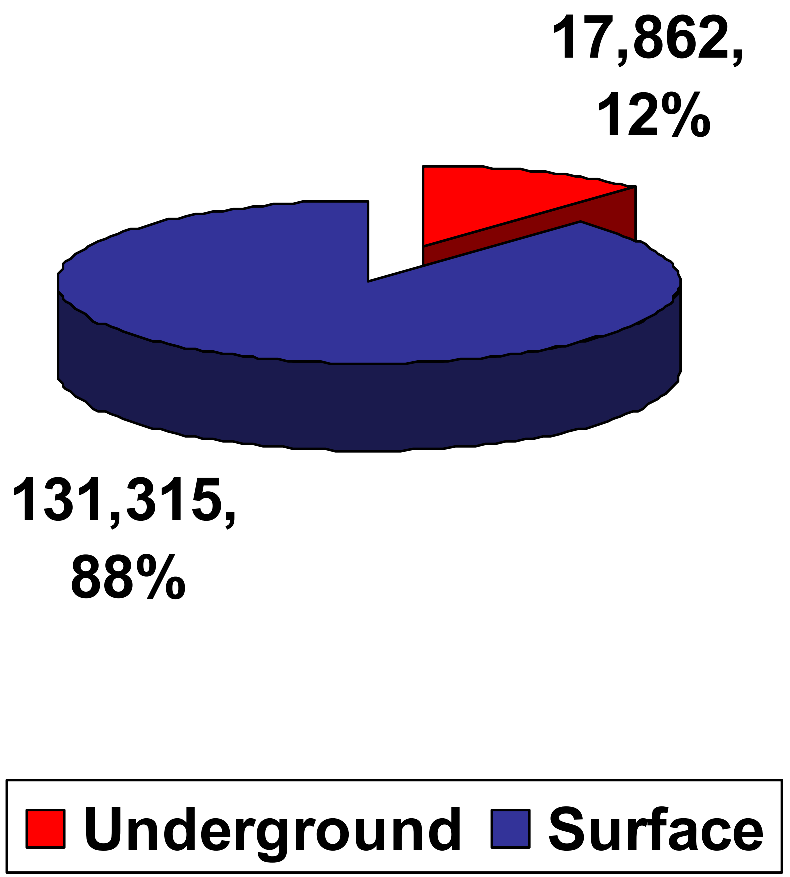
Operations

Metal/Nonmetal, Stone, and Sand & Gravel (2007)



Miners

Metal/Nonmetal, Stone, and Sand & Gravel Miners (2007)



Job Classifications Exceeding Permissible Exposure Limit

2004–2008 MSHA Data

• Stone polisher/cutter	34%
• Bagging operator	26%
• Cleanup man	18%
• Laborer, bullgang	17%
• Utility man	16%
• Dry screen plant operator	16%
• Crusher operator	13%

Maximizing Air Quality in Enclosed Cabs of Mobile Mining Equipment (Construction/Agriculture)

OFFICE OF MINE SAFETY AND HEALTH RESEARCH

Health Study (1996–1997)

8 Different Surface Coal Operations in Pennsylvania

1,236 miners: 6.7% classified 1/0 silicosis

Clearfield County – 213 miners: 16% classified 1/0 silicosis

What Level of Protection is Achieved?

What is the Operator's Level of Protection Inside the Enclosed Cab?

Dust Control Efforts Discussed

Presentation Outline:

- Mineral processing dust control handbook
- Dual-nozzle bag system
- Clothes cleaning system
- Overhead air supply island system (OASIS)
- Push-pull ventilation system
- Bag & belt cleaner device
- Secondary dust sources
- Worker's impact on dust exposure
- Total structure (mill) ventilation system
- Reducing dust levels in iron ore processing operations
- Improving ventilation in turkey barns
- Wet suppression
- Primary dump/conveyors/transfer points
- Foreign work efforts

NIOSH/IMA–NA Mineral Processing Dust Control Handbook

To be patterned after the ACGIH Industrial Ventilation Handbook

OFFICE OF MINE SAFETY AND HEALTH RESEARCH

Handbook Committee Members

Members:

Co–Chairmen: Andy O'Brien, Unimin Corporation

Andy Cecala, NIOSH

John Rounds, Unimin Corporation

Rick Fox, Unimin Corporation

Mark Shultz, Mine Safety and Health Administration

Robert Franta, Spraying Systems Company

Randy Reed, NIOSH

Joe Schall, Technical Writer/Editor, NIOSH

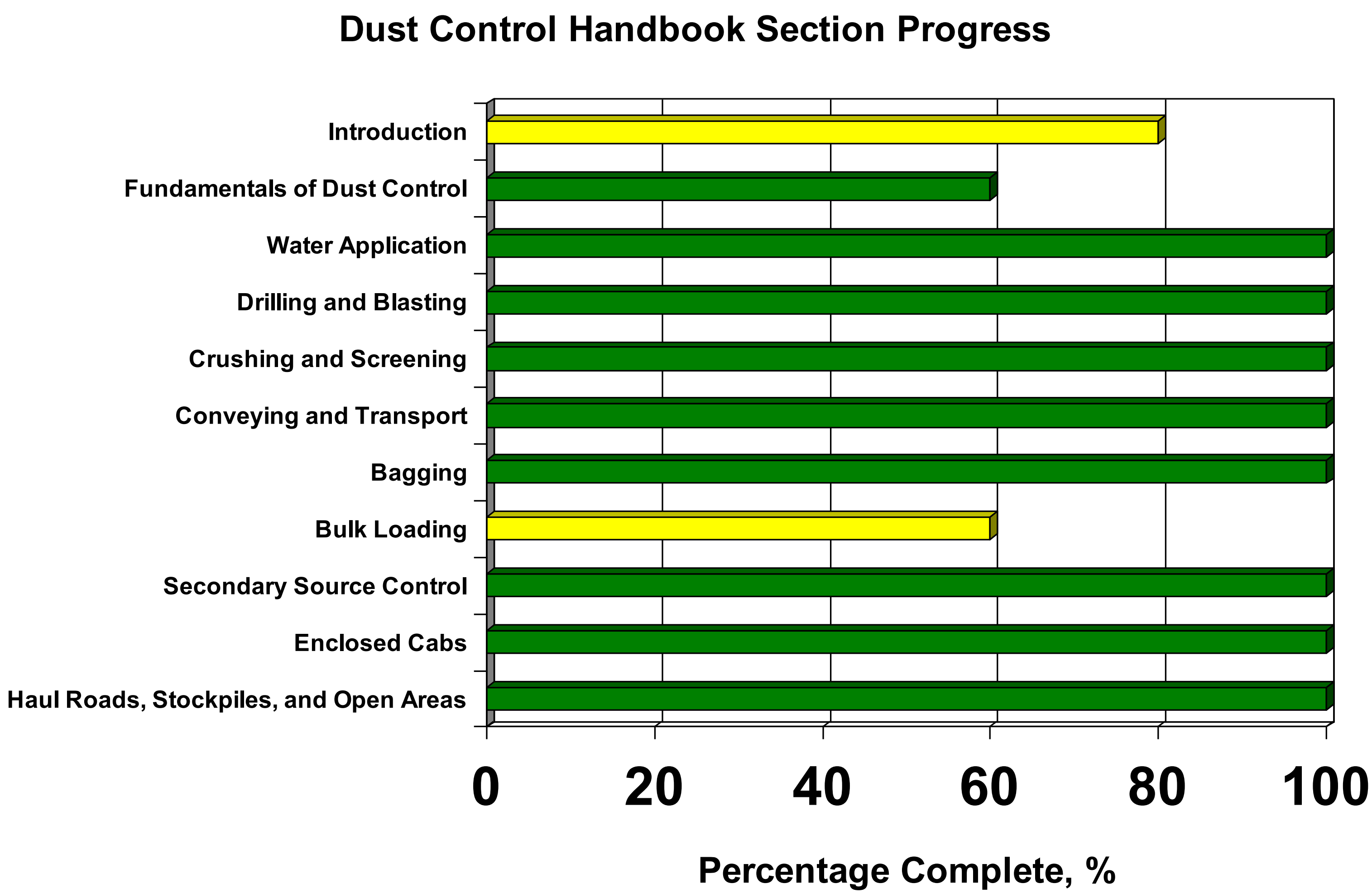
Jerry Joy, NIOSH

Pat Reeser, U.S. Silica Company

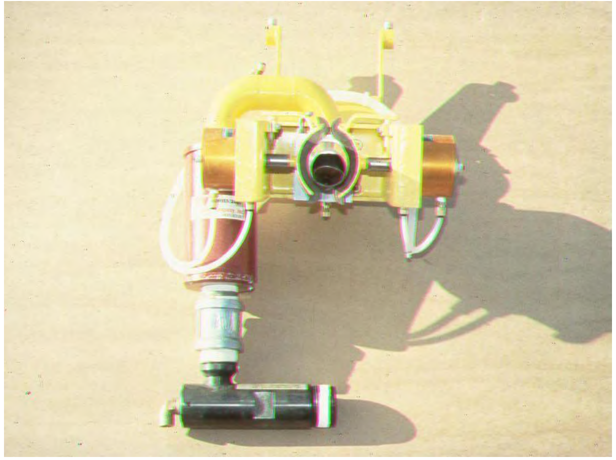
Jay Colinet, NIOSH

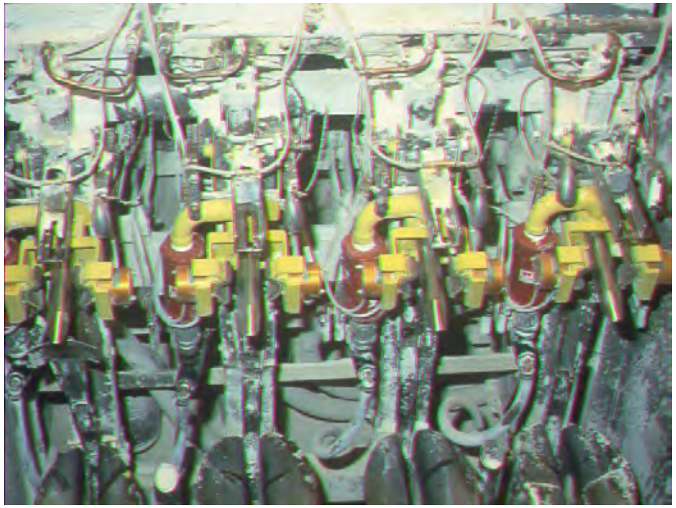
IMA-NA Coordinator: Mark Ellis, President

Handbook Progress



Dual-nozzle Bag System

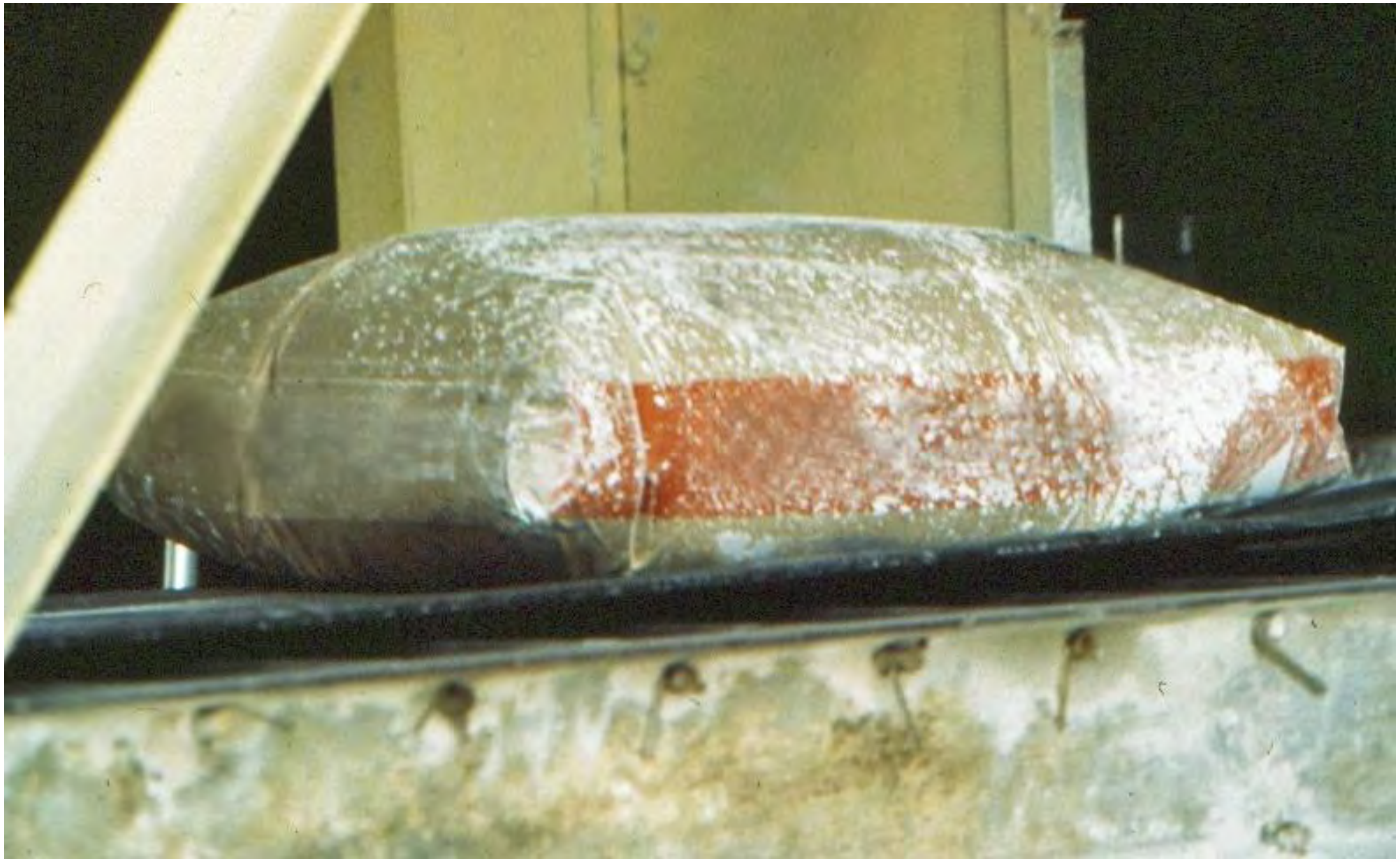




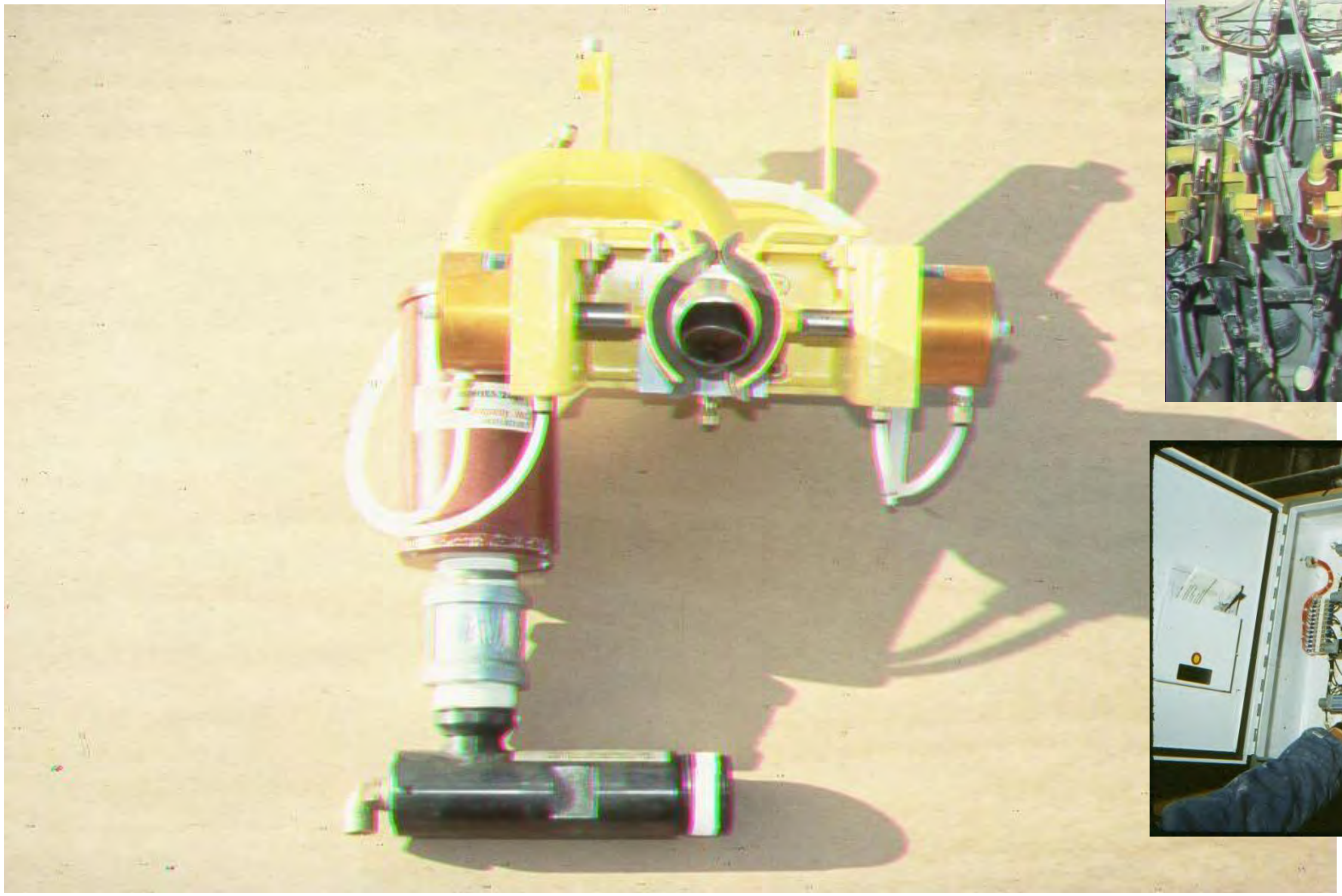
Product Blowback

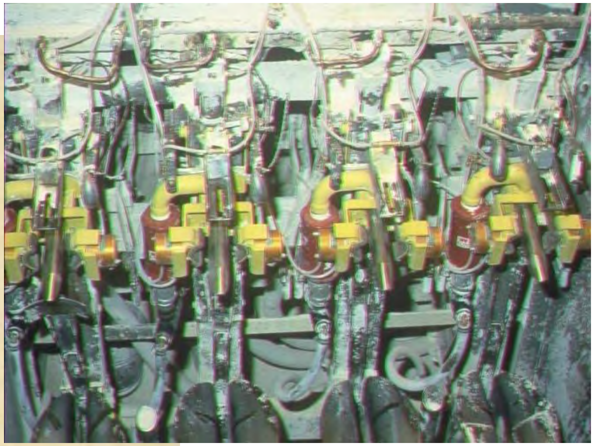
Product Rooster-tail

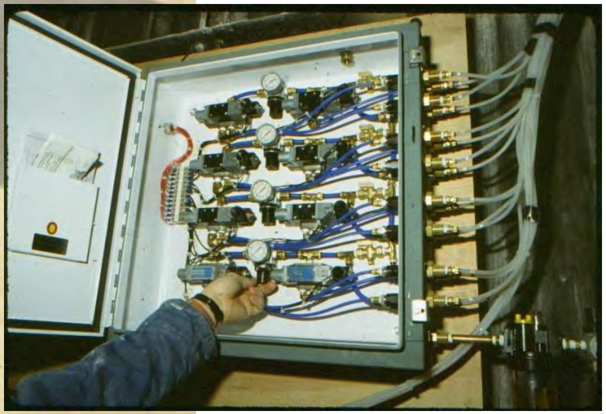
Soiled Bags



Dual-nozzle Design







After filling completed, bag remains on fill nozzle for additional 3-5 seconds. Venturi effect exhausts each bag at 50 cfm.

Dust Reductions

Exhaust: 89%

Transfer: 61%

Intake: 79%

Operator: 83%

Background: 78%

Product Blowback
(Before and After)

Product Rooster-tail (Before and After)

89% reduction

Soiled Bags (Before and After)

78% reduction

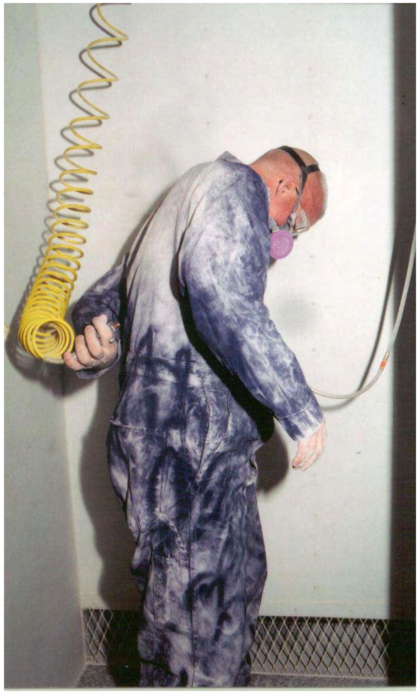
Bag Operator

83% reduction

Key: Depressurize the bag after filling is completed. Technology has been adopted by OEMs.

Clothes Cleaning System

A safe and effective method for removing dust from work clothes



Clothes Cleaning Video link

http://www.cdc.gov/niosh/mining/products/product21.htm

Cleaning Booth

Vacuuming

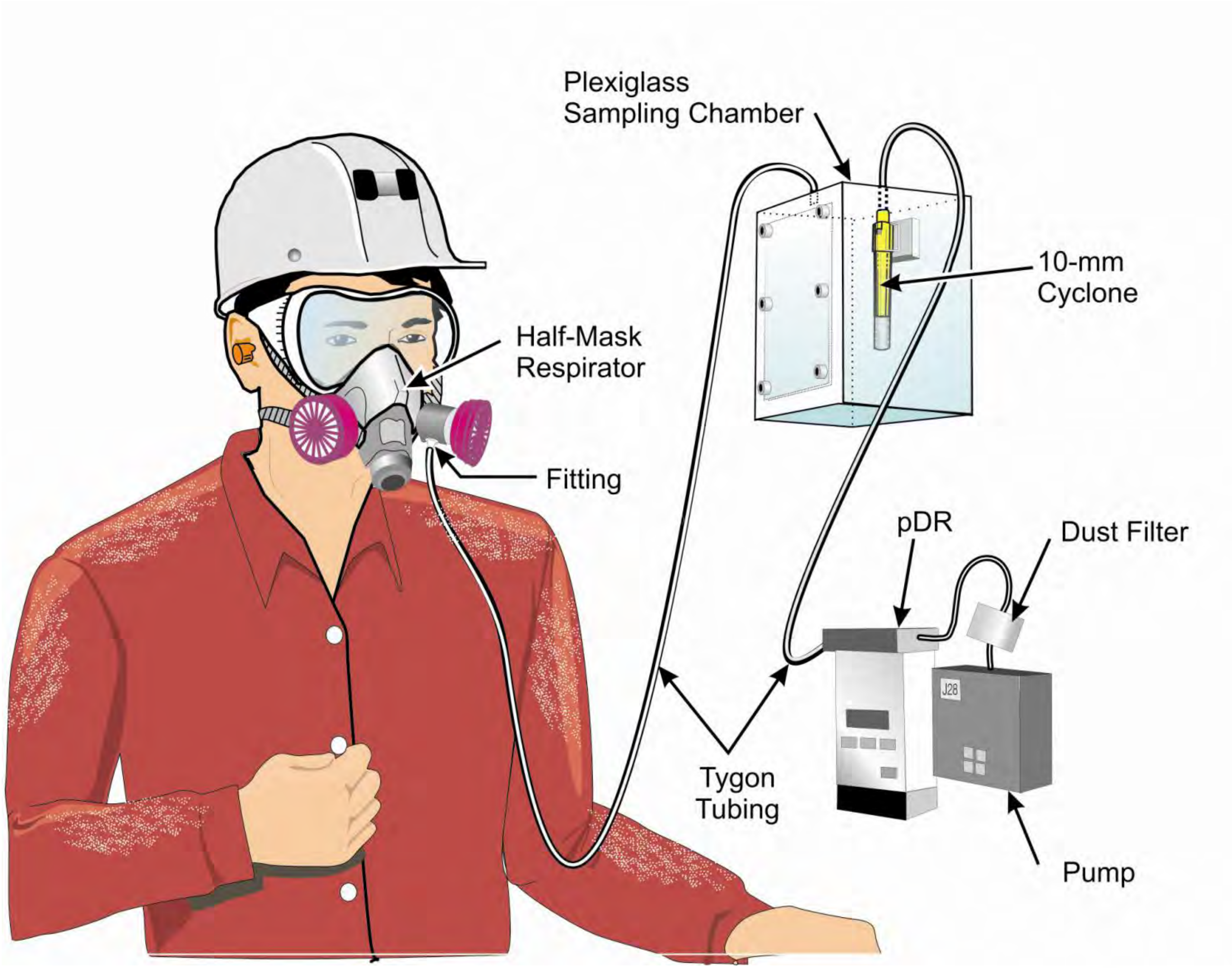
Single Air Hose

Air Spray Manifold

Inside Booth **Inside Respirator**

Tubing connects dust monitor to cyclone inside of PPE

Sampling Setup



Half-mask Respirator

Laboratory Testing (Pittsburgh Lab)

Analysis of Three Air Spray Nozzles

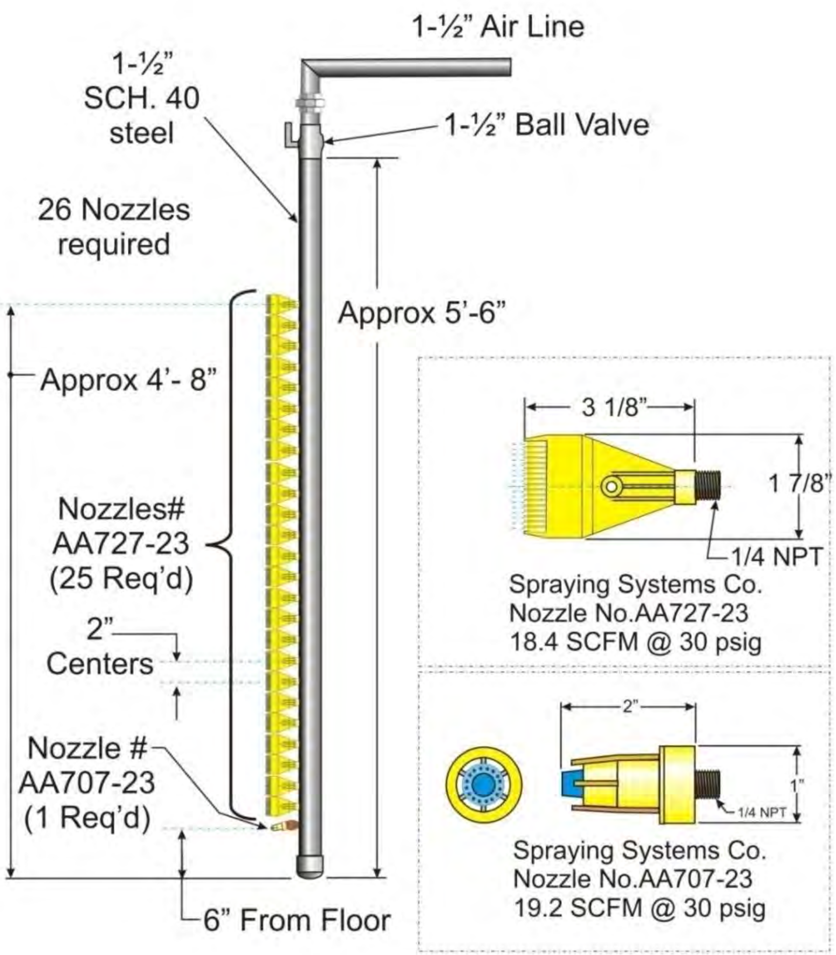
Cleaning Effectiveness at Increasing Distances

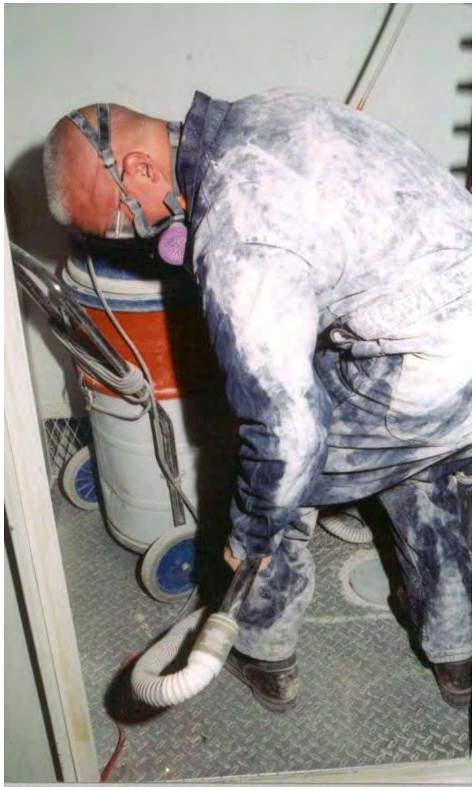
Cleaning Effectiveness: Air Pressure (30–5 psi)

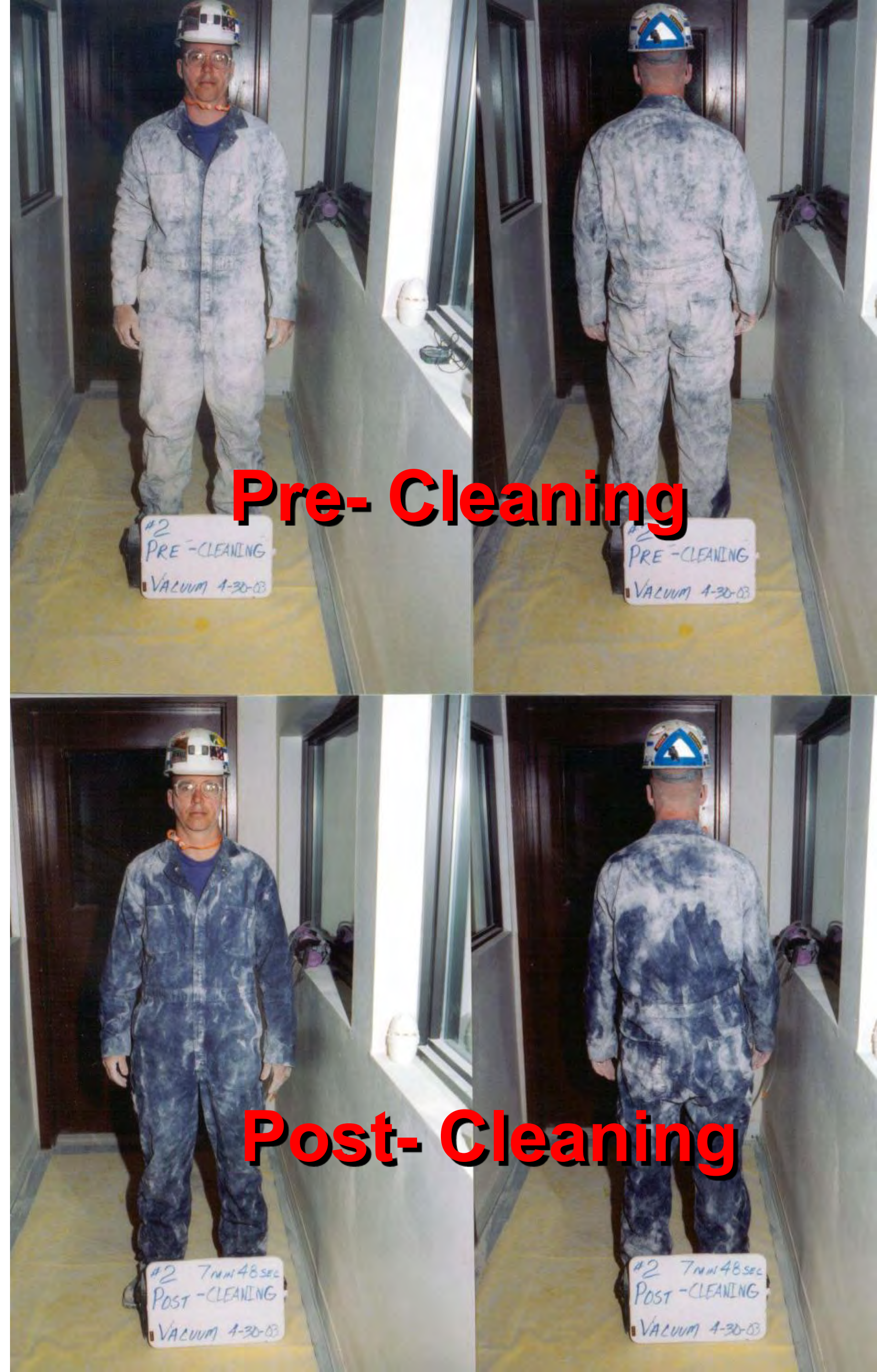
Cleaning Effectiveness: Nozzle Operating Time

Soiling clothes with crushed limestone dust (rockdust) for testing

Air Spray Manifold
Final Design



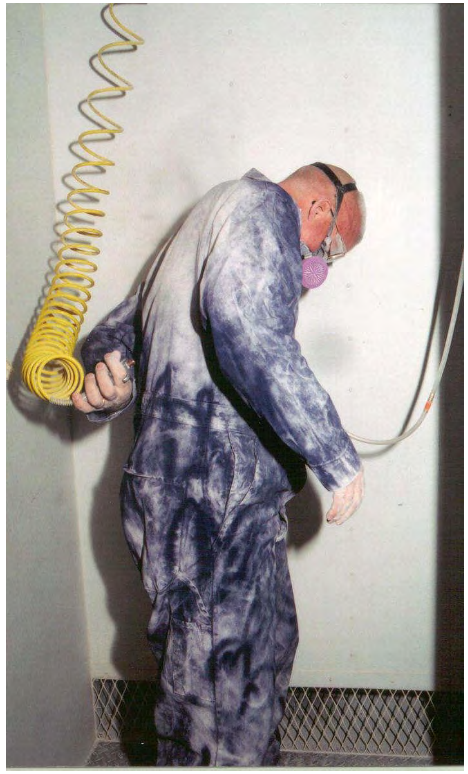




Vacuum

Cleaning Time:

7 minutes 48 seconds



Air Hose

Cleaning Time:

3 minutes 6 seconds

Air Spray Manifold

Cleaning Time:

17 seconds

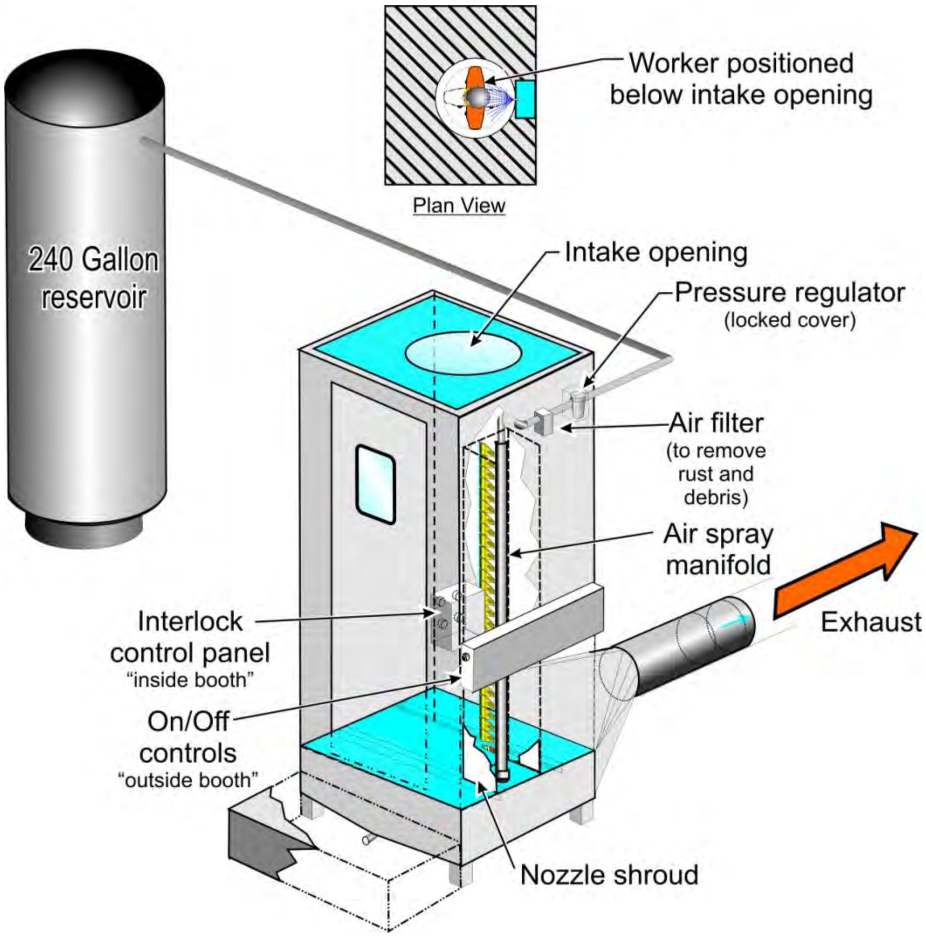
Dosimeter Noise Measurements

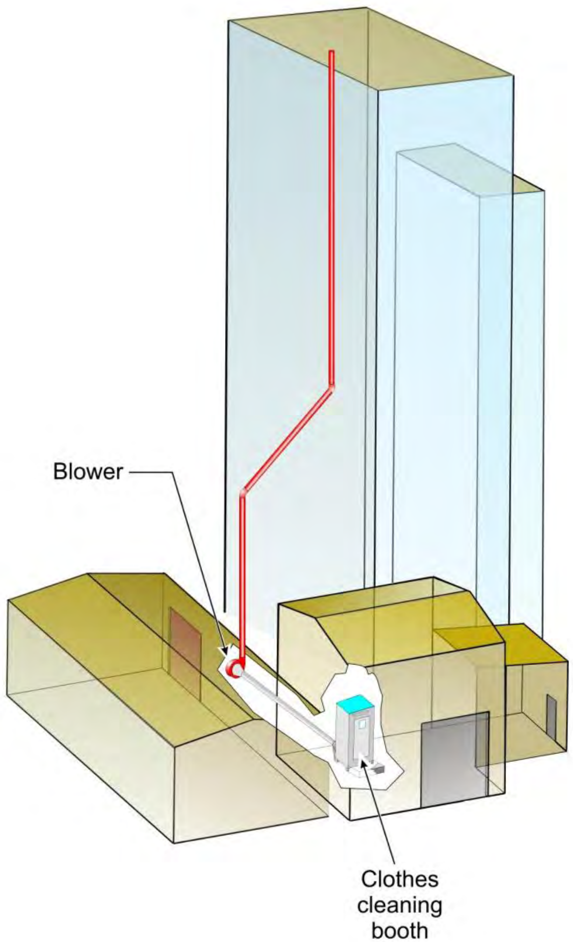
General Mill Levels:	91.5 dB
Inside Booth – not operating	86.5 dB
Inside Booth – operating	101.4 dB
Outside Booth – operating	91.4 dB
Outside Booth – not operating	90.6 dB

Note: Hearing protection is required when using clothes cleaning system.

Health and Safety Requirements

Modification: Exhaust Air Outside



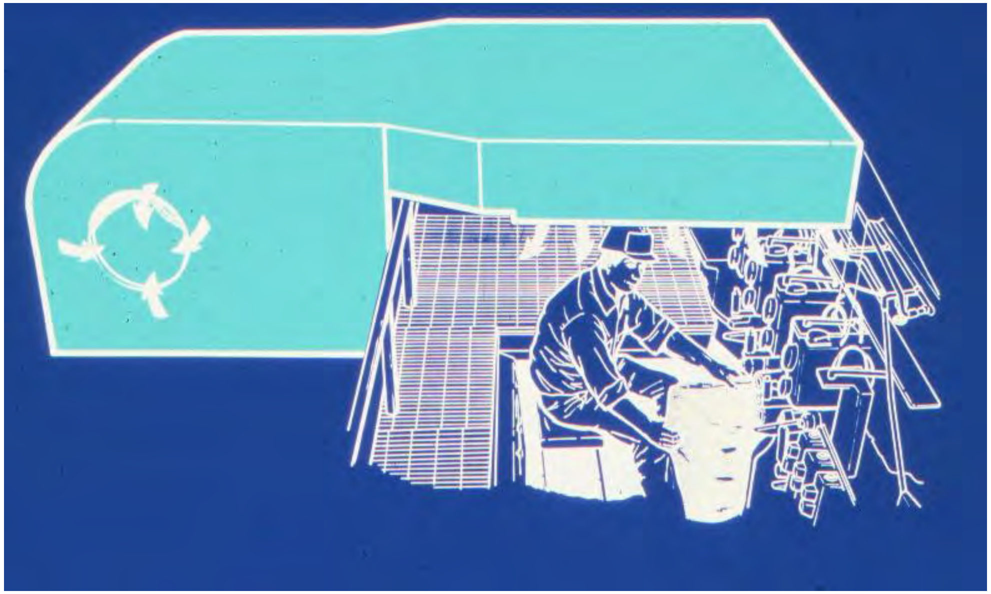


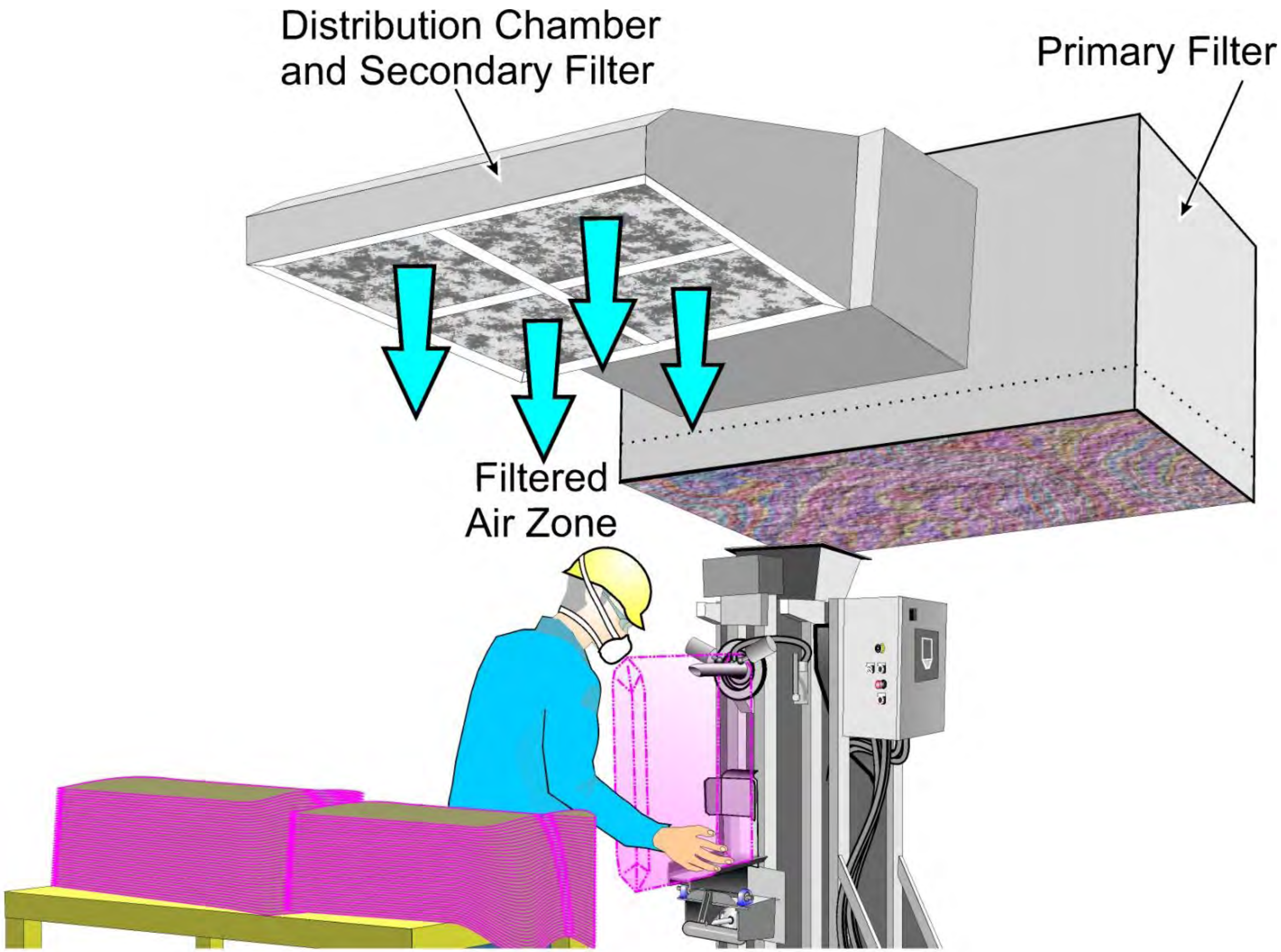
Cleaning Effectiveness (18 seconds cleaning time)

Clothes Cleaning Booth System (Wilson, NC)

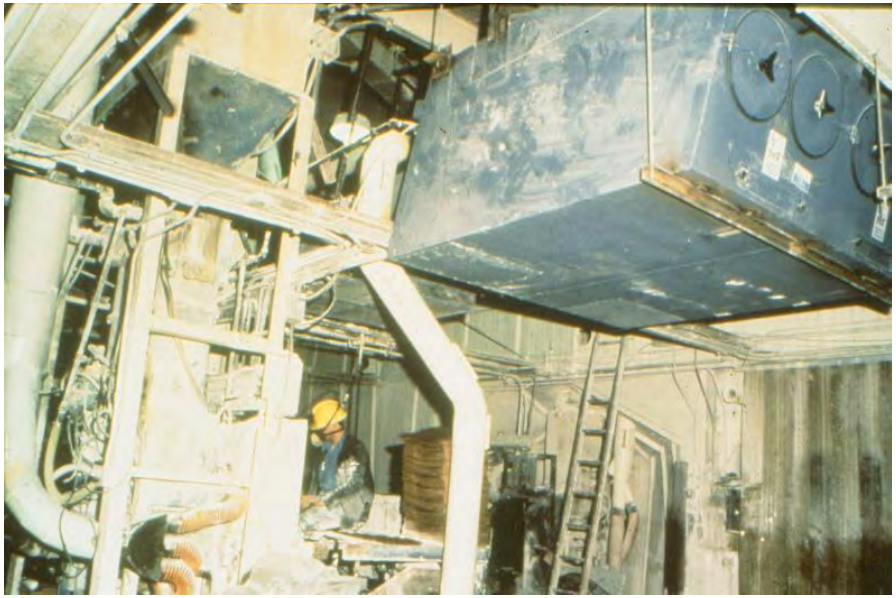
http://www.cleanclothbooth.com/

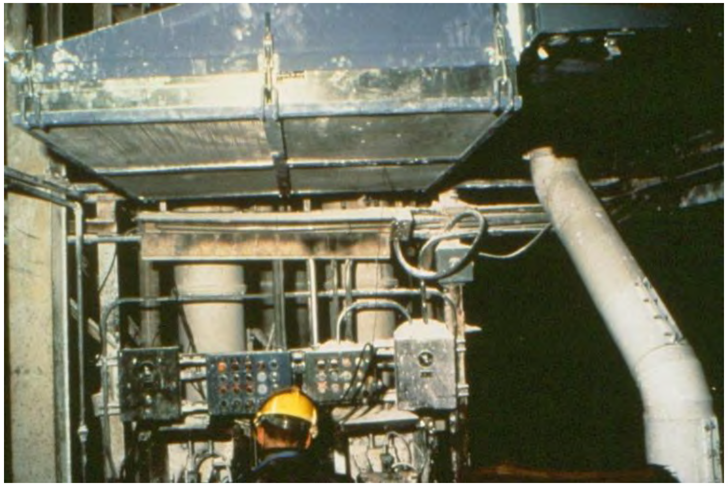
Overhead Air Supply Island System (OASIS)





Air velocity of 375 ft/min flowing over worker

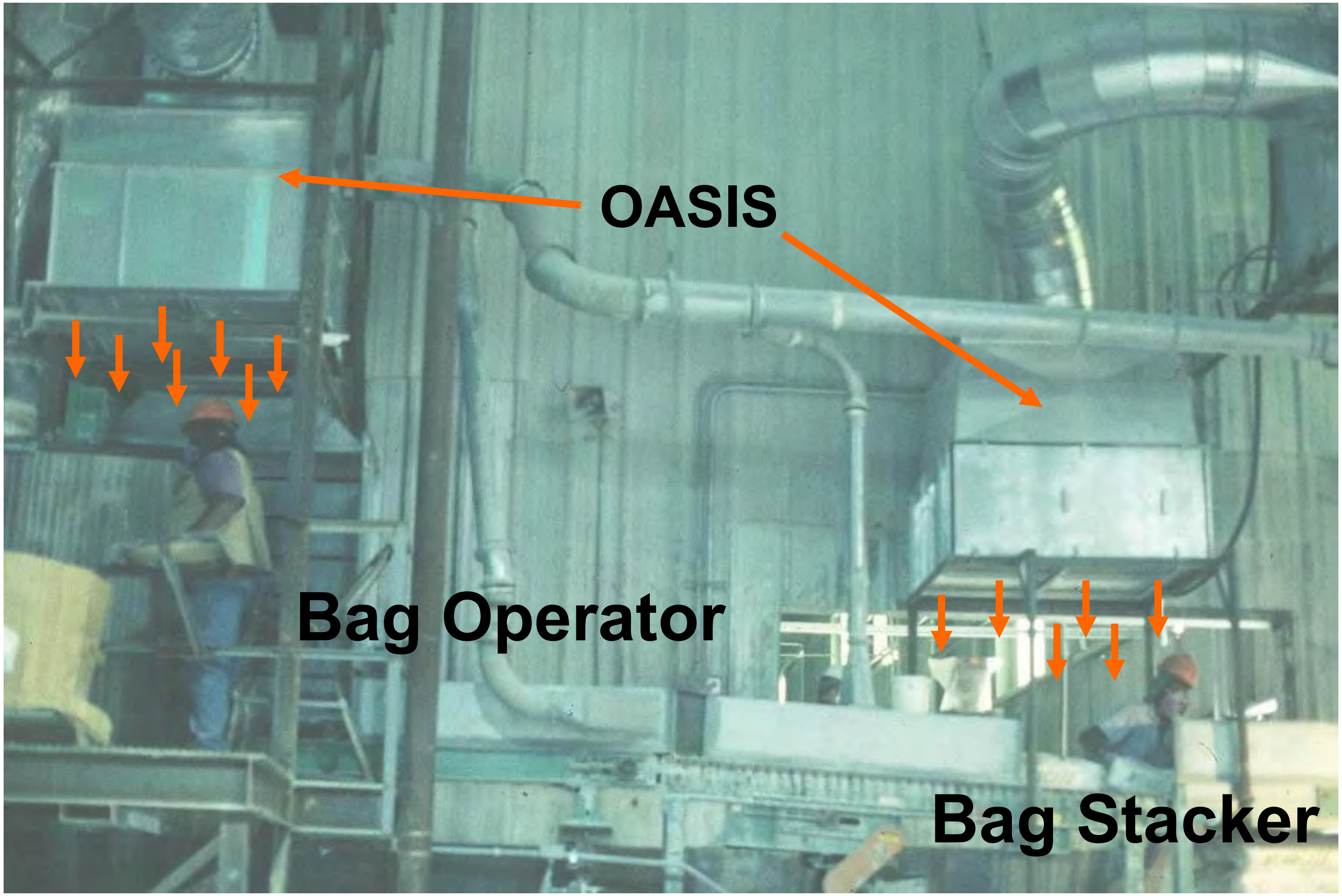




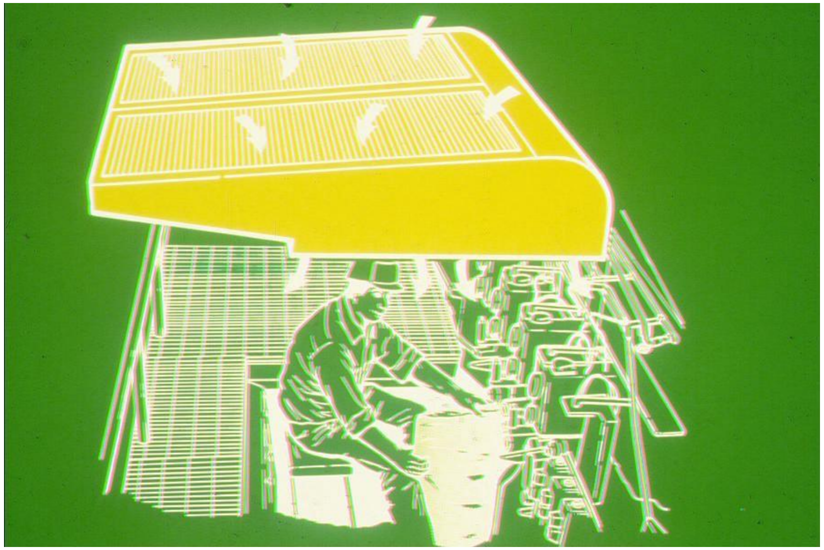
Outside Air Intake

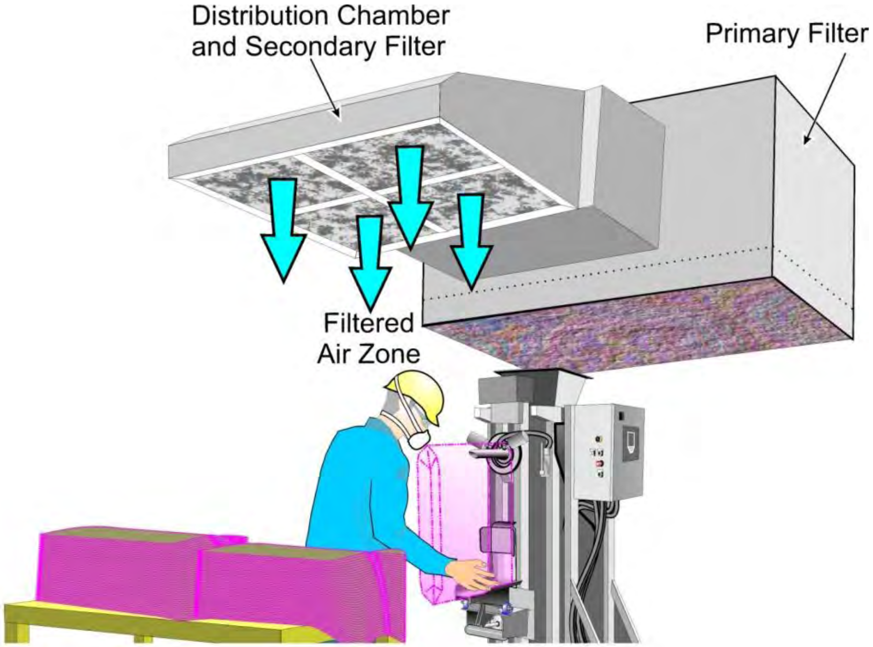
Main Filter Unit

Bag Loading and Stacking Area



Respirable Dust Reductions: 82–98%



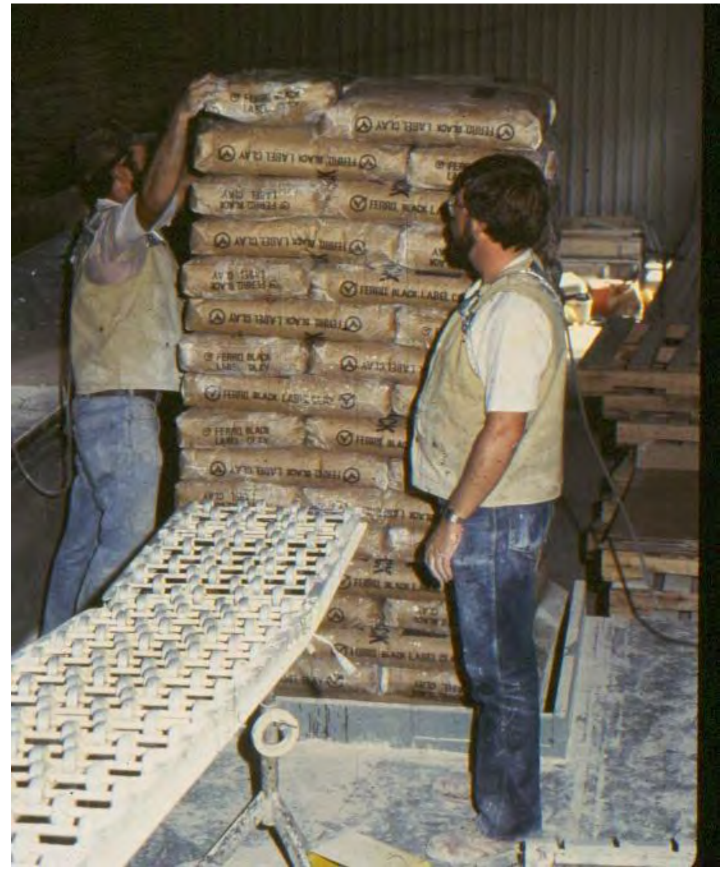


Key: Provide an envelope of clean filtered air down over the worker.
Can be designed and installed in-house or by local engineering firms.

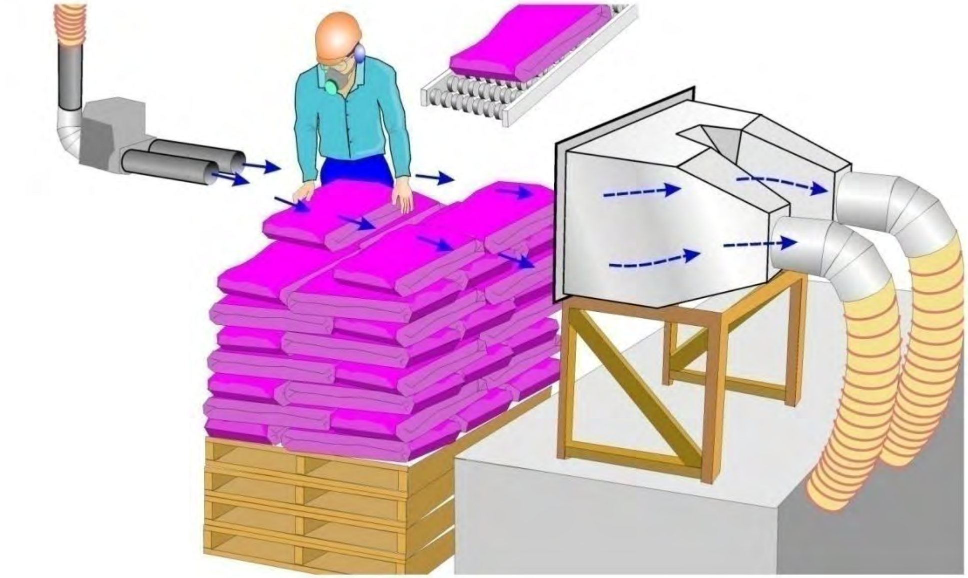
Pallet Loading Dust Control System

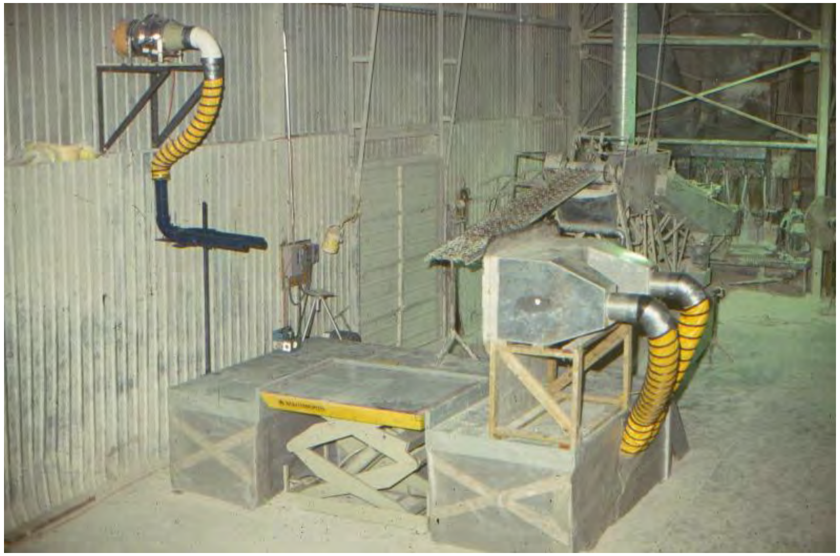
Two Problem Areas

1. Dust Exposure
2. Ergonomic



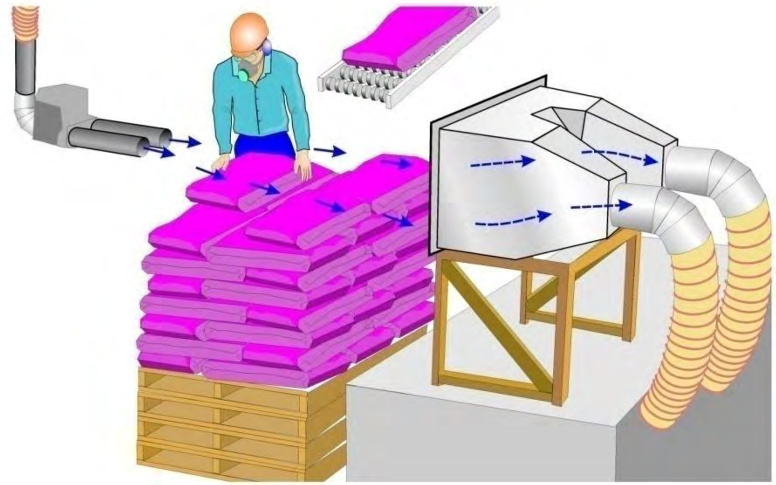
Push-pull Ventilation System





Blowing jets: 2–3” circular/1,200 ft/min
Blowing volume: 470 cfm
Exhaust volume: 2,500–2,800 cfm

Loading height: knuckle level (28–30 inches)
Air jets should be 10–12 inches above loading height (40 inches)

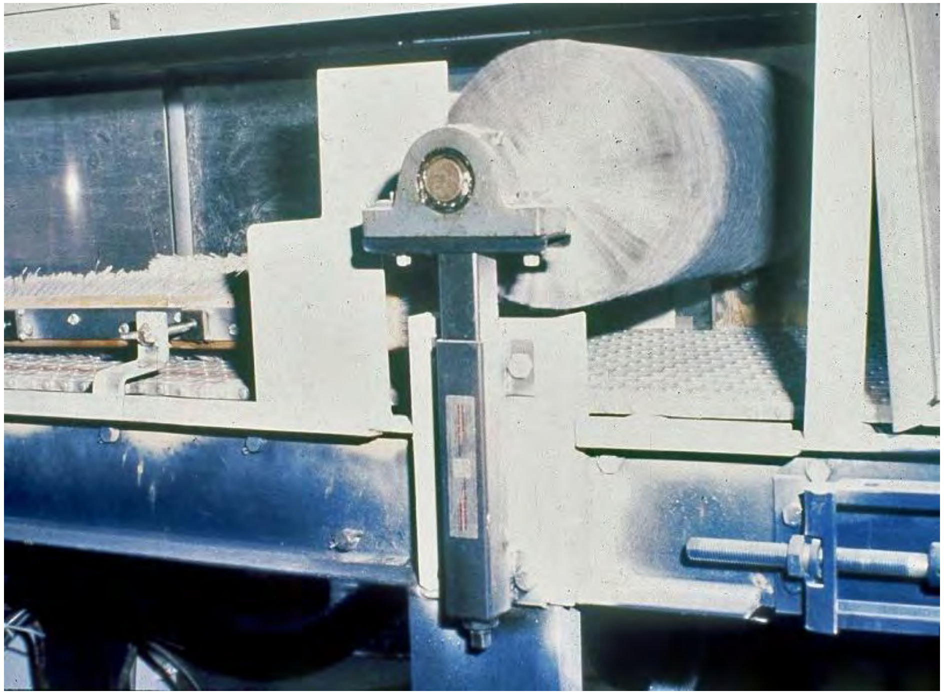


Results

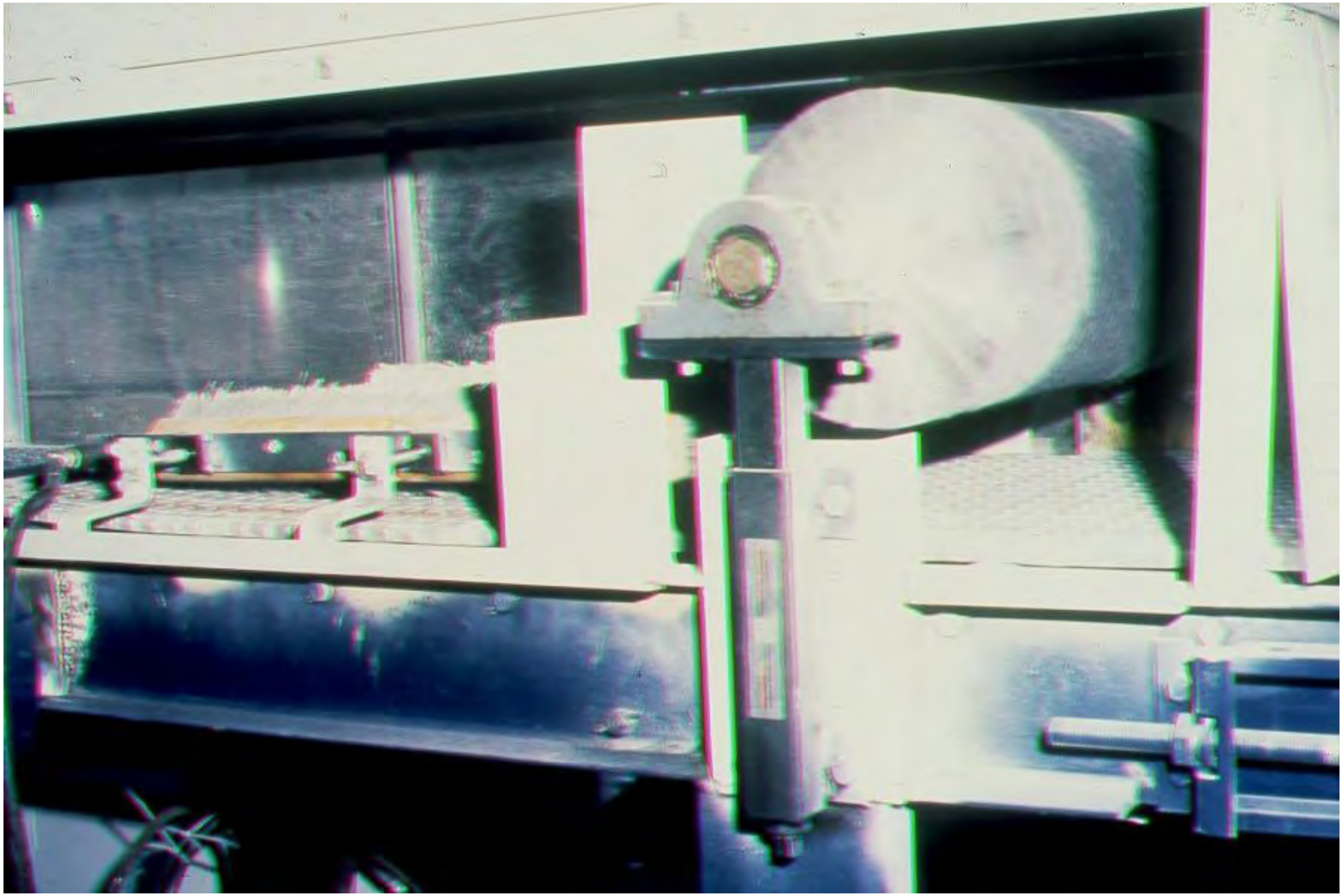
- **Lowers respirable dust exposure**
- **Reduces back stress**
- **Increases production, less downtime**

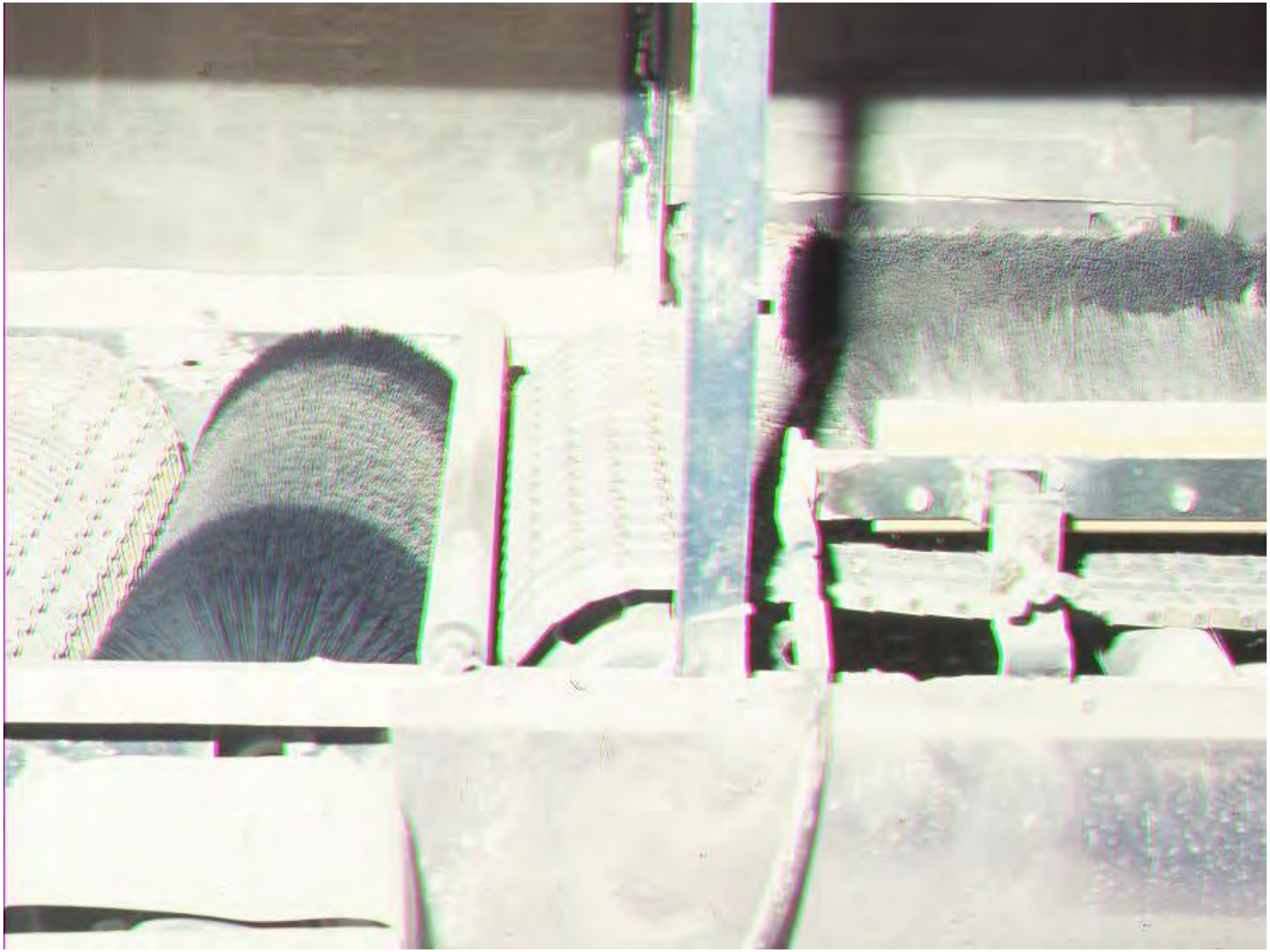
Bag Stacker's Average Dust Reduction: 30–80%

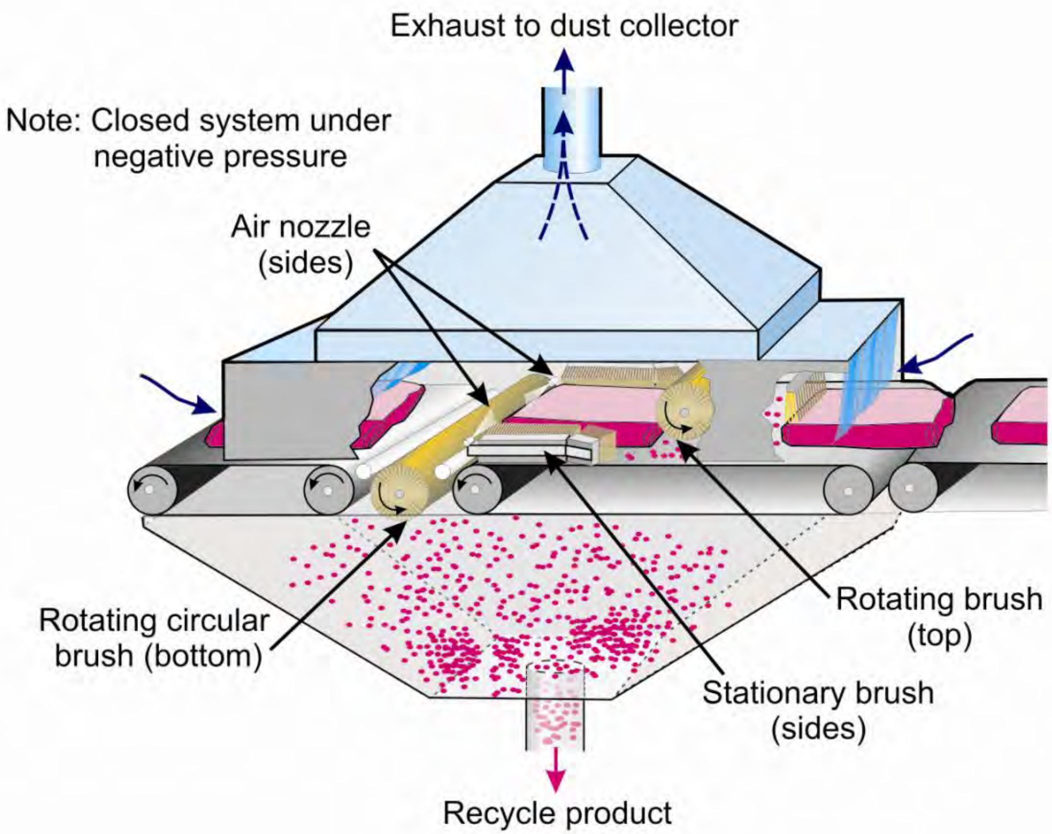
Bag and Belt Cleaning Device (B&BCD)



Cooperative research effort with silica sand company






Exhaust to dust collector
Note: Closed system under negative pressure
Air nozzle (sides)
Rotating circular brush (bottom)
Rotating brush (top)
Stationary brush (sides)
Recycle product

Soiled Bags
(Before and After)

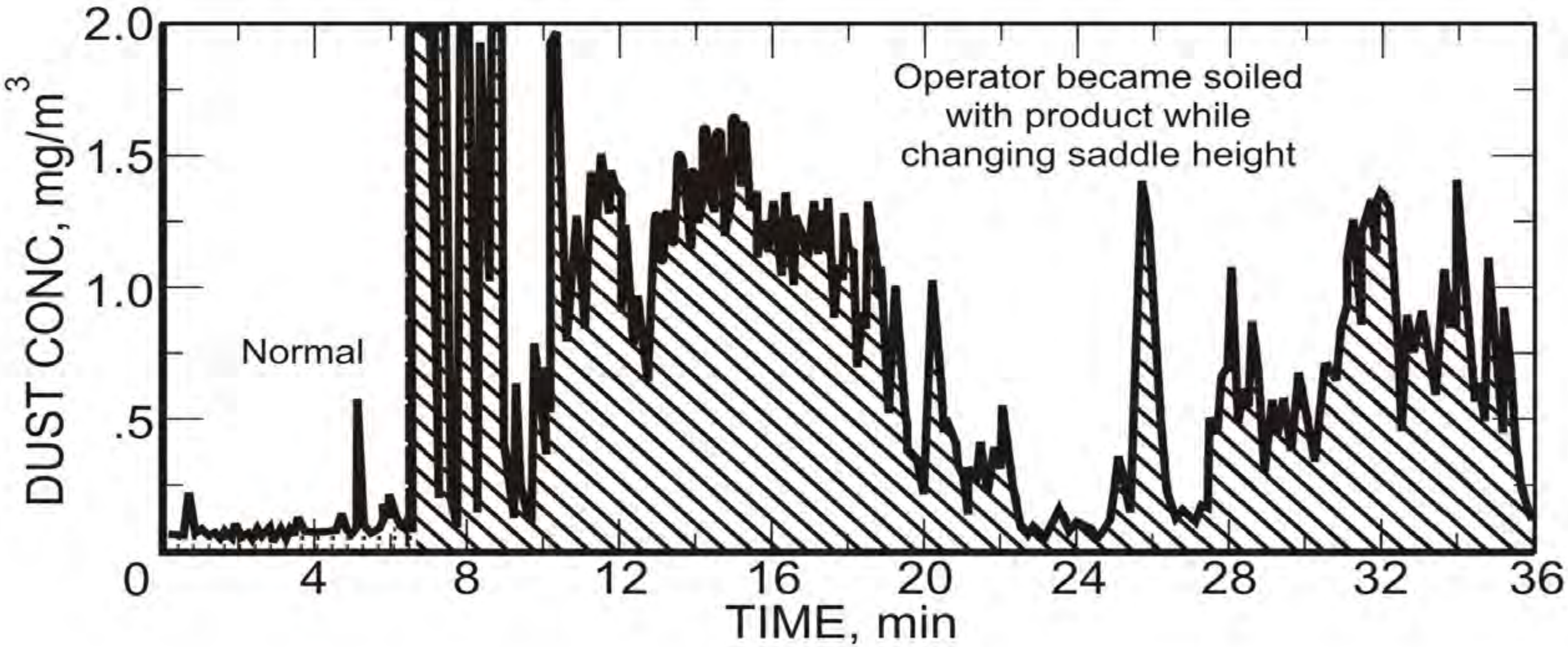
325 Mesh Product

Dust Reduction: 78–93% reduction

Key: Clean product from bags using mechanical/stationary brushes and air jets in contained unit under negative pressure. Technology is being used by OEMs.

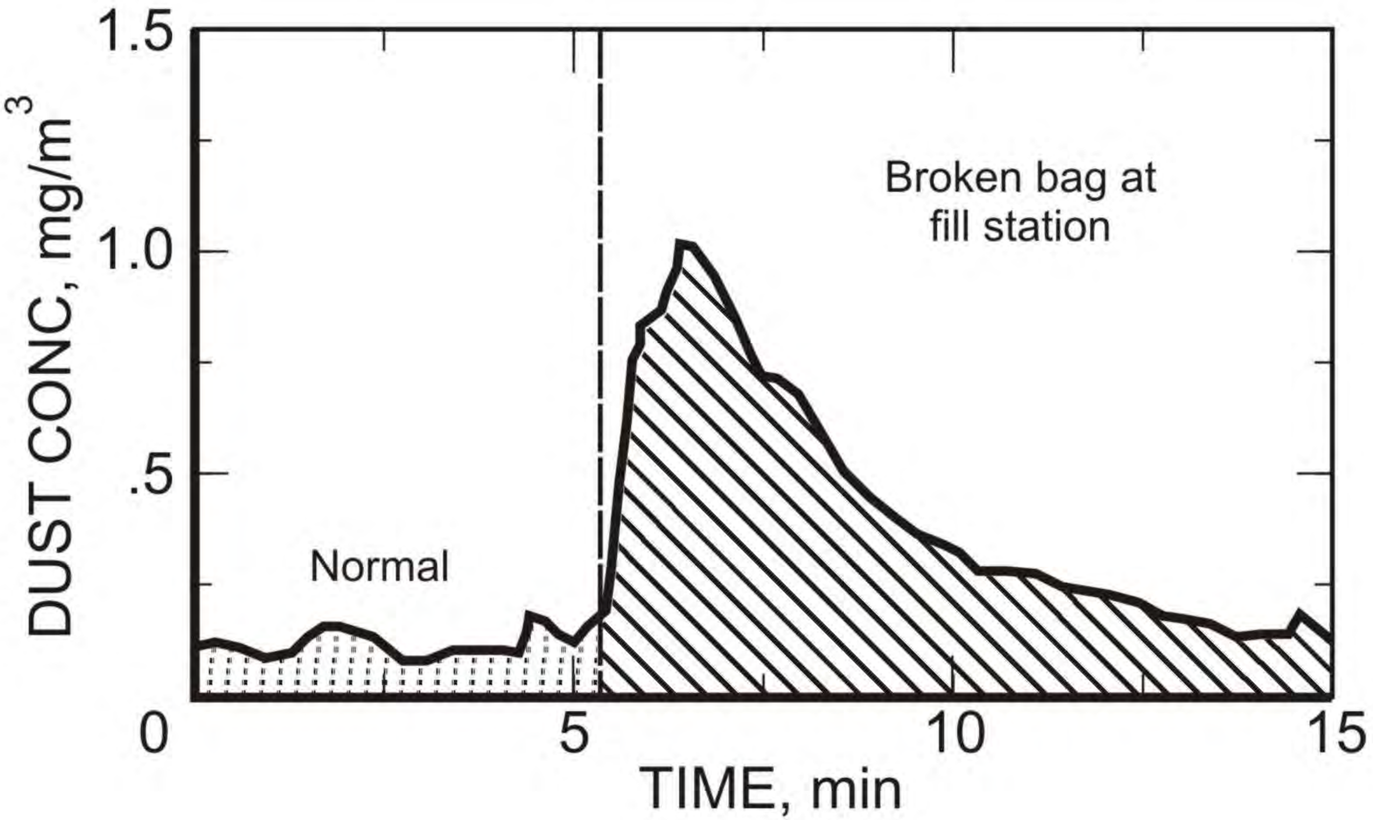
Secondary Dust Sources

Soiled Work Clothes

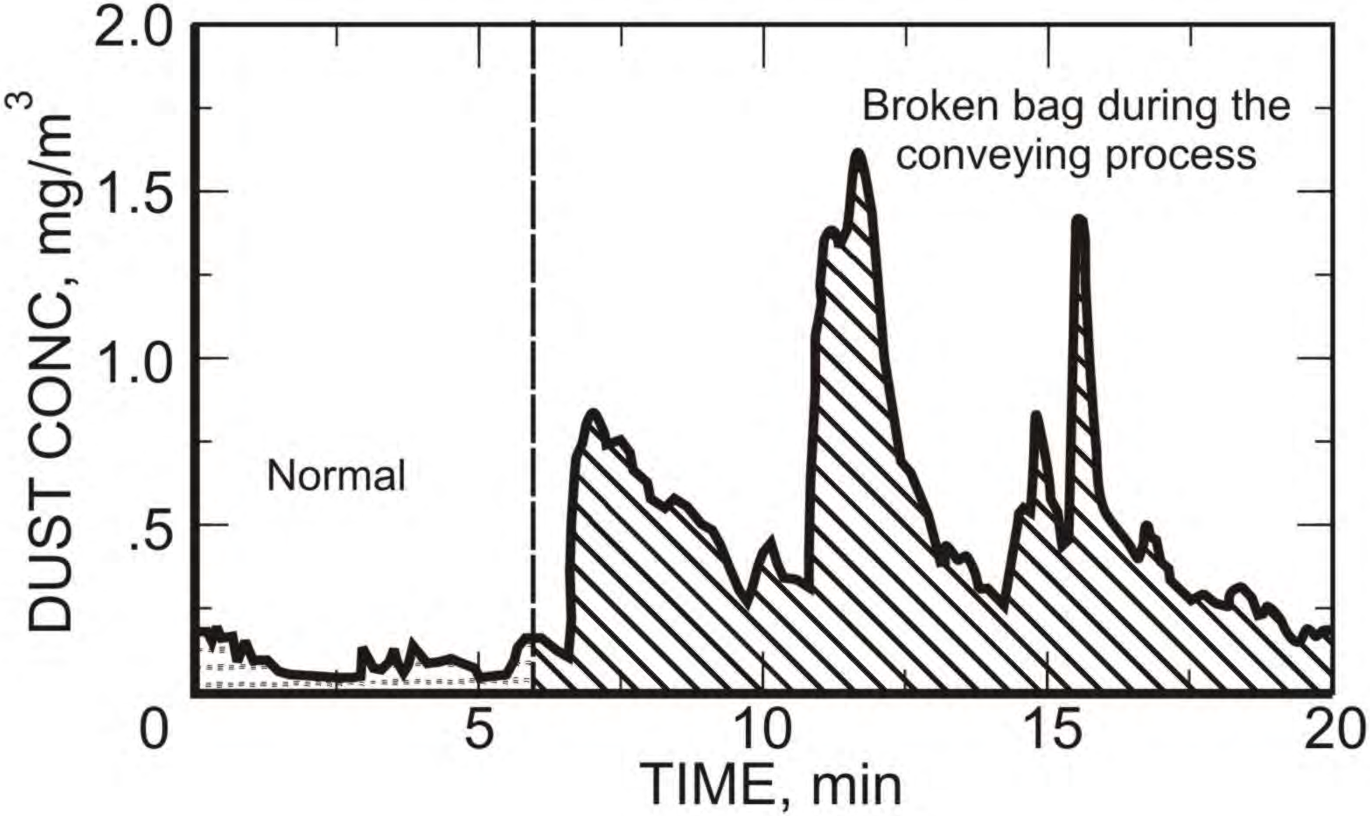


DUST CONC, mg/m 3
2.0
1.5
1.0
.5
0
4
8
12
16
20
24
28
32
36
TIME, min
Normal
Operator became soiled
with product while
changing saddle height

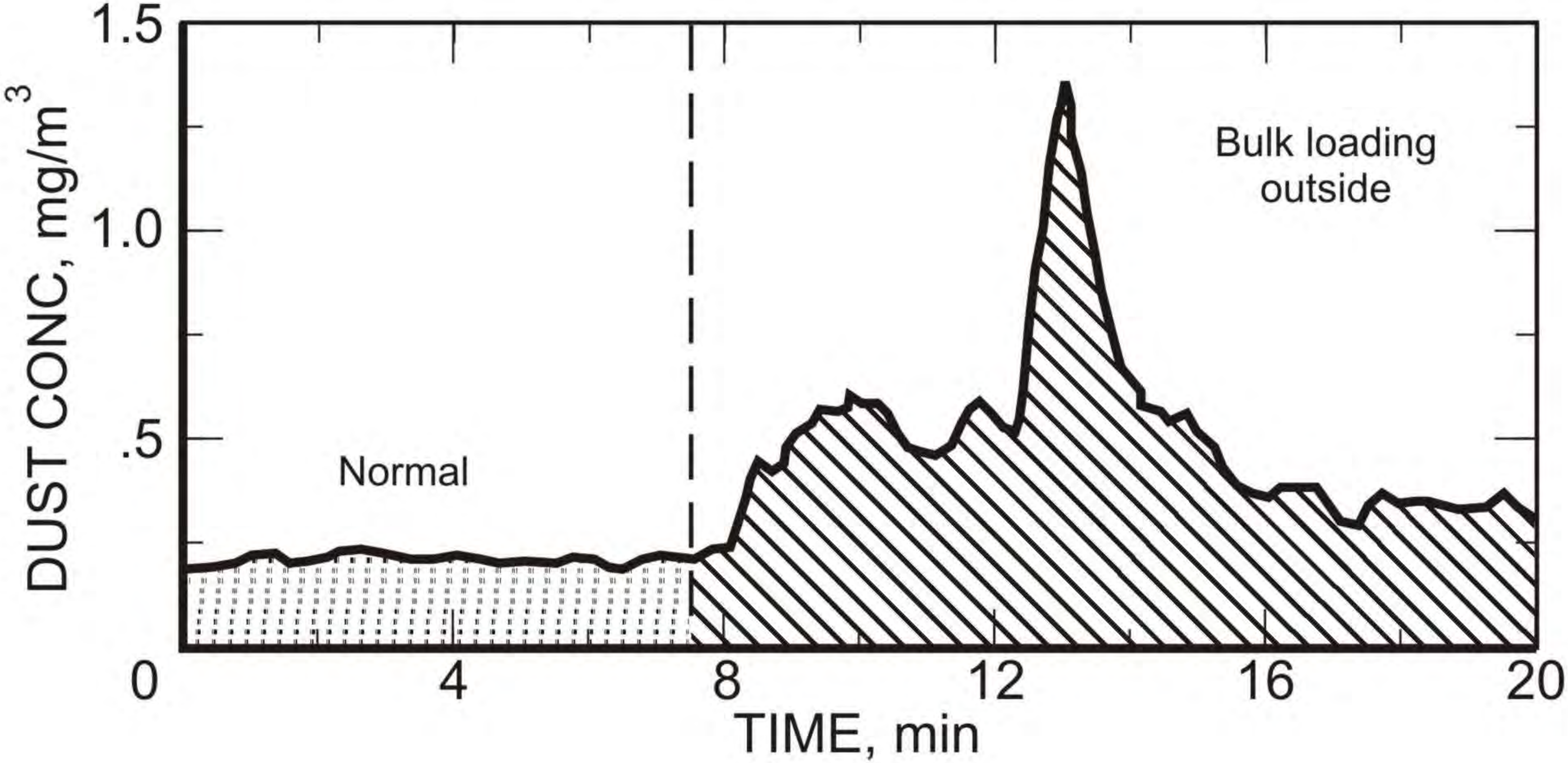
Broken Bags



1.5
1.0
.5
0
5
10
15
DUST CONC, mg/m3
TIME, min
Broken bag at
fill station
Normal


DUST CONC, mg/m3
2.0
1.5
1.0
.5
0
5
10
15
20
TIME, min
Normal
Broken bag during the
conveying process

Bulk Loading Outside



1.5
1.0
.5
0
4
8
12
16
20
DUST CONC, mg/m3
TIME, min
Normal
Bulk loading
outside

Increase in Dust Exposure from Secondary Sources

CASE	Increase Factor	TLV Exposure Time
Contaminated Work Clothes	10.1	1 hr 35 min
Blowing Clothes with Compressed Air	2.4	3 hr 33 min
Broken Bag (Fill Station)	3.2	4 hr 34 min
Broken Bag (Conveyor)	6.9	3 hr 20 min
Bulk Loading Outside	2.5	3 hr 48 min
Bag Hopper Overflowing	12.2	2 hr 11 min
Dry Sweeping Floor	5.7	9 hr 24 min

Occurrence Totals for Overexposures

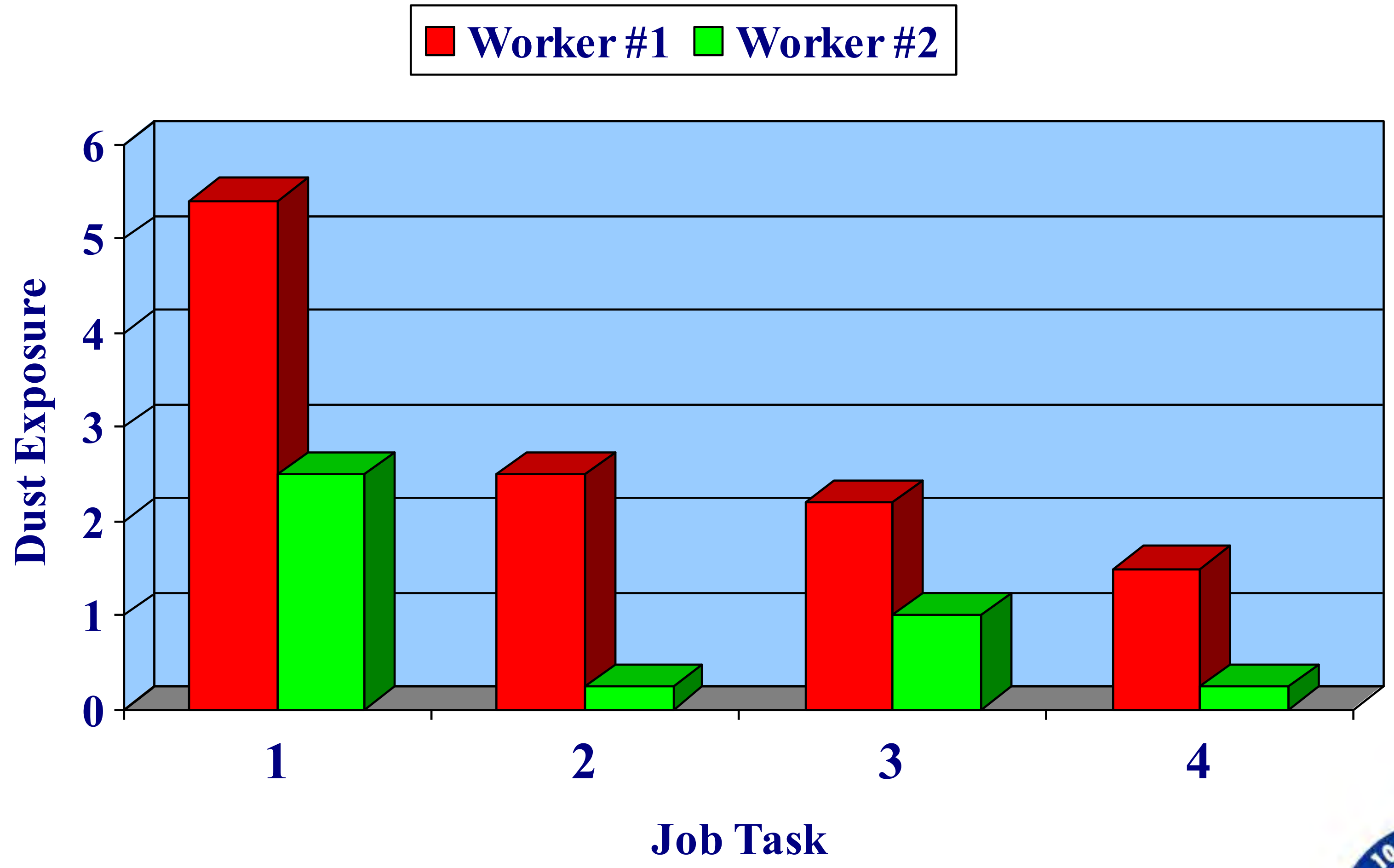
Sources of Dust	Estimated Occurrences to Exceed TLV
Contaminated Work Clothes	1
Bag Breakage During Filling	14-18
Bag Breakage During Conveying	6-10
Bulk Loading Outside	3-4
Bag Hopper Overflowing	3-4

Secondary Dust Sources

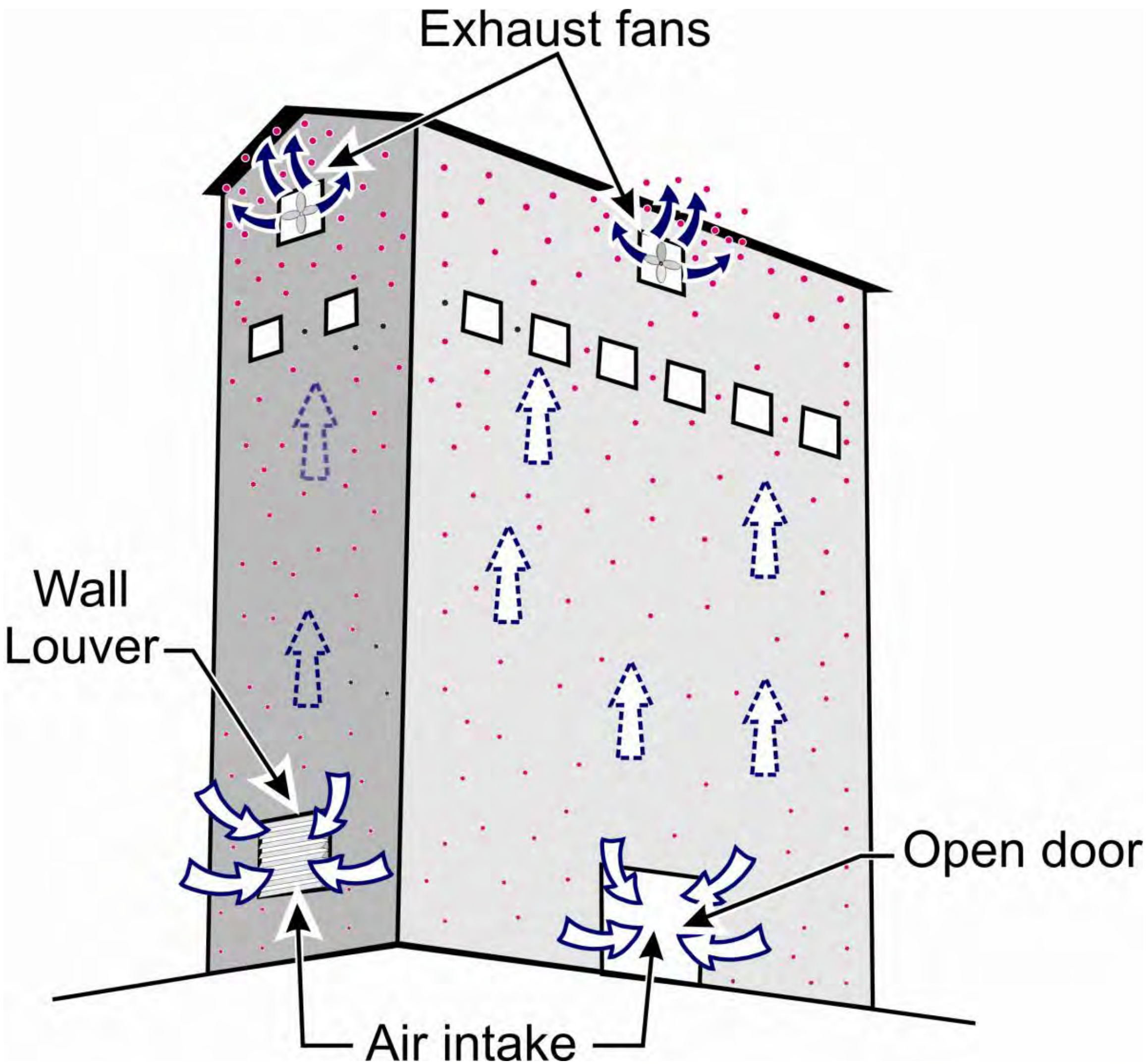
- **Be aware of the problem**
- **Identify the problem**
- **Control the problem**

Worker's Impact on Dust Exposure

Dust Exposures of Two Workers Using Different Work Practices



Total Mill Ventilation System



Evaluation Site

Clay Processing Structure

- Three 8,500 cfm roof exhausters

- 25,500 cfm system, 10 ACPH

- Three wall louvers provide inlet for makeup air

Smoke Bomb Release

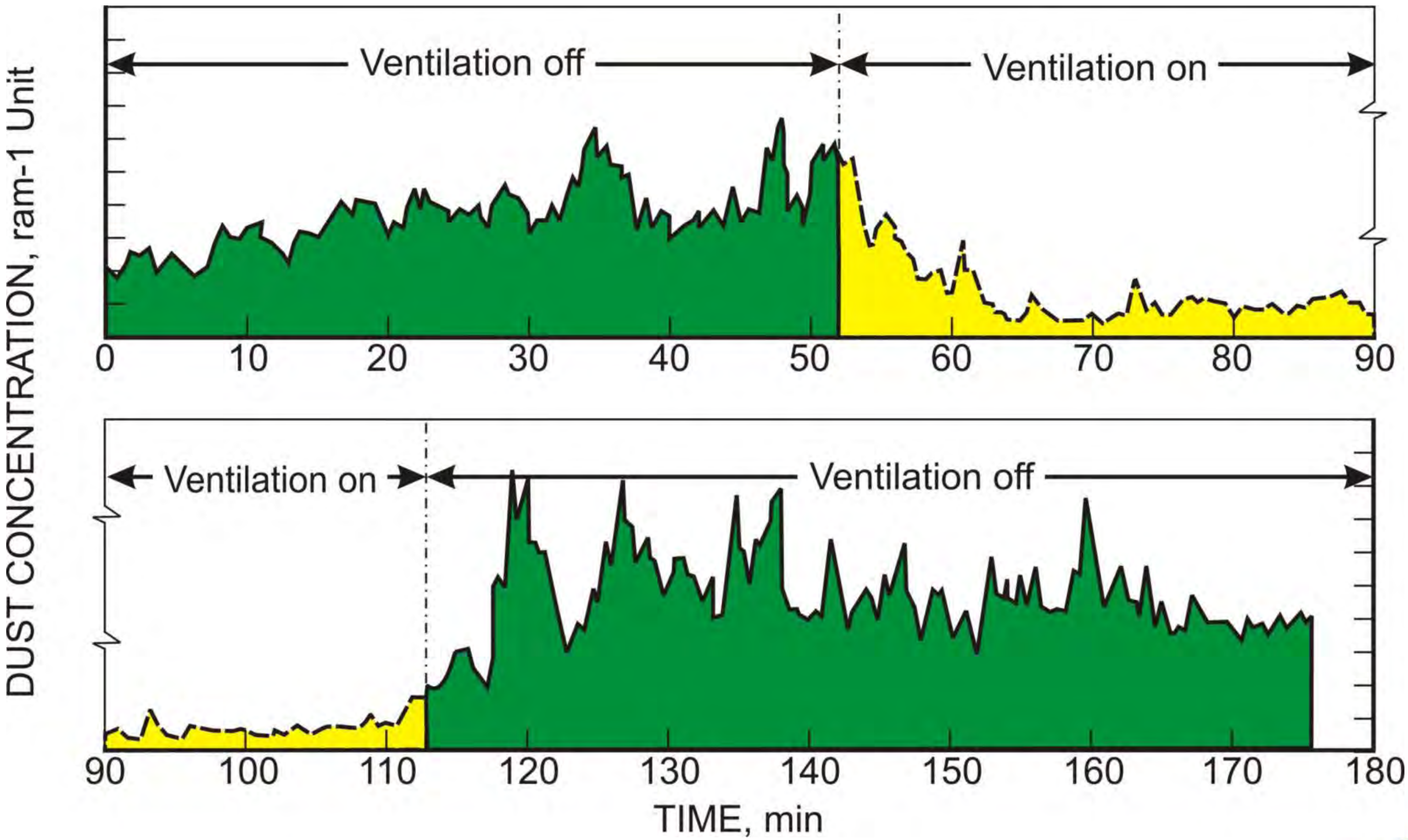
Immediately After Release

2 Minutes After Release

4 Minutes After Release

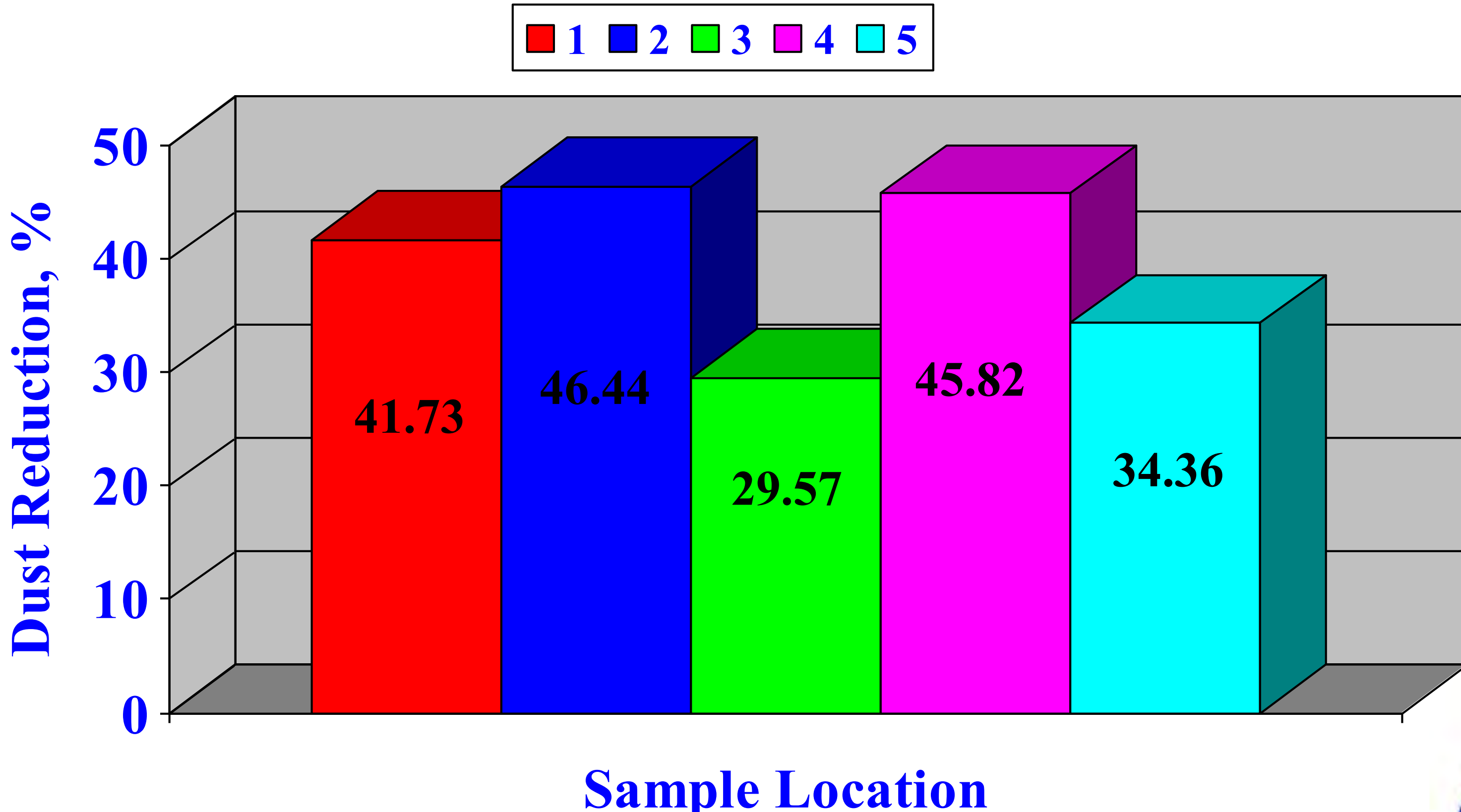
6 Minutes After Release (one air change)

Total Mill Vent System On and Off



Dust Reduction at Sample Locations for Field Evaluation Site #1

40% average reduction

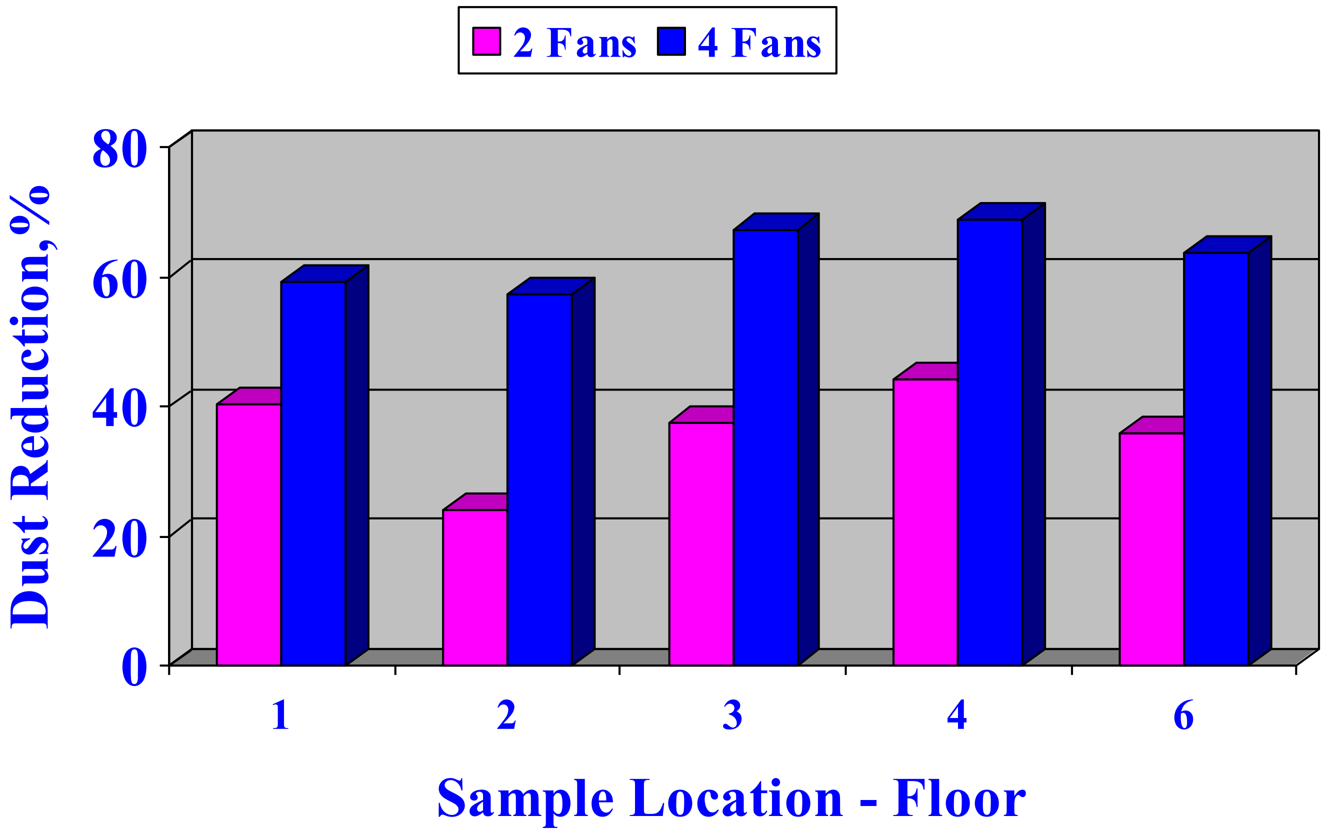


Site #2

- 100,000 cfm system, 34 ACPH
- Four 25,000 cfm propeller type wall exhausters
- Open bay doors – inlet for makeup air
- Material and installation (in-house) minimal

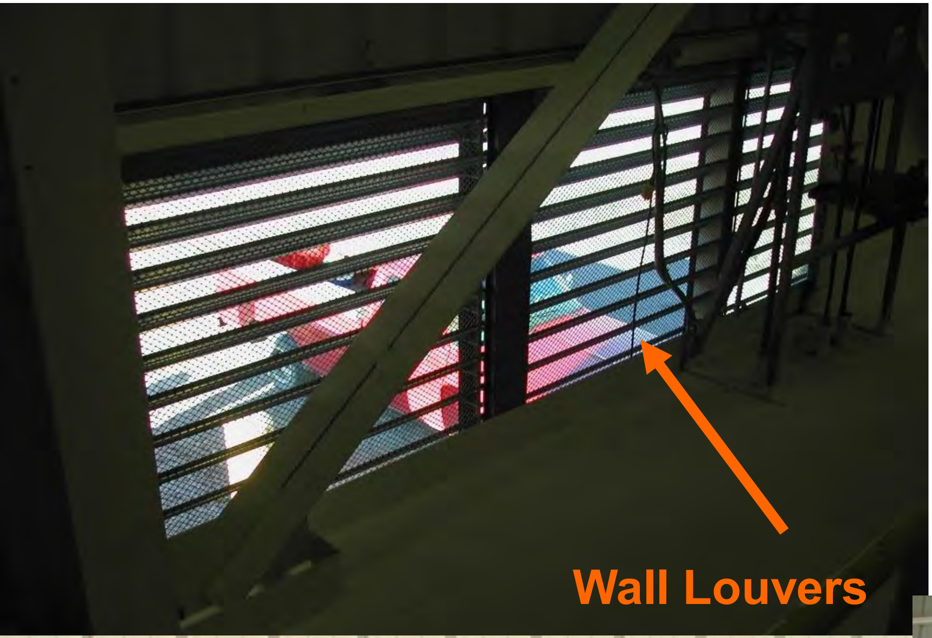
Dust Reduction at Sample Locations for Field Evaluation Site #2

50,000 cfm (17 acph): 36% / 100,000 cfm (34 acph) : 63%



The technique has been adopted by the mineral processing operations and is a standard practice throughout the industry.

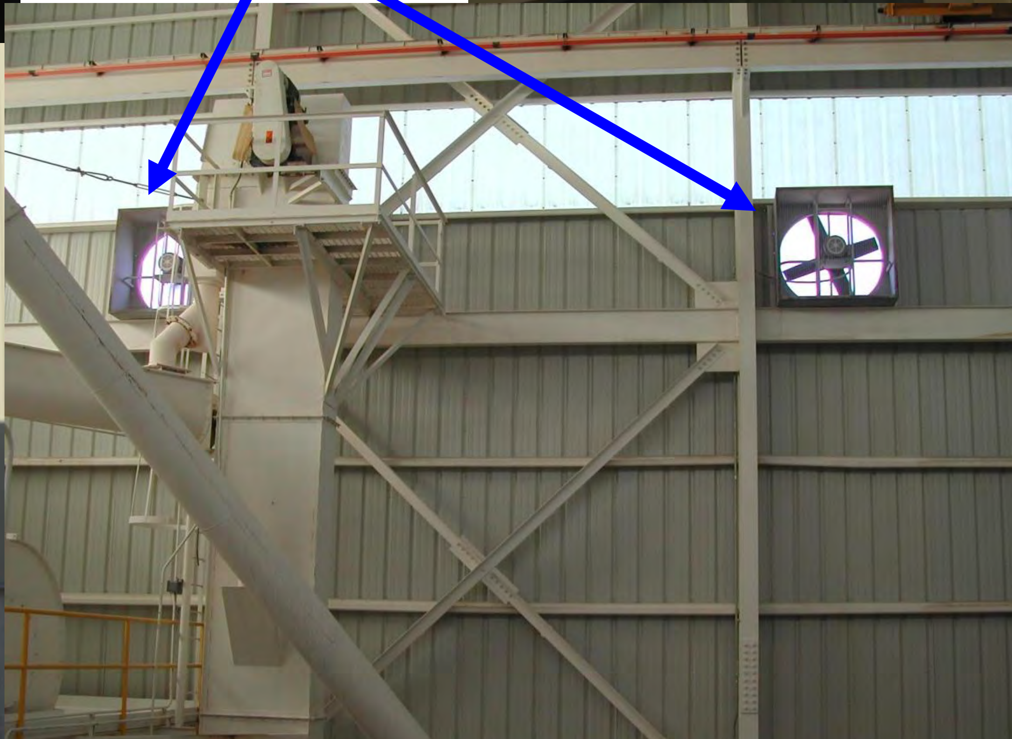
Relatively New Primary Grinding Mill Facility



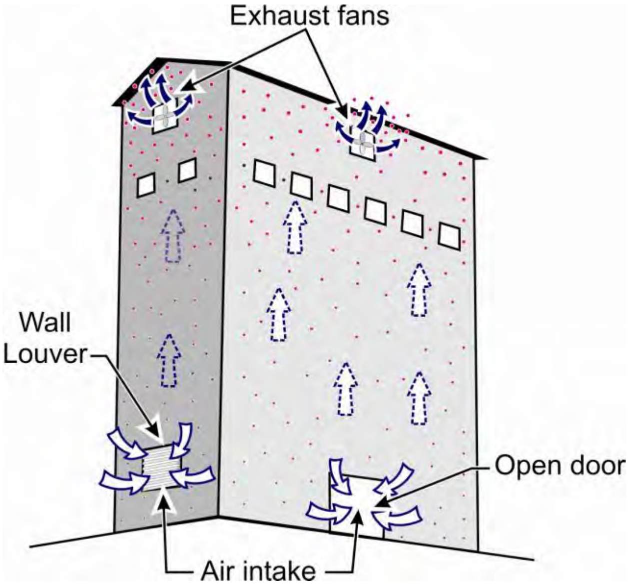
Average Respirable Dust Concentrations: 0.0 mg/m3

Fans

Wall Louvers



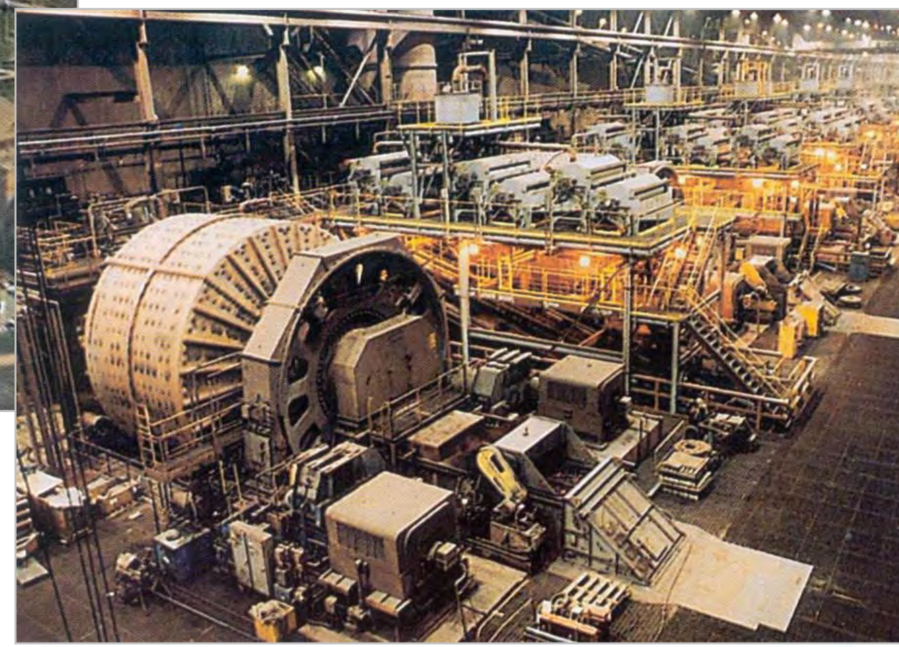
Total Mill Ventilation System



Respirable Dust Reduction: 36%–63% reduction throughout entire structure

Key: Common practice throughout the industry at mineral processing plants

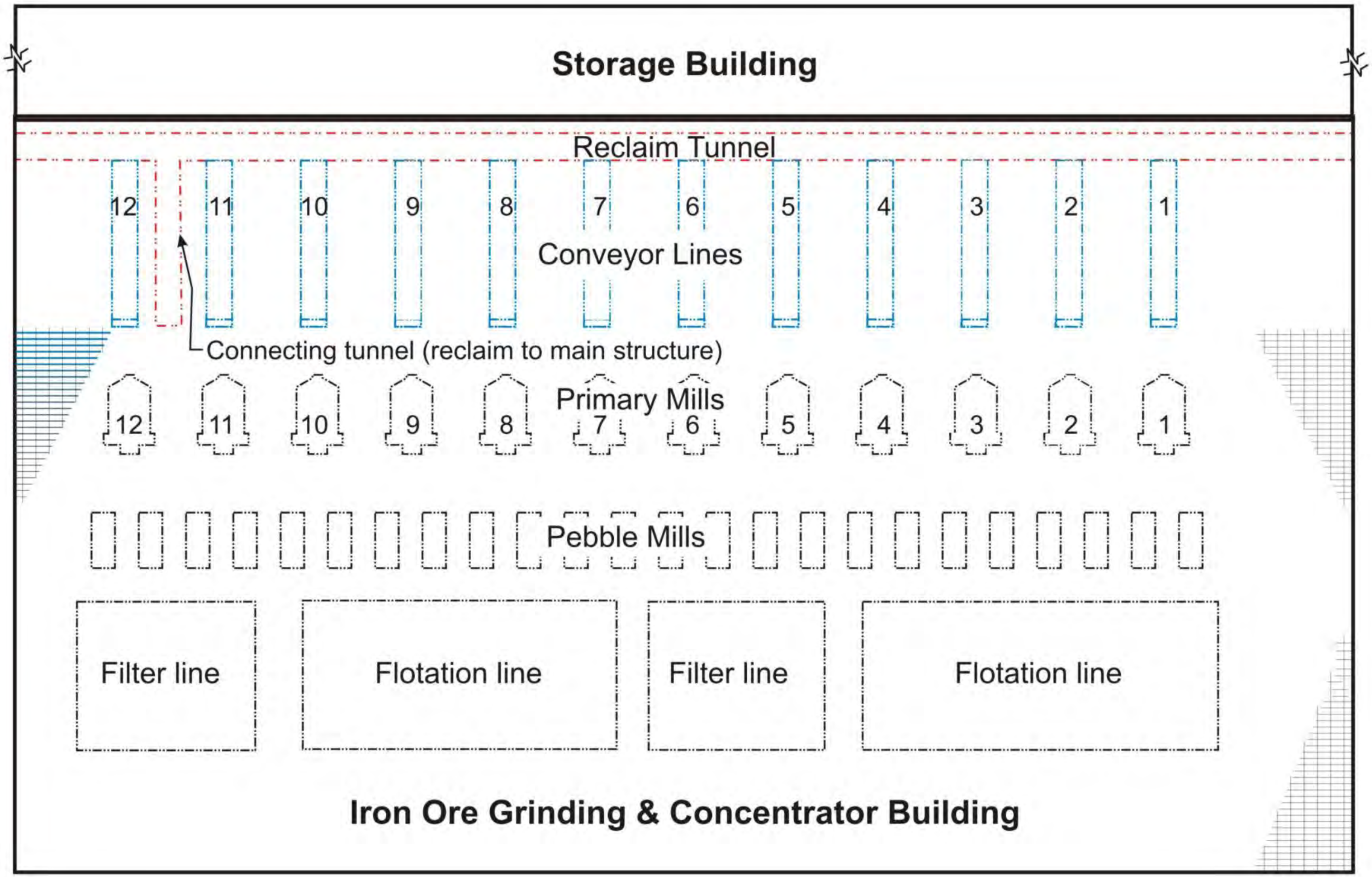
Reducing Dust Levels in Iron Ore Processing Plant



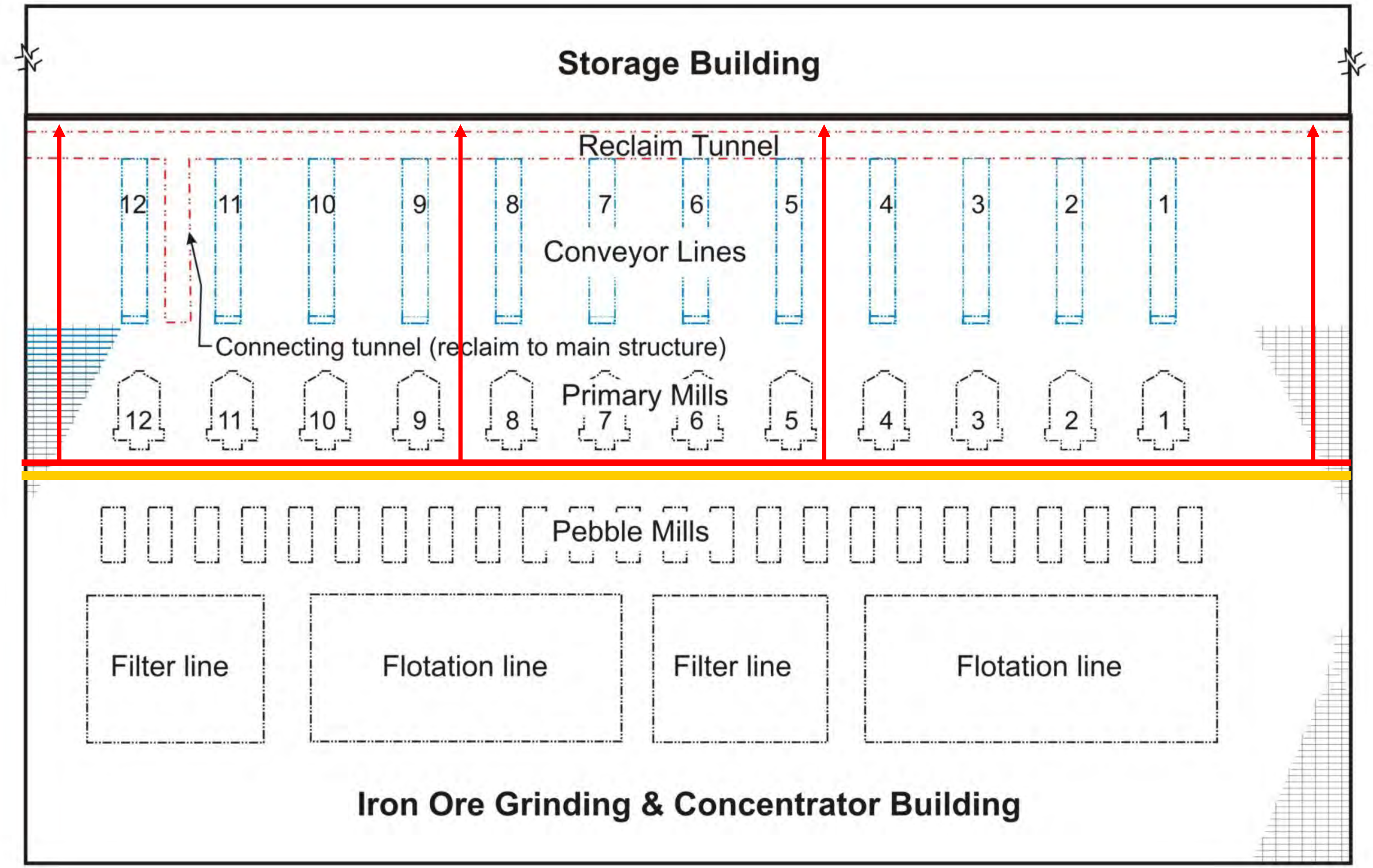
Unique Facility:

940,000 ft^2 structure with an internal air volume of 45,000,000 ft^3

Iron Ore Facility

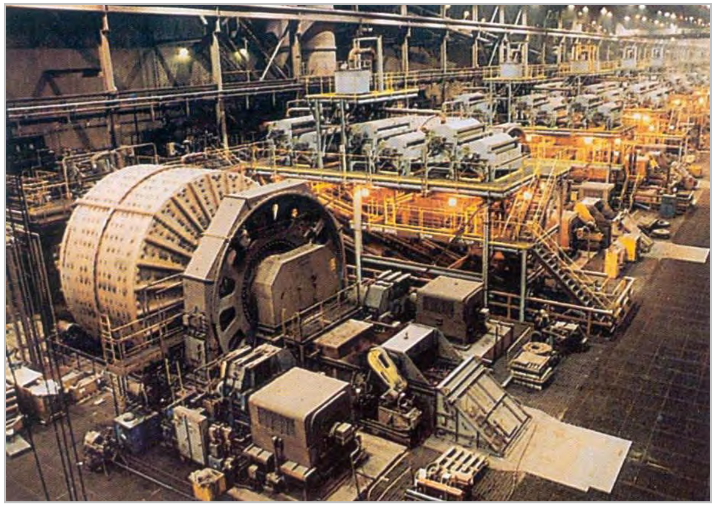


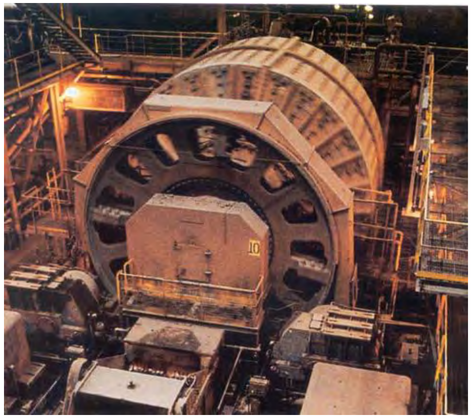
High Respirable Dust Levels Result in Respirator Requirement Zone



Major Objective: Optimize and balance airflow throughout structure

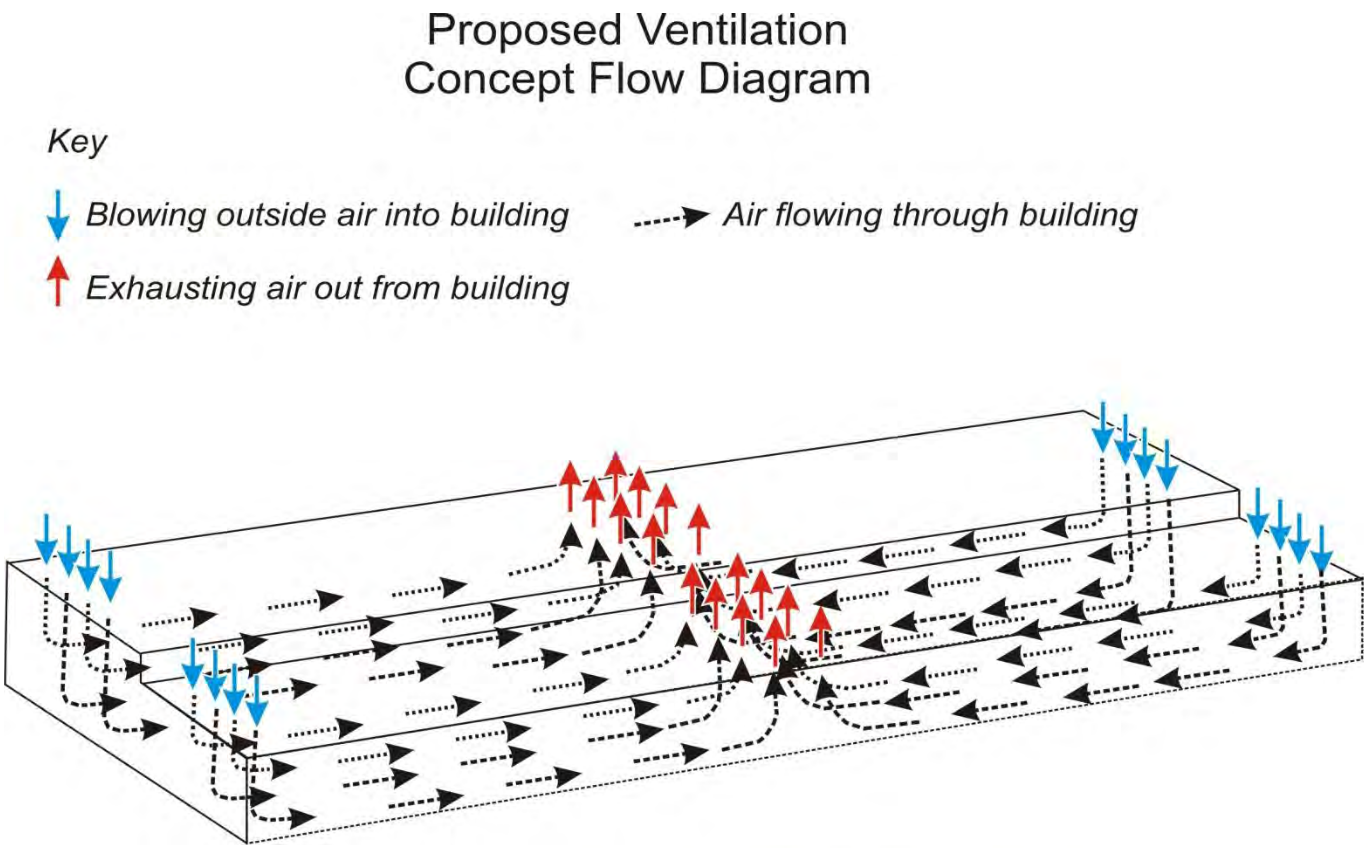
Secondary Objective: Lower respirable dust levels in and around the twelve primary grinding mills





Ventilation Recommendation

- **Proposed two significant changes to concentrator structure ventilation: 1) balance intake and exhaust air volumes and 2) create a directional airflow pattern**



Roof Fan Setup at Tilden

Tuesday, March 9

Intake: 2 intake heaters/3 intake roof fans - 600,000 cfm

Exhaust: 39 exhaust fans – 1,930,500 cfm

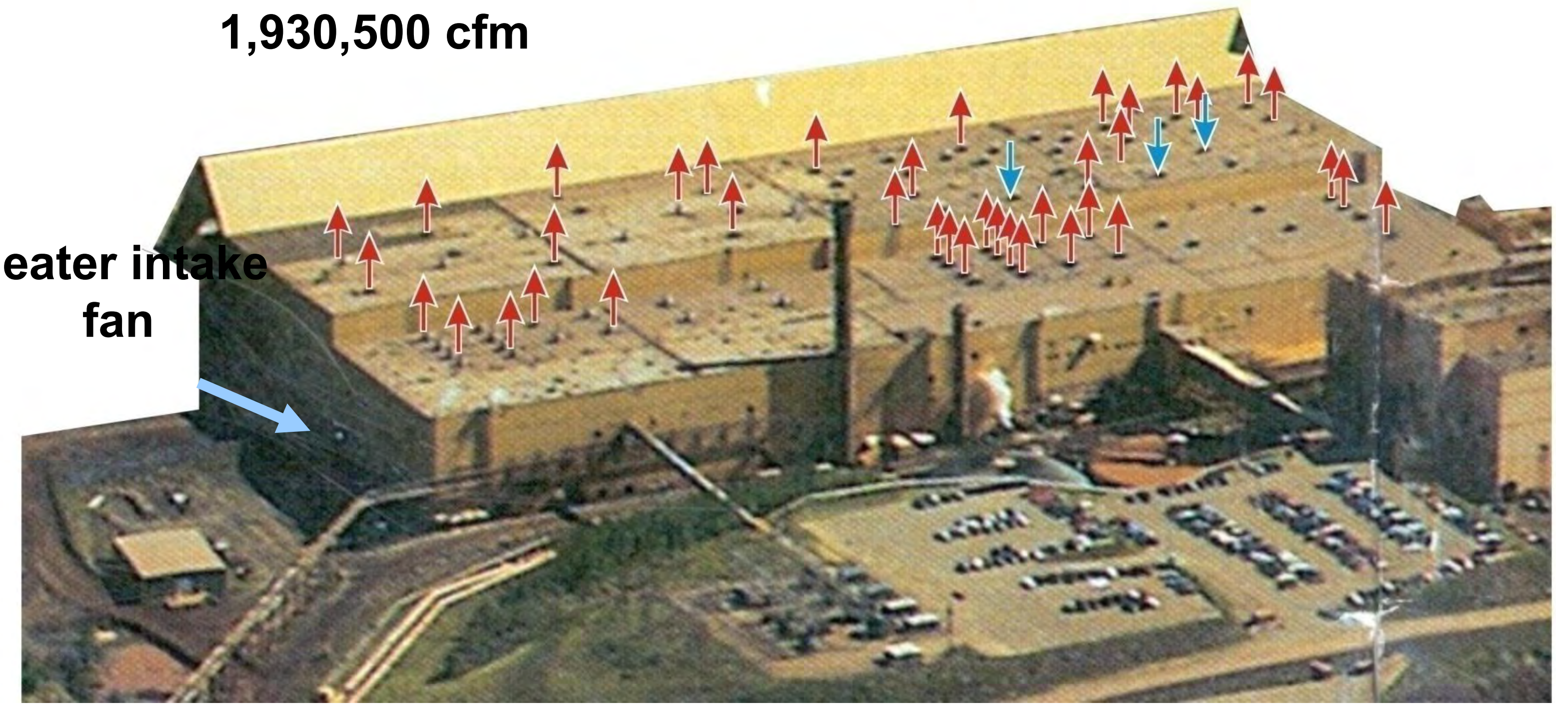
3.2 times more air exhausted

Key

Intake Fan

Exhaust Fan

Heater intake fan



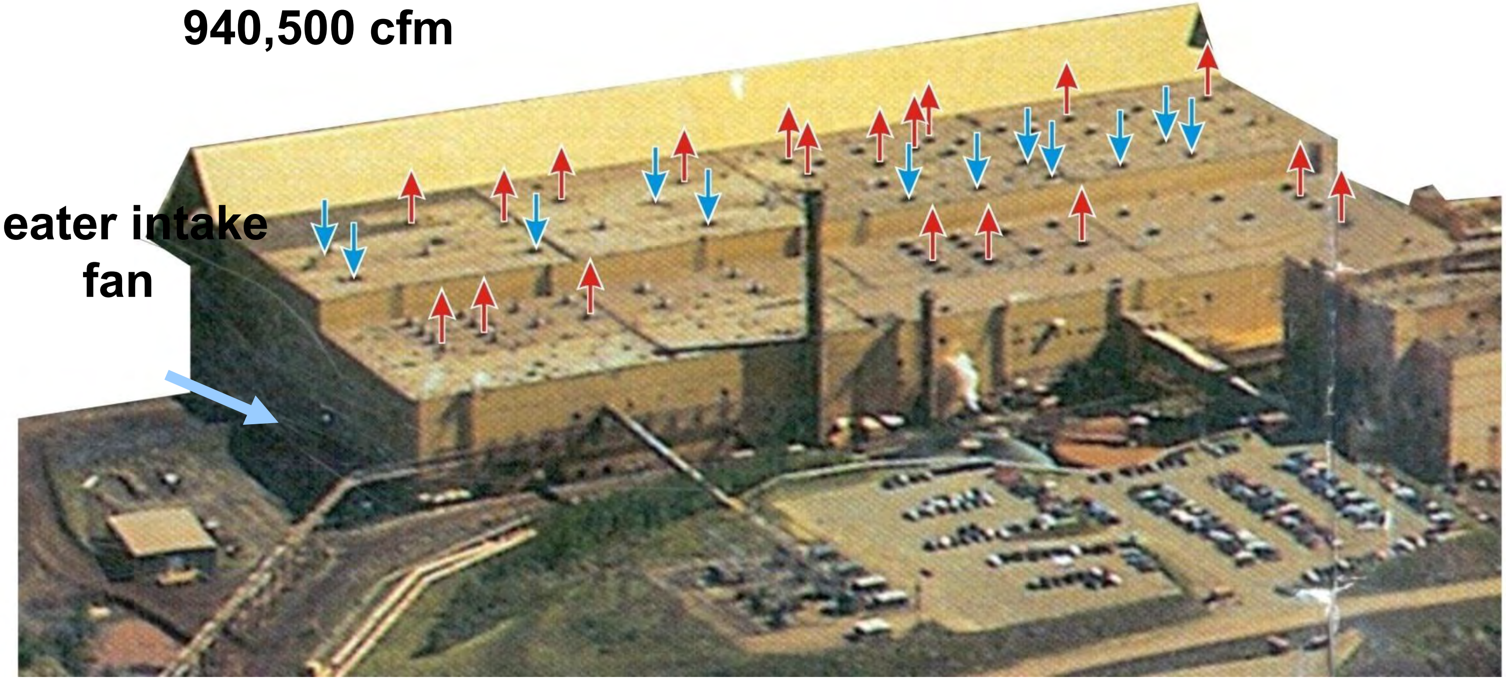
Roof Fan Setup at Tilden
as of 9:30 a.m.
Wednesday, March 10

Intake: 2 intake heaters/12 intake roof fans – 1,045,000 cfm
Exhaust: 19 exhaust fans – 940,500 cfm

Key
Intake Fan
Exhaust Fan

1.1 times more intake air

Heater intake fan

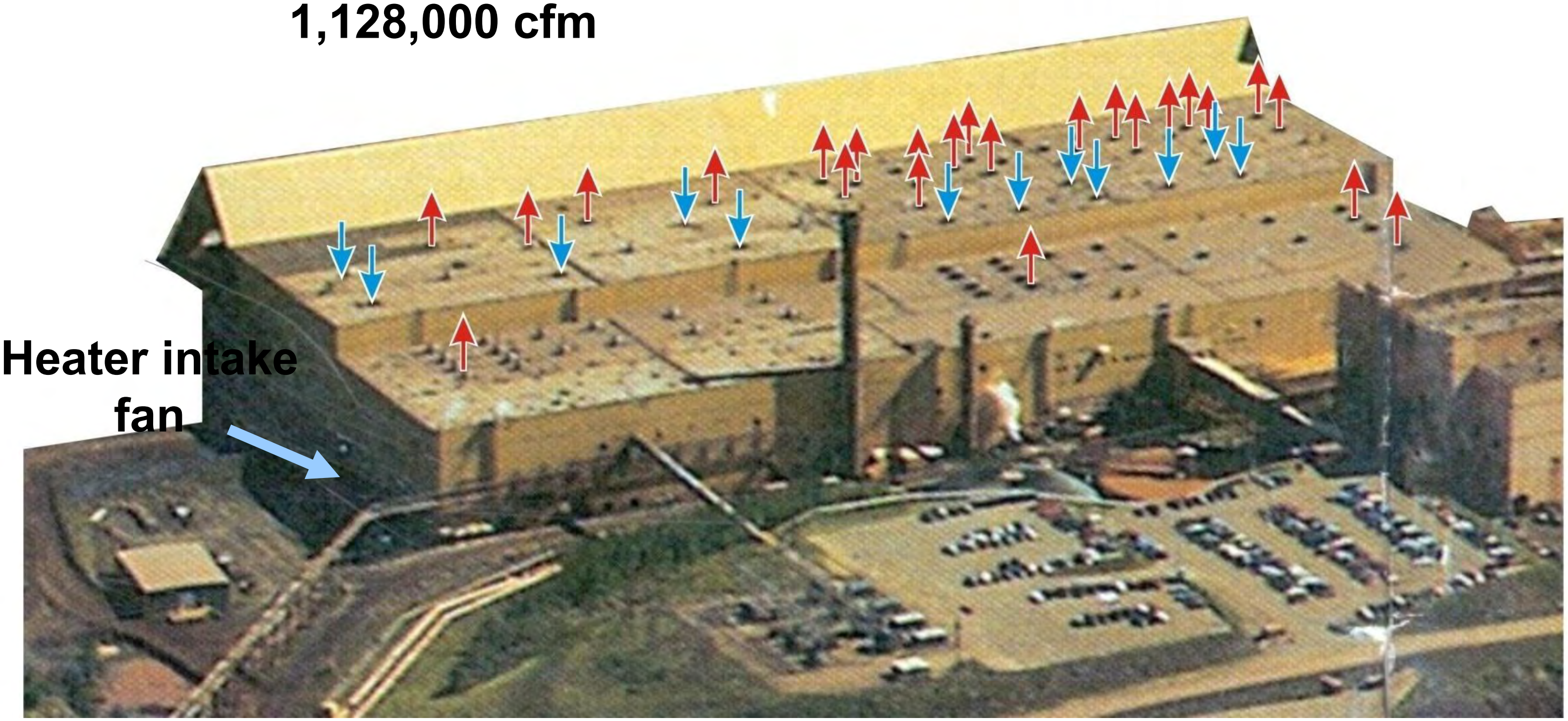


Roof Fan Setup at Tilden
as of 7:00 a.m.
Thursday, March 11

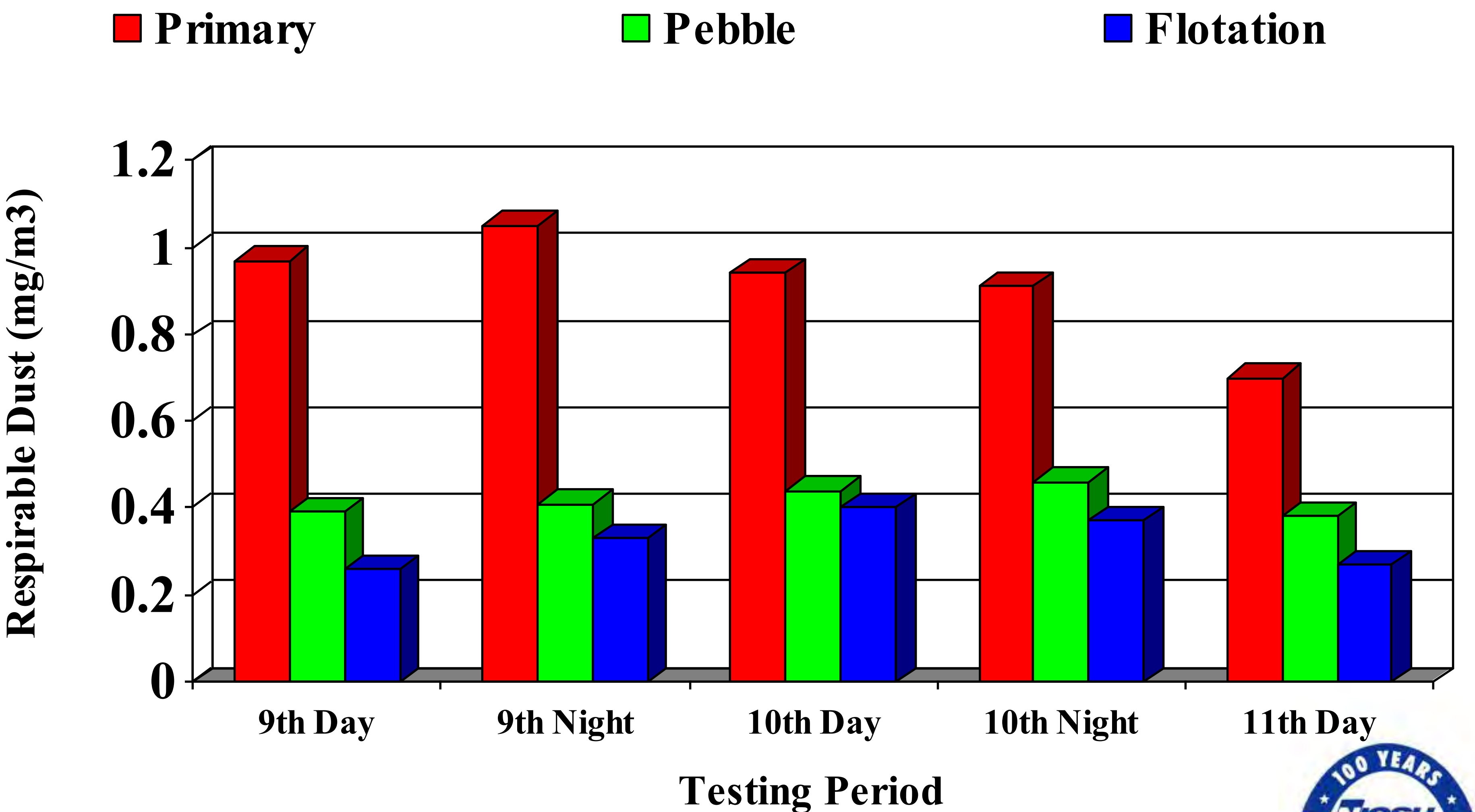
Intake: 2 intake heaters/12 intake roof fans – 1,045,000 cfm
Exhaust: 24 exhaust fans – 1,128,000 cfm

Key
Intake Fan
Exhaust Fan

1.1 times more air exhausted



Respirable Dust Averages

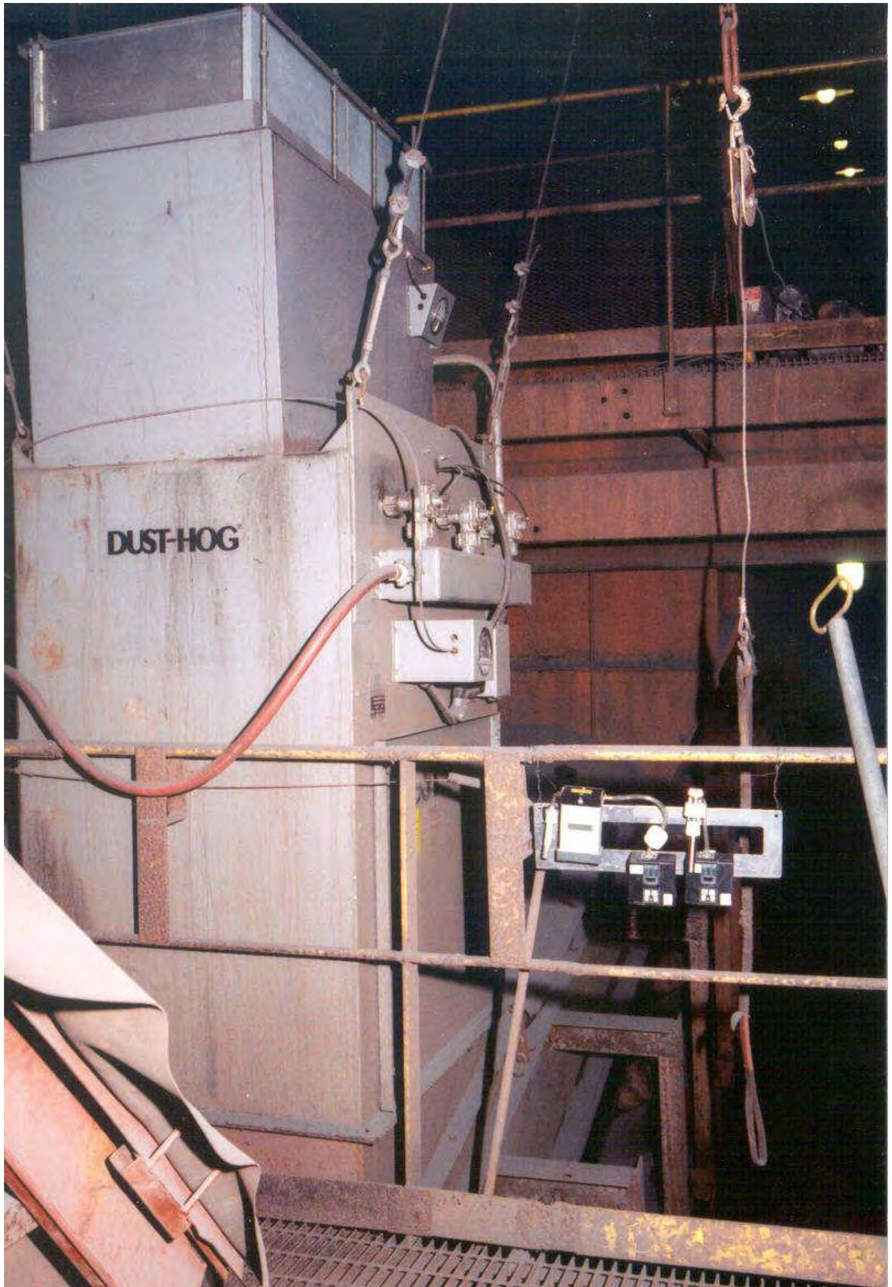


Results from Ventilation Change to Balance and Optimize Airflow

- Respirable dust levels lowered by 31% in the primary grinding area, third ventilation design
- Respirable dust levels slightly lowered in pebble mill and flotation areas

Poor Dumpster Placement (Used Collector Bags)

Dust Collector Evaluation vs. Water Spray Application



OF MIN

Water Spray Application

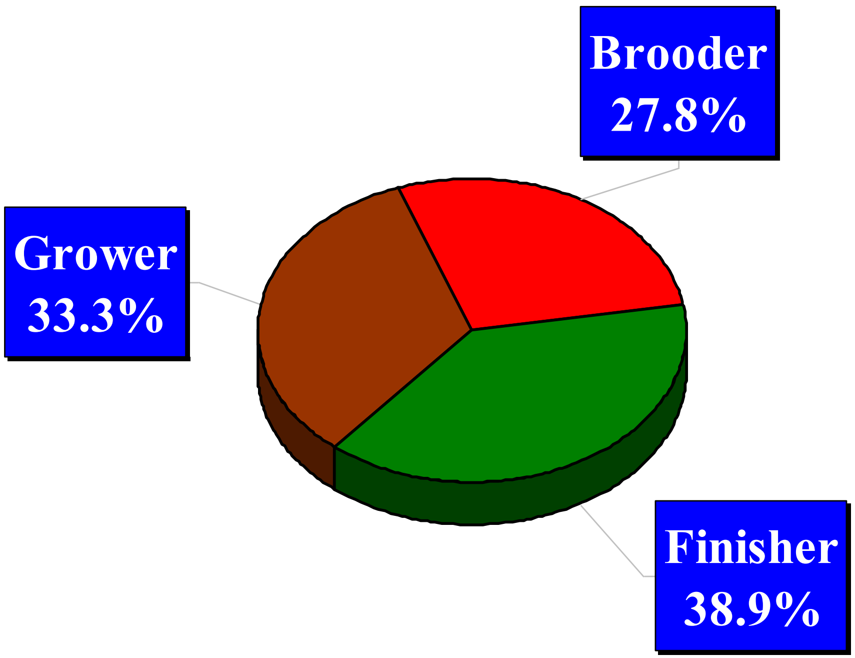
5 - 29 pct reduction

Improving Ventilation in Turkey Farms

Problem: Poor air quality causes high dust levels, ammonia, and humidity.

Turkey Growth

Birth to 18 Weeks



Poults: Brooder Barn

Grower Barn

Finisher Barn

Airflow and Ammonia Measurements

Testing During Winter Months

Heaters for Warming Barns

Curtain Running the Length of the Barn

Installation of Curtains to Force Heat Downward

Comparison

Birds: heated barn 2.3–2.8 lbs heavier

Normal Barn: 2,000 gallons propane
Curtain Barn: 1,100 gallons propane

Estimated savings: $1.5 million in heating cost, while also yielding additional profit because of heavier and healthier birds.

Wet Suppression

Water Application

Two Methods:

- Airborne dust prevention: achieved by direct spraying of the ore to prevent dust from becoming airborne
- Airborne dust suppression: involves knocking down dust already airborne by spraying the dust cloud and causing the particles to collide, agglomerate, and to fall out from the air

Water Considerations:

- Has a limited residual effect due to evaporation; will need to be reapplied at various points throughout the process
- Obviously, under-application is ineffective
- Over-application in amount/volume can cause various problems, impacting equipment and the overall process

Rule of Thumb: **A good starting point is in the 0.5–1.0% moisture range. Early stages of process (course product) is not as critical as later stages. Ideally, vary the amount/volume at each application to determine the optimal design.**

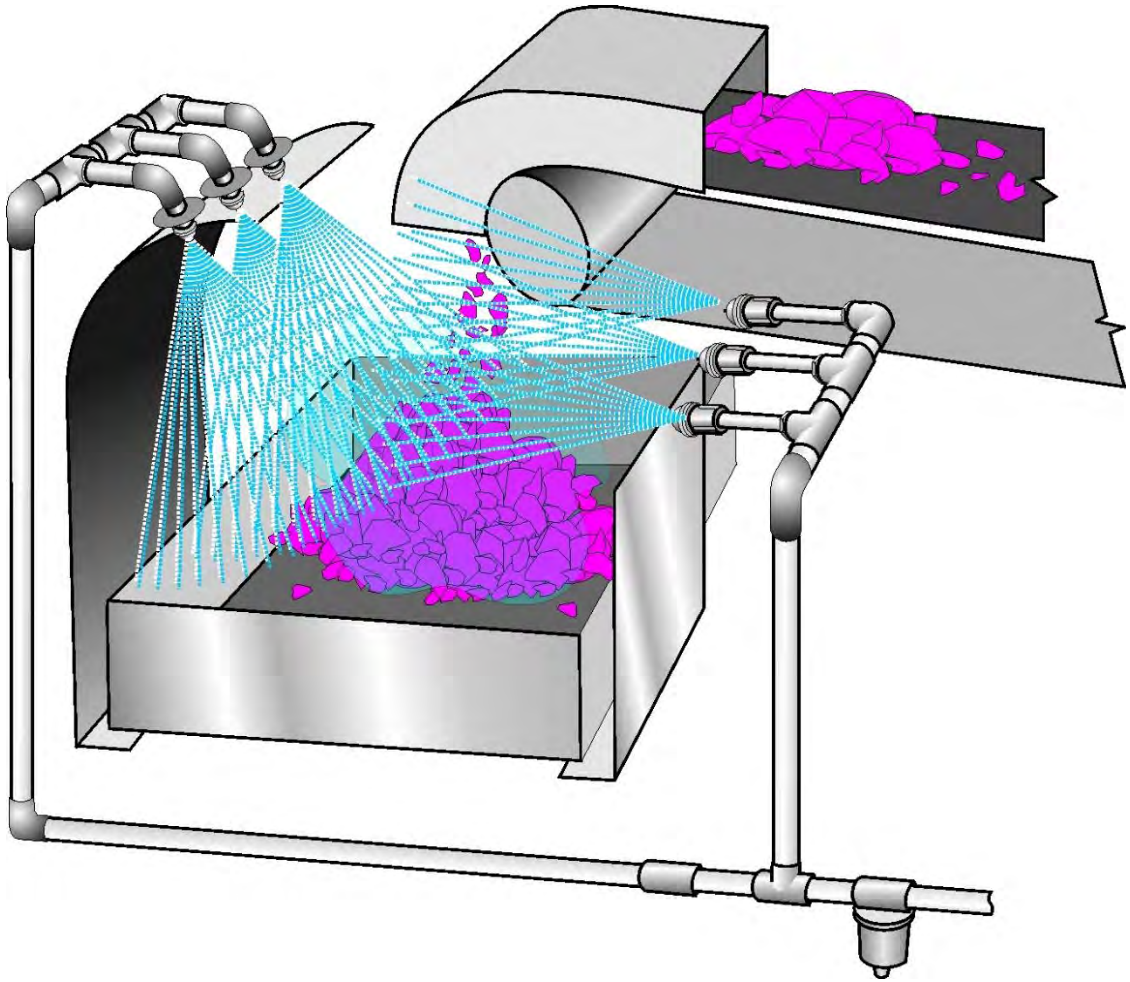
Other Considerations:

- **Important to ensure that dust particles stay attached to the ore material**
- **Uniformity of wetting is important**
- **Best application is spraying ore with water and then mechanically mixing together**
- **Ideal system should be automated so that sprays are only activated when ore is actually being processed**

Nozzle Location

- Nozzle should be located upstream of transfer points
- Locate nozzles at locations for best mixing
- Nozzles should be an optimum target distance from the ore, far enough to provide coverage, but close enough so that air currents do not carry droplets away from intended target
- Droplet size should be considered

Effective Spray Pattern and Distance From Ore

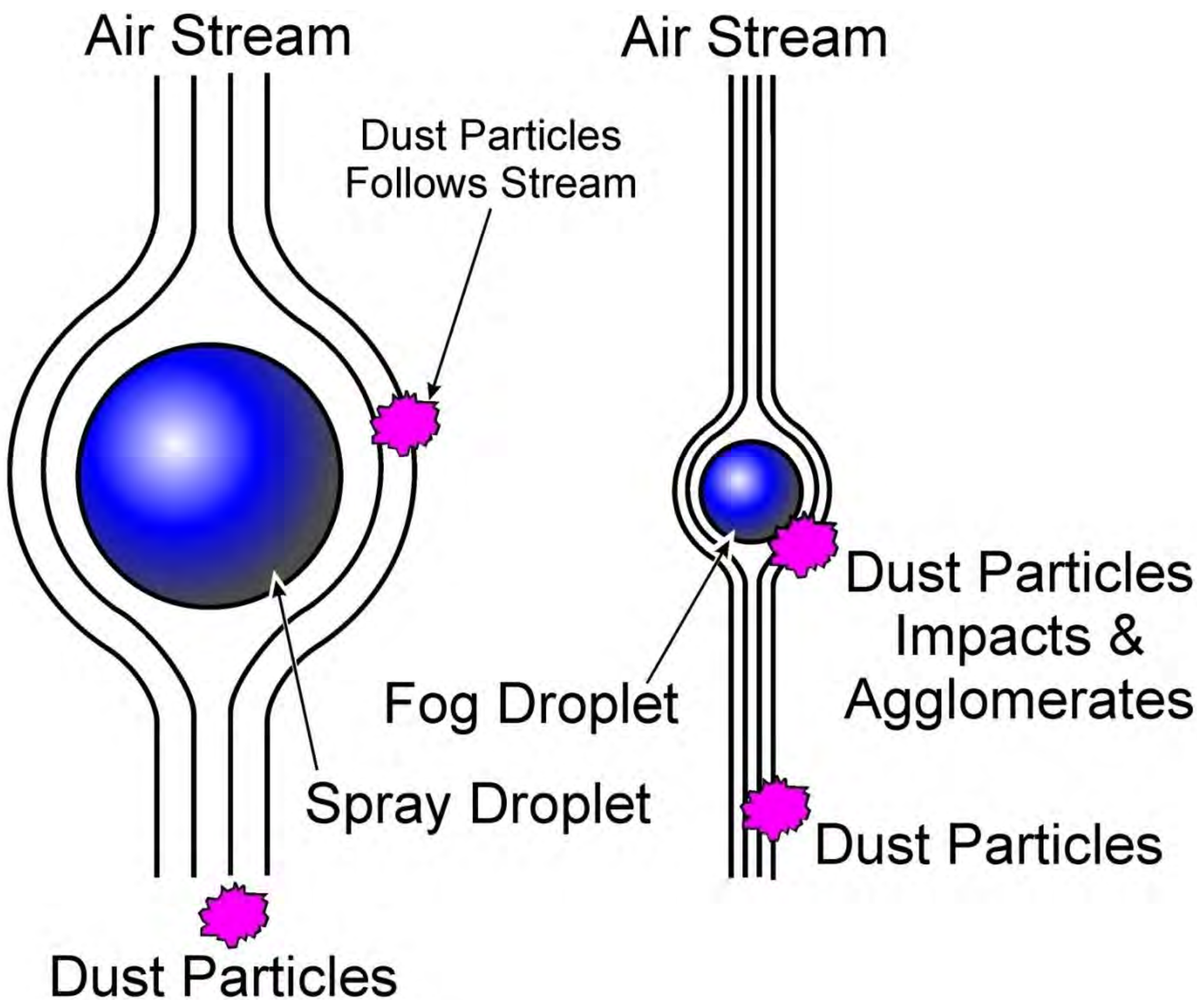


Ineffective/Effective Water Application

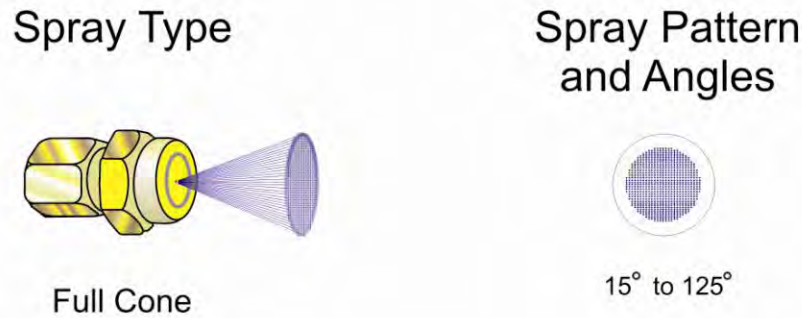
Droplet Size:

- **To keep dust from becoming airborne:**
  Water droplet sizes above 100 microns should be used.
- **To knock down existing dust in air:**
  Water droplets should be in a similar size range to the dust particles.

Water droplet size should be matched to the size of the dust particles.



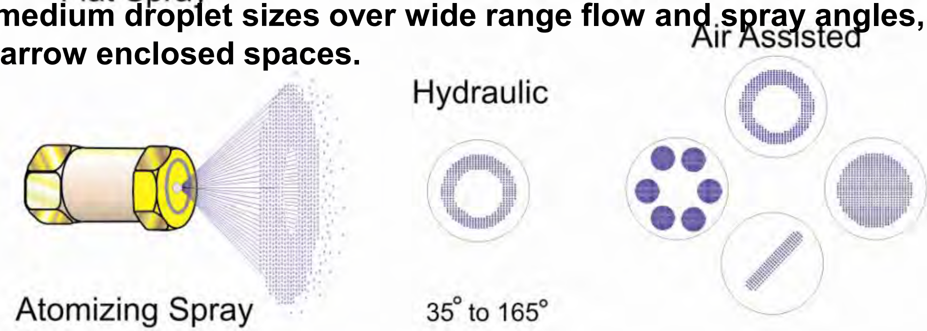
Spray Pattern and Nozzle Type



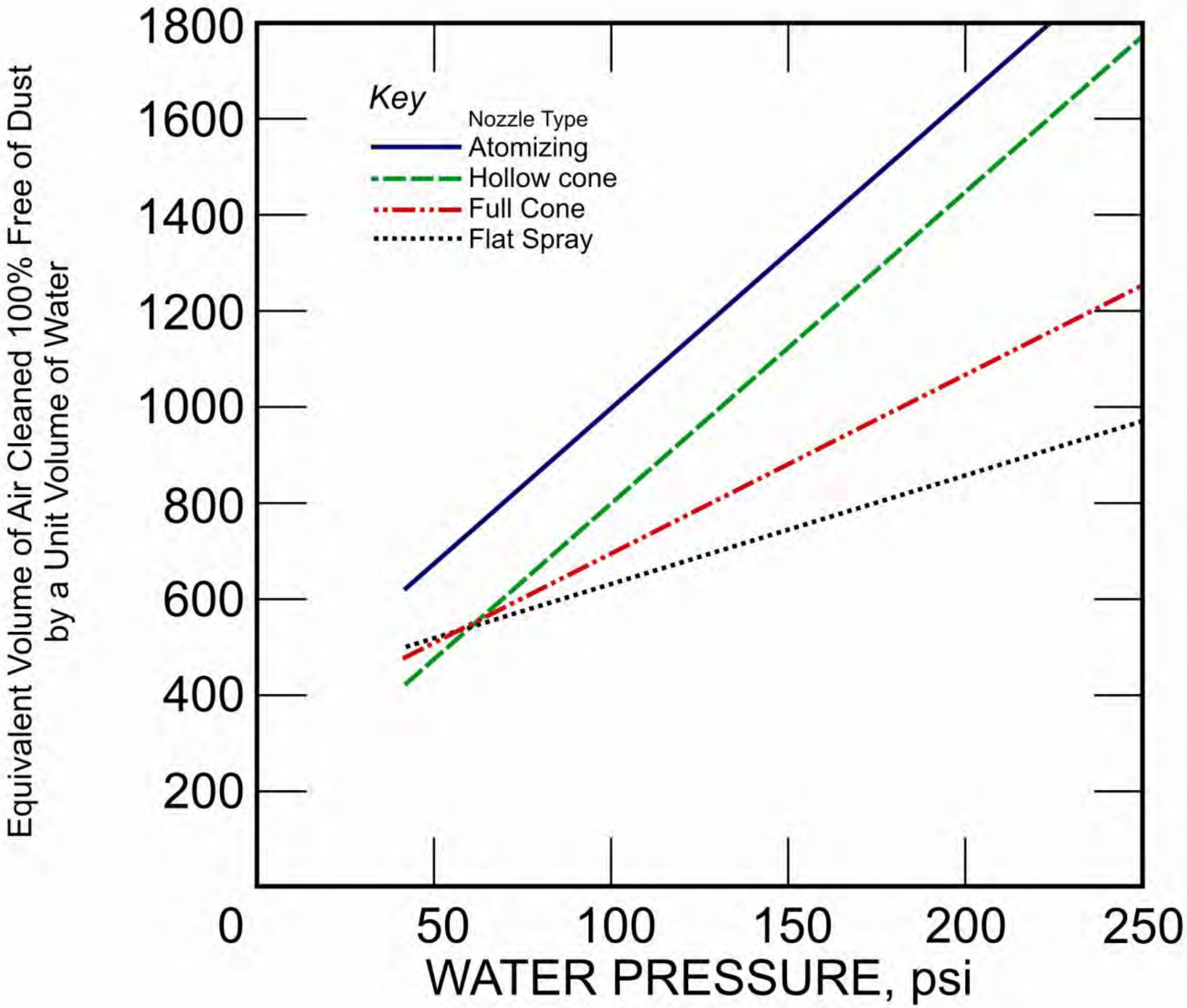
Medium to large droplet sizes, wide range pressures and flows. Normally used when sprays are further from dust sources.

Produce small to medium droplet sizes.

Small to medium droplet sizes over wide range flow and spray angles, used in narrow enclosed spaces.



Two designs: hydraulic (fine droplets) and air-assisted (finest droplets). Both types need to be located close to the dust source.


Equivalent Volume of Air Cleaned 100% Free of Dust by a Unit Volume of Water
WATER PRESSURE, psi
Key
Nozzle Type
Atomizing
Hollow cone
Full Cone
Flat Spray
1800
1600
1400
1200
1000
800
600
400
200
0
50
100
150
200
250

Common dust control application areas and the type of spray nozzle typically used for that application

	Air Atomizing	Hydraulic Fine Spray	Hollow Cone	Flat Spray	Full Cone
Airborne Dust Suppression					
Jaw crushers	●	●	●		
Loading terminals	●	●			
Primary dump hopper	●	●			
Transfer points	●	●			
Dust Prevention					
Stackers, reclaimers		●			●
Stockpiles		●		●	
Transfer points		●	●		●
Transport areas/roads			●		

.

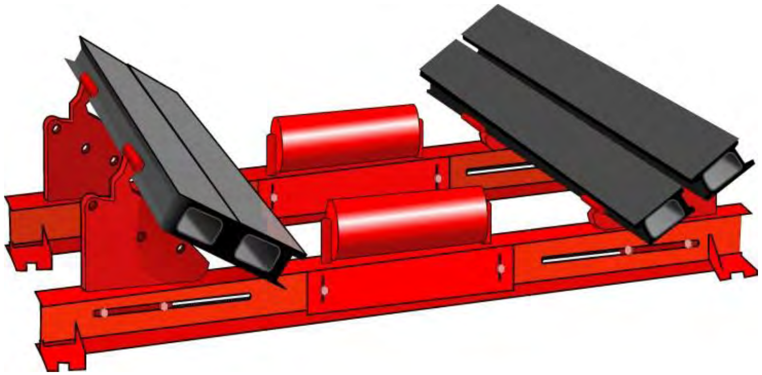
Water Cleanliness

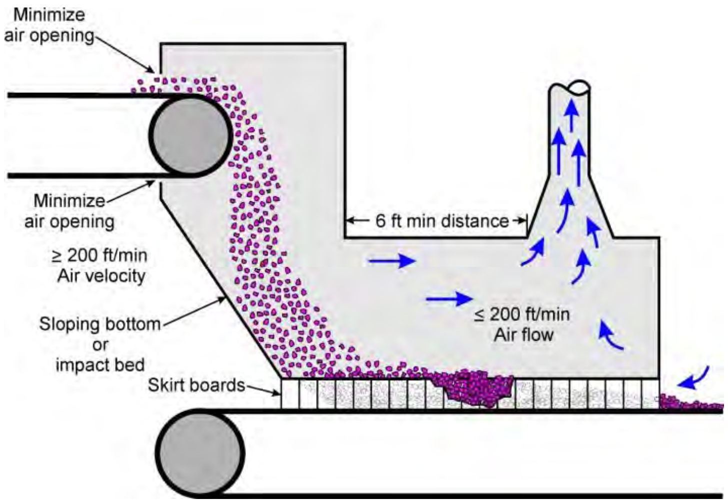
- If spray nozzles become plugged with sediment or debris, rendered ineffective
- Because the water used at most operations is from a settling pond, water purity is a great concern
- Water filtering system is critical. A hydro-cyclone system with a built-in accumulator flush should be considered as the first stage of a filtering system

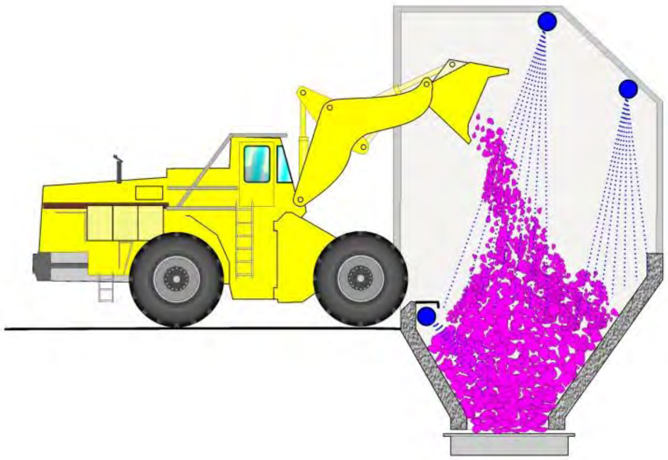
Nozzle Maintenance

- **Erosion and wear**
- **Corrosion**
- **Accidental damage**
- **Checking nozzle performance**

Primary Dump/Conveyors/Transfer Points







Primary Dump

Two Dust Sources: Billowing and Rollback

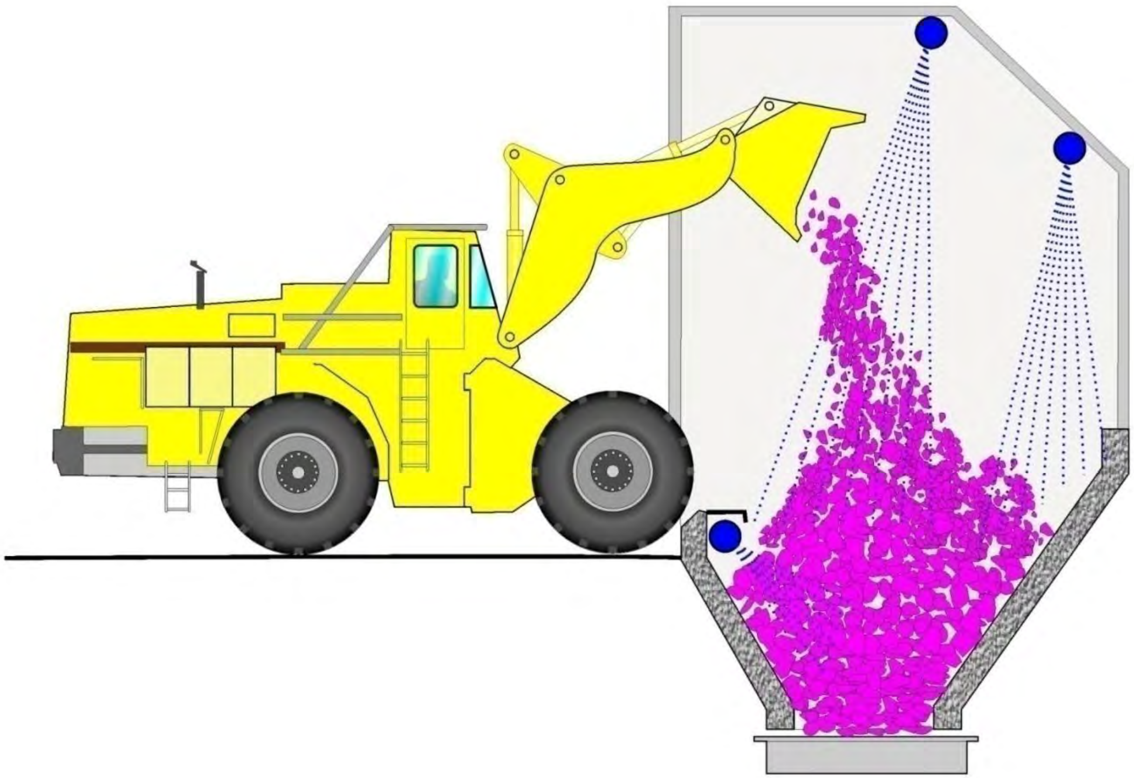

Control Methods

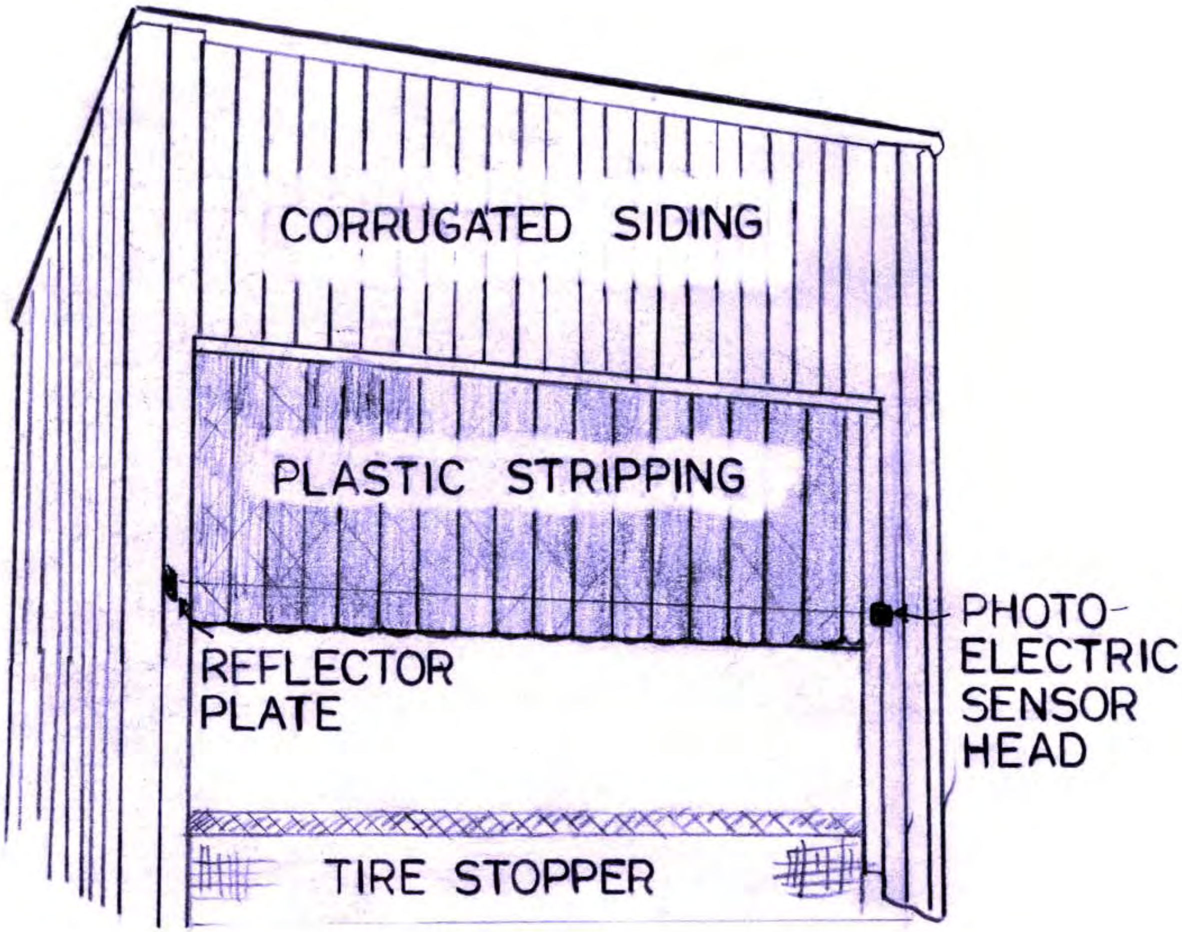
Billowing:

- Suppress
- Enclose
- Filter (LEV)

Rollback:

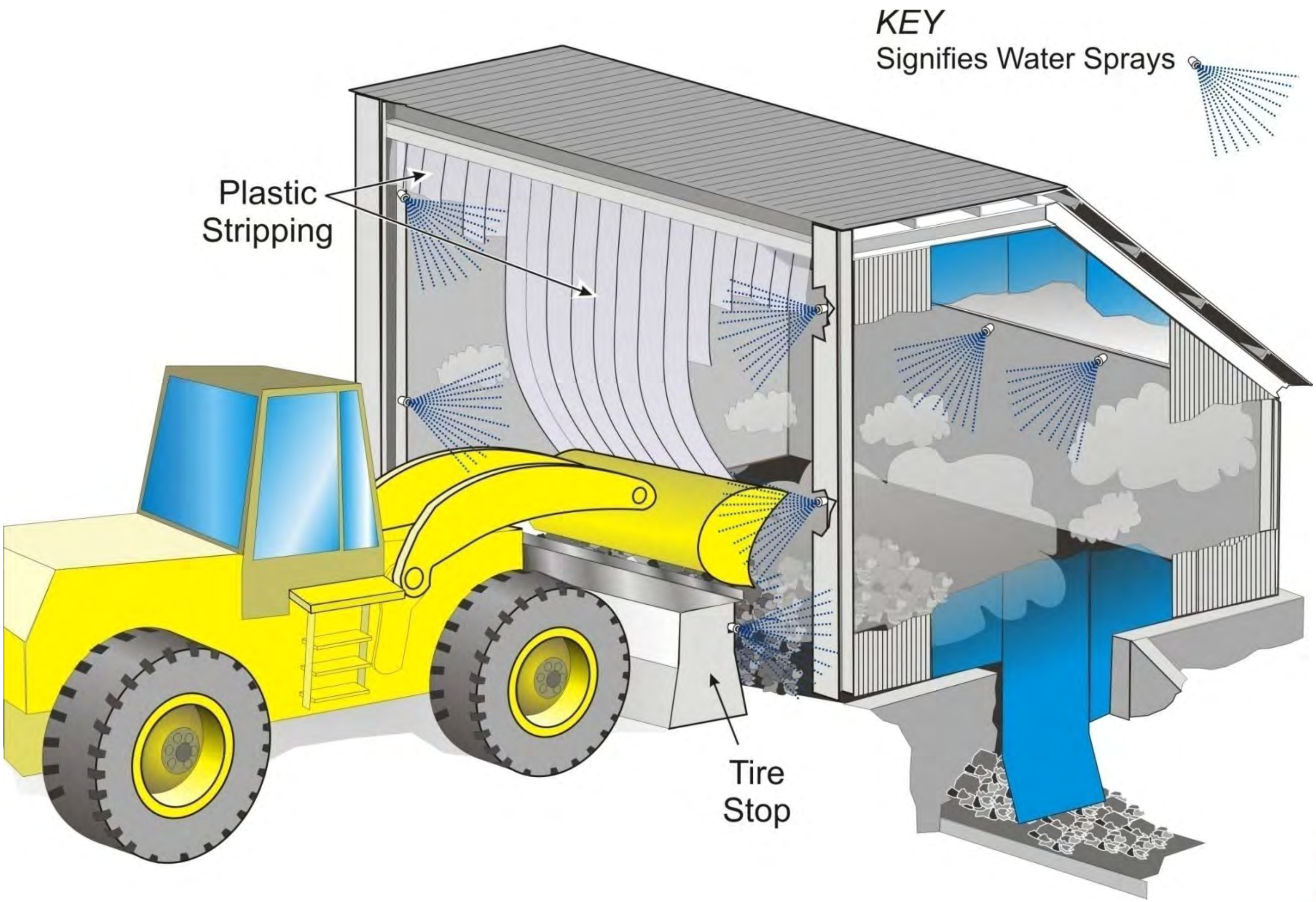
- Tire stop water spray system



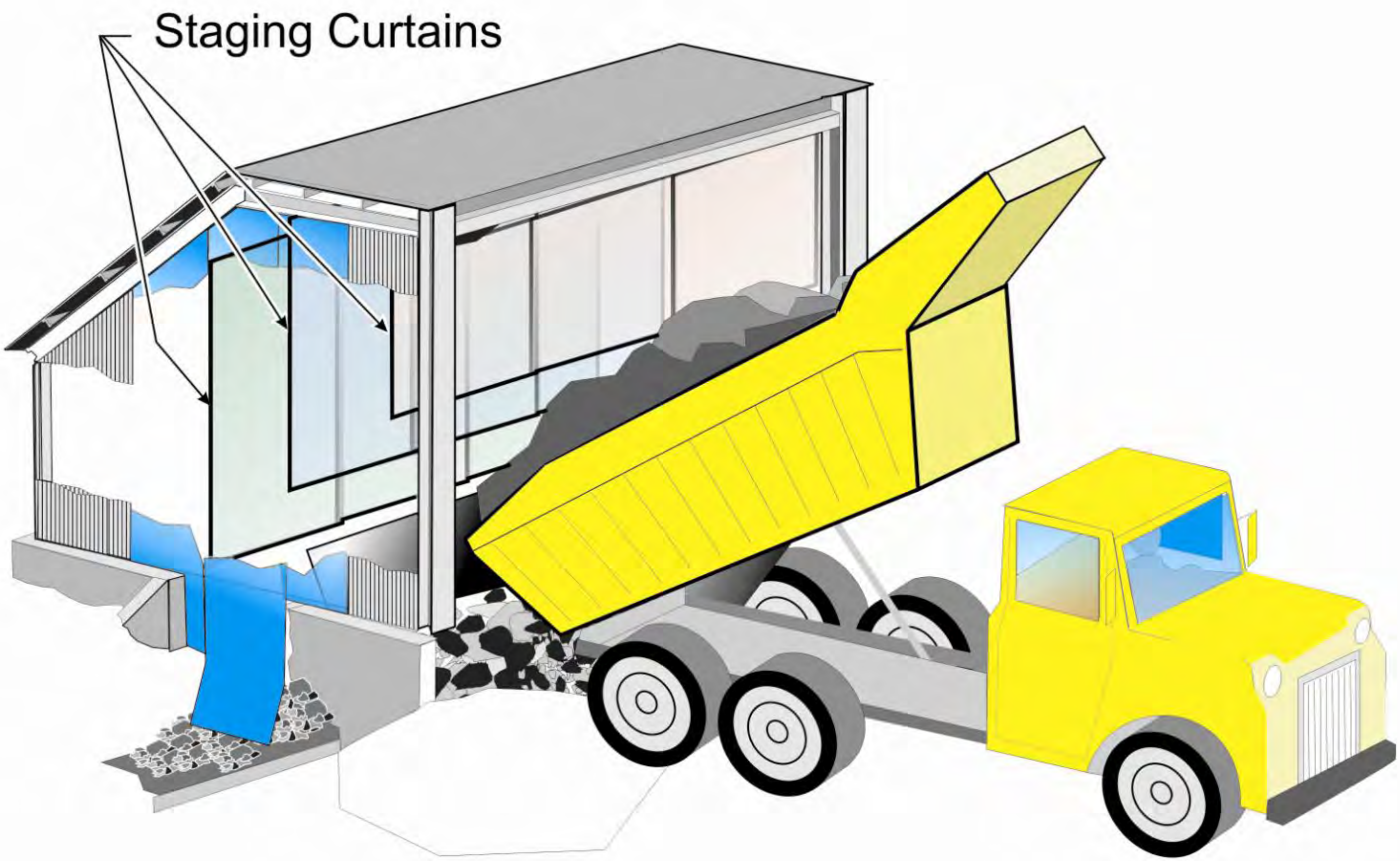

CORRUGATED SIDING
PLASTIC STRIPPING
REFLECTOR PLATE
PHOTO-ELECTRIC SENSOR HEAD
TIRE STOPPER

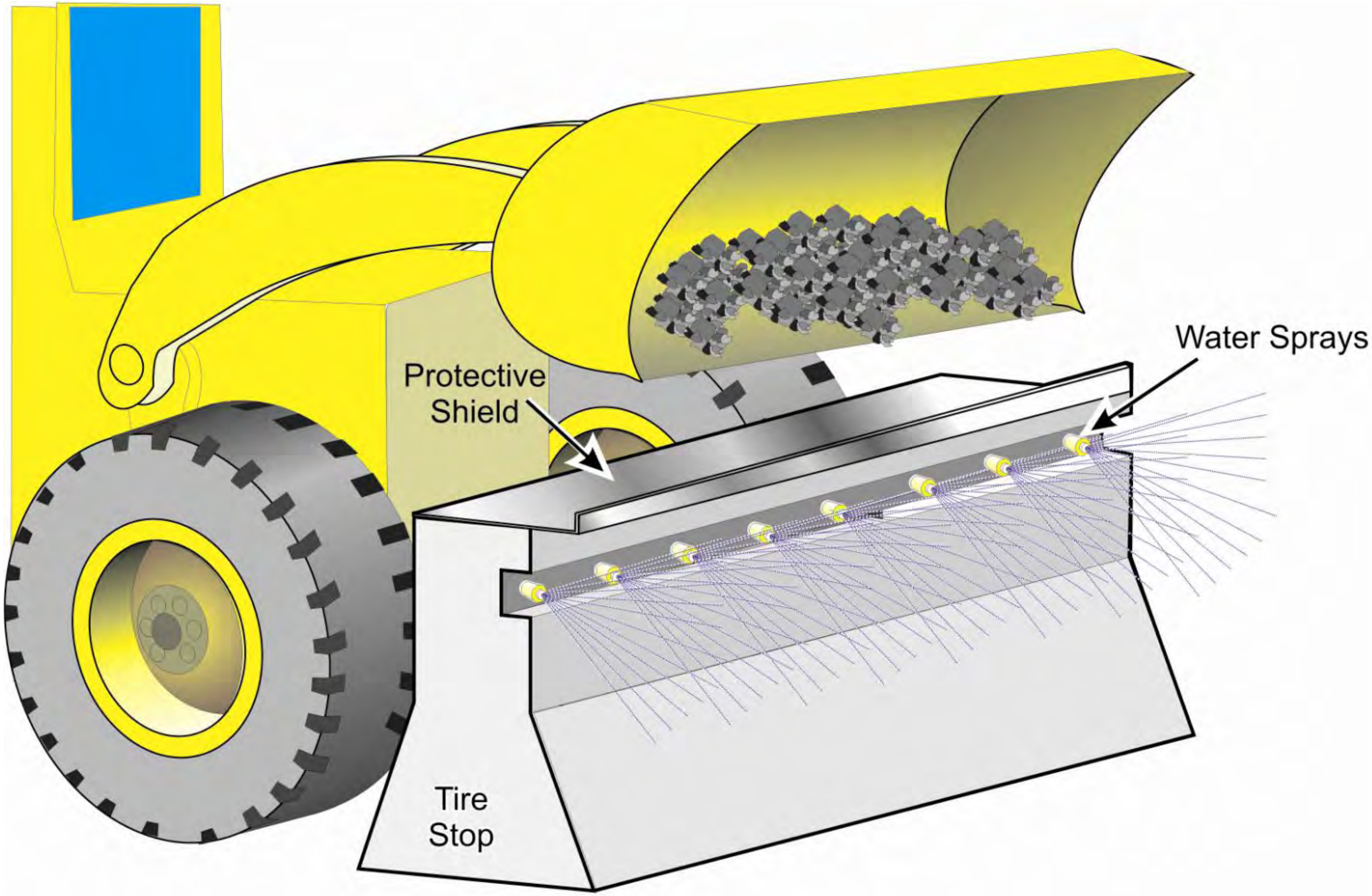
Installing Clear Plastic Stripping

Plastic Stripping and Tire Stop Water Spray System



OFFICE OF MINE SAFETY AND HEALTH RESEARCH


Staging Curtains

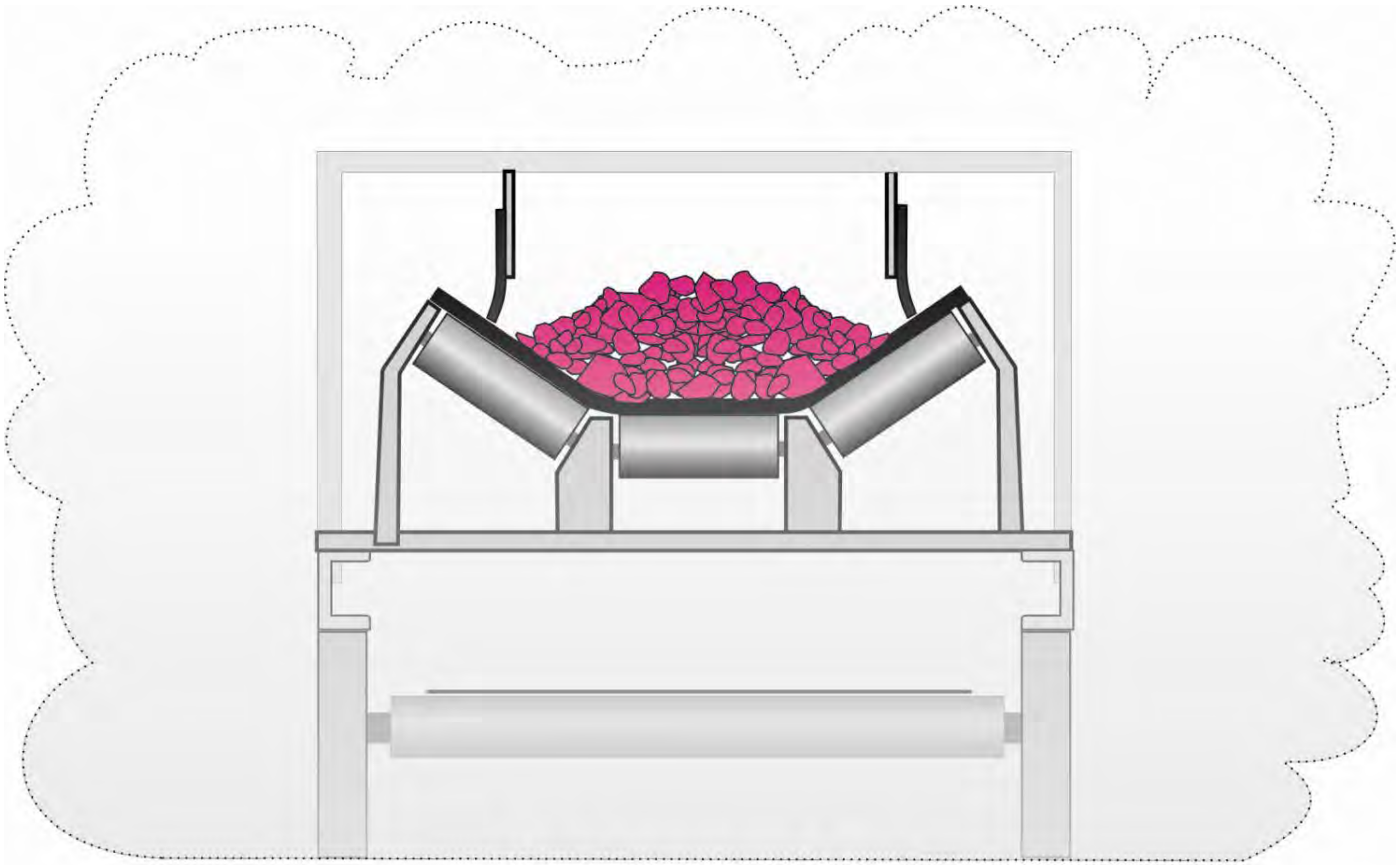

Water Sprays
Protective
Shield
Tire
Stop

Other Application of Plastic Stripping to Enclosed Areas

Conveyor Belt Dust:

Four Main Sources of Dust Generation and Liberation:

- Ore is dumped onto belt
- Ore travels on belt
- Ore dropping from underside return idlers (carryback dust)
- Ore transferred from belt



Airborne dust

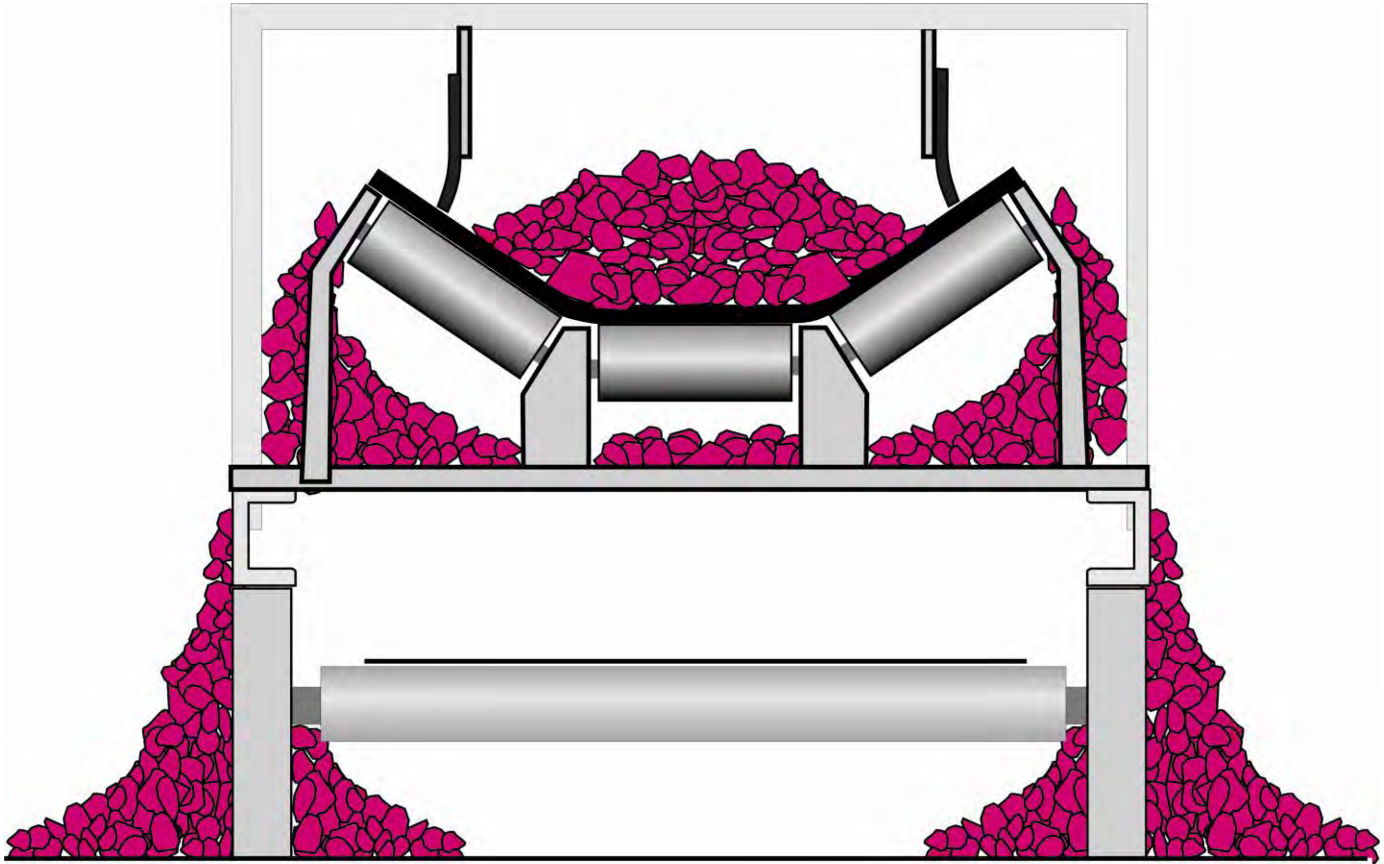
Airborne Dust

Conveyor Belt Considerations

One challenge with conveyors is the number of belts used and the total distance traveled throughout the operation. When belts are outside, dust liberation is not as critical as within a facility.

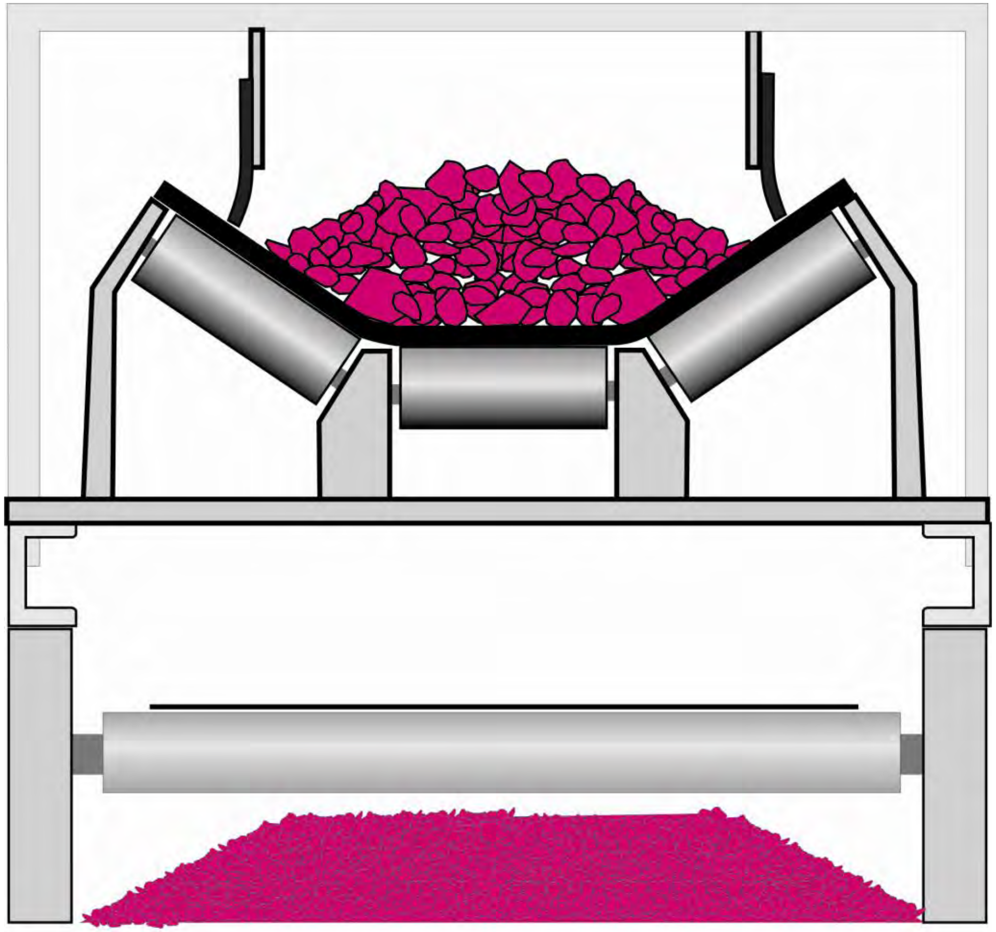
Another challenge is their ability to liberate dust while operating whether they are loaded or empty.

Controlling dust from conveyors requires constant vigilance by maintenance staff to repair and replace worn and broken parts, and to perform constant housekeeping.



Spillage

Spillage: Poor Conveyor Housekeeping Practices

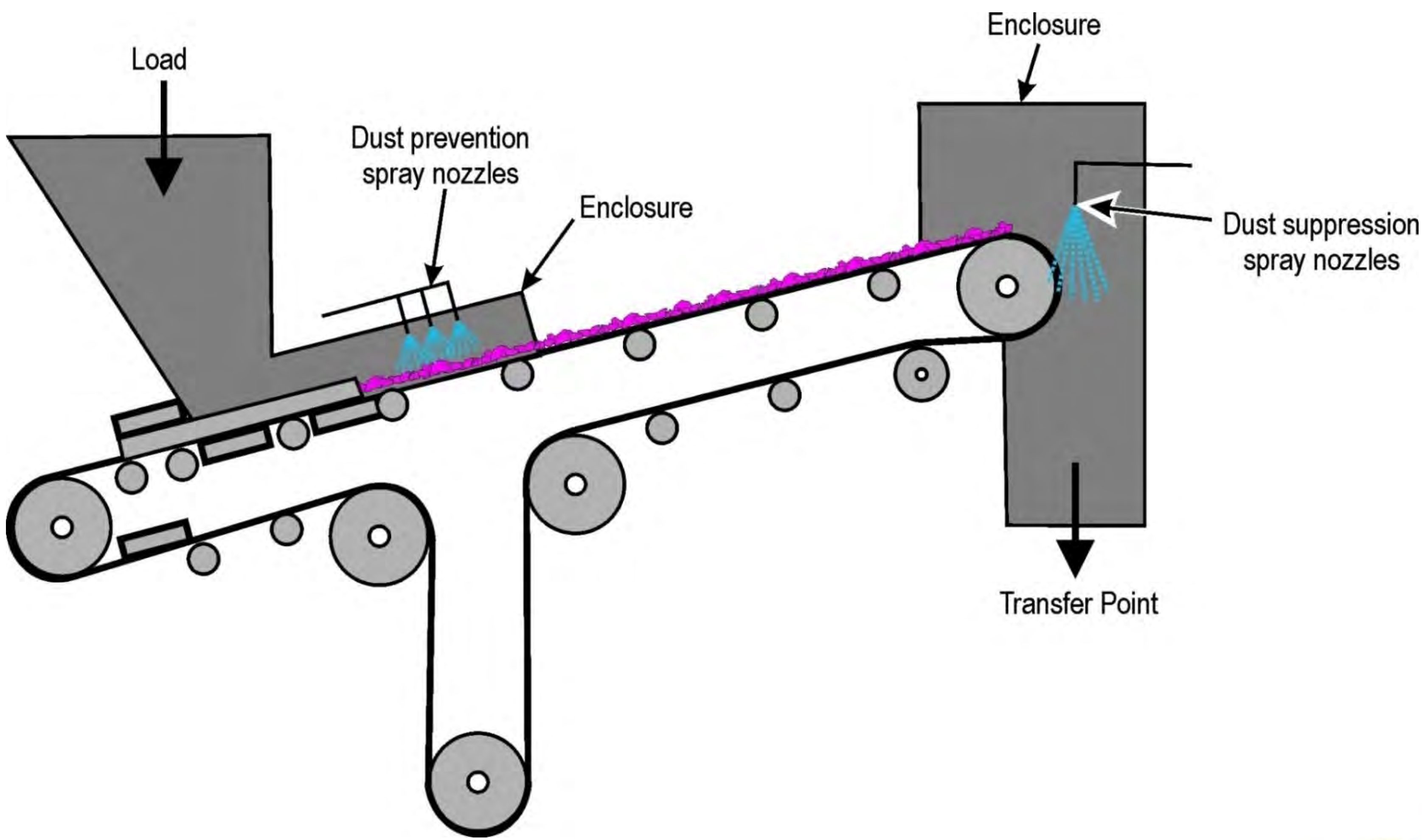


Carryback

Carryback Dust

Conveyor Belt Control Techniques

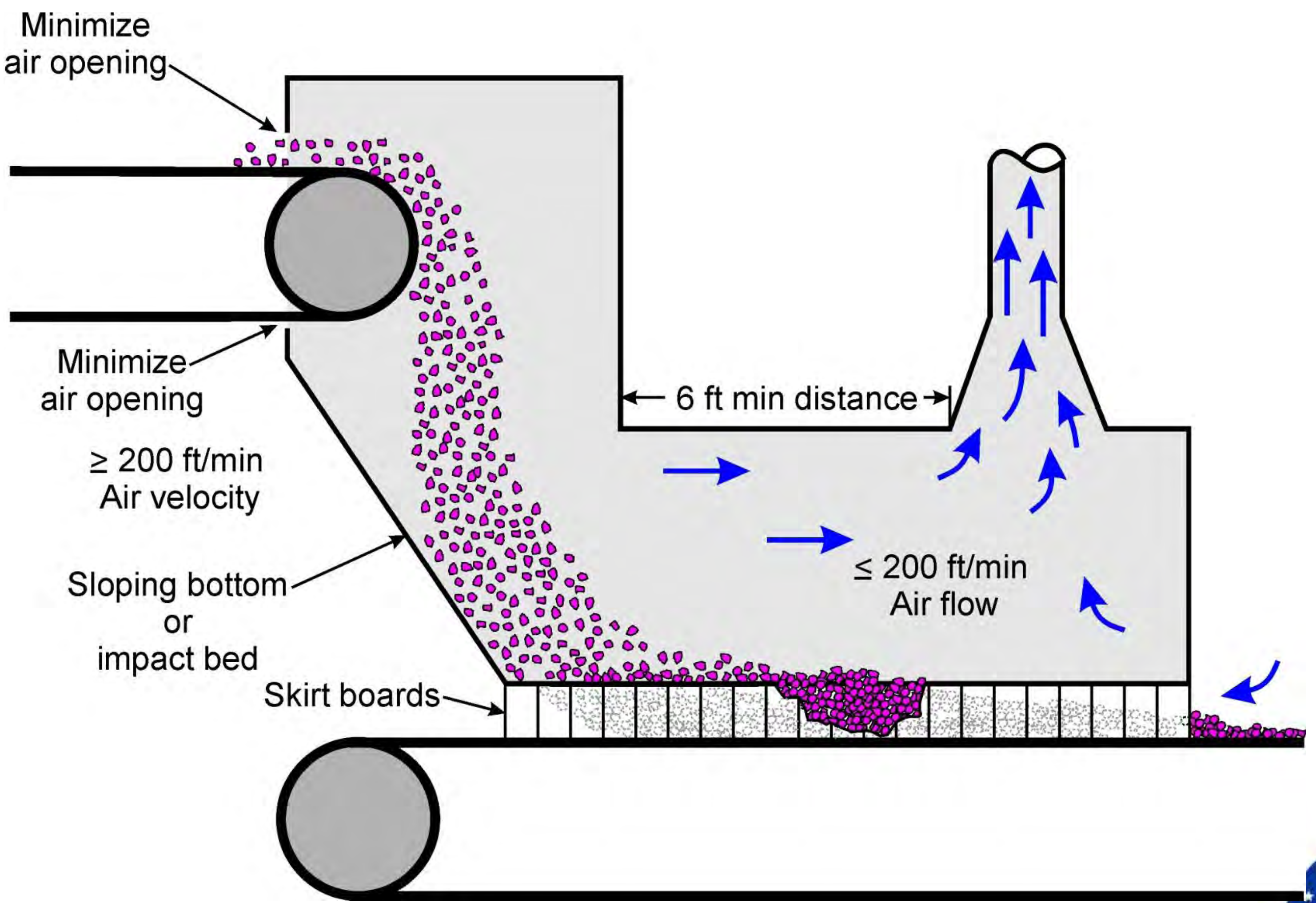
- Suppression
- Enclosures
- Belt scrapers
- Belt wash
- Effective belt loading


Load
Dust prevention
spray nozzles
Enclosure
Enclosure
Dust suppression
spray nozzles
Transfer Point

Conveyor Water Sprays:

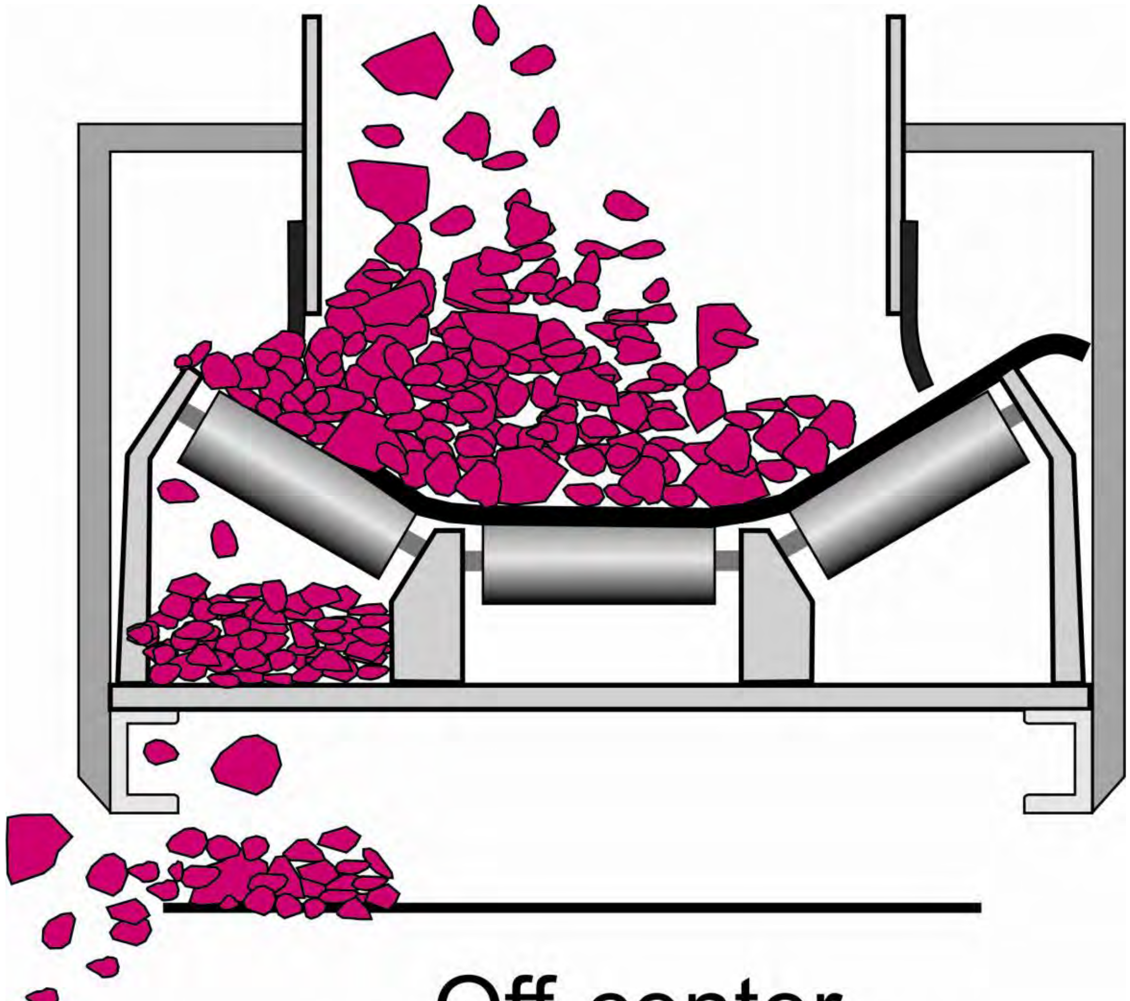
- High-volume, high-pressure sprays should be avoided.
- Amount of moisture applied should be varied and tested. The 0.5 to 1.0% moisture to product ratio is a good starting point. Excess moisture can cause slippage problems (belt performance).
- Some studies show wetting return side of conveyors can also minimize dust liberation. Can locate sprays on top (wetting product) and bottom (belt bottom and idlers) at same location.
- Fan sprays are most common; they minimize volume for the amount of coverage. Advantageous to place at beginning of process.
- Using more spray nozzles at lower flow rates and positioning them closer to the ore/product is more advantageous.

Enclosures



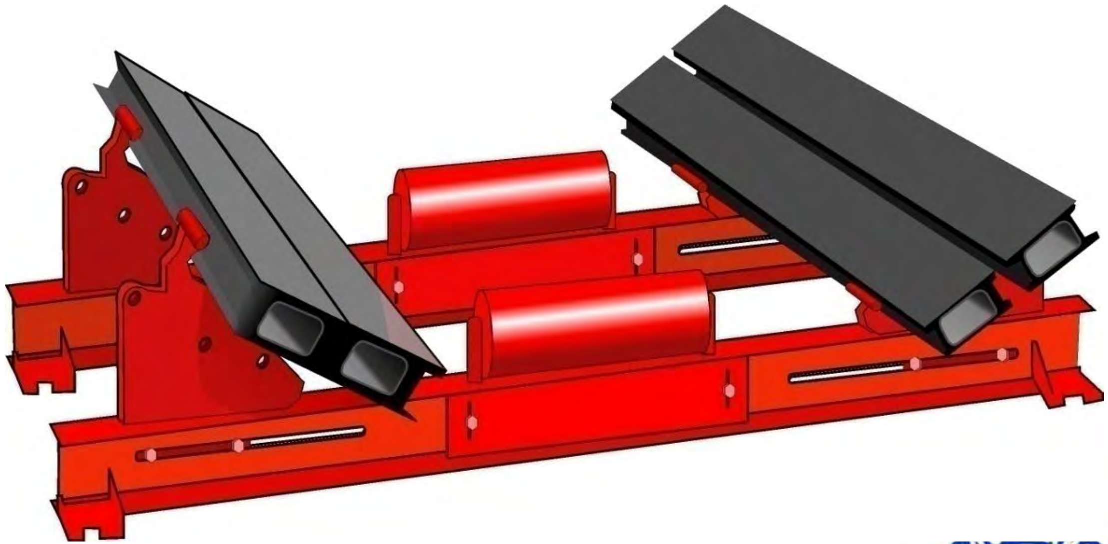
Minimize
air opening
Minimize
air opening
≥ 200 ft/min
Air velocity
Sloping bottom
or
impact bed
Skirt boards
6 ft min distance
≤ 200 ft/min
Air flow

Ineffective Belt Loading



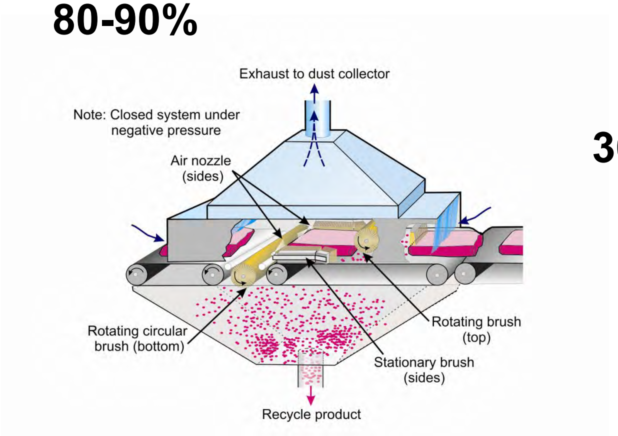
Off-center

Impact-absorbing Belt Cradles

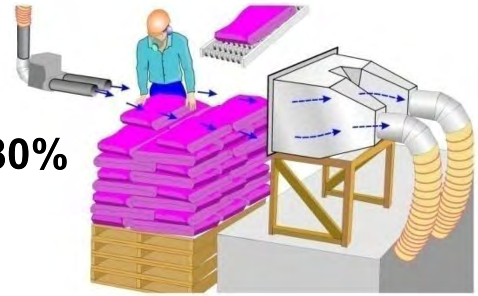


Conclusion

80-90%

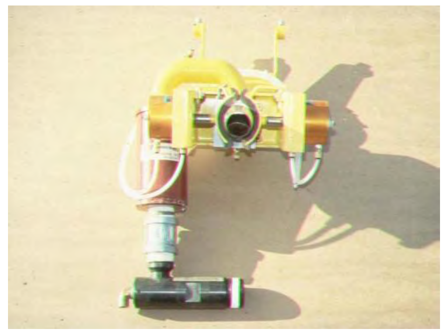


30-80%

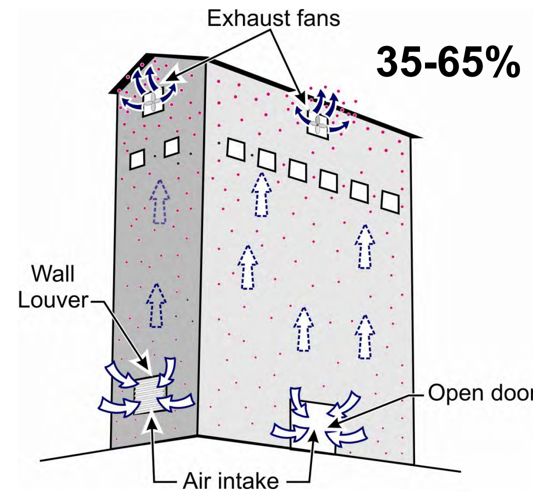


90-99%

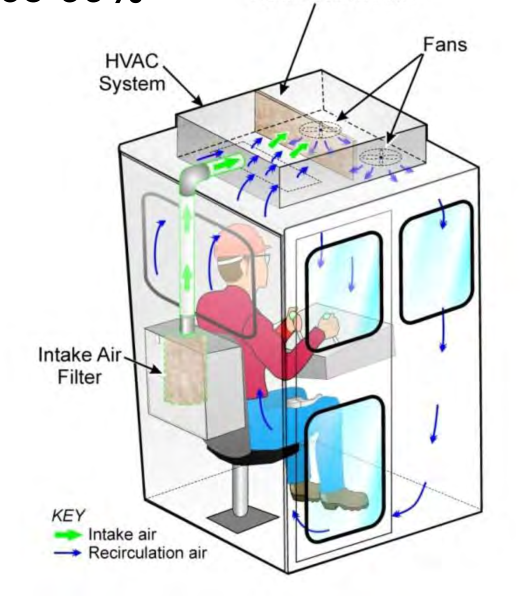
80-90%

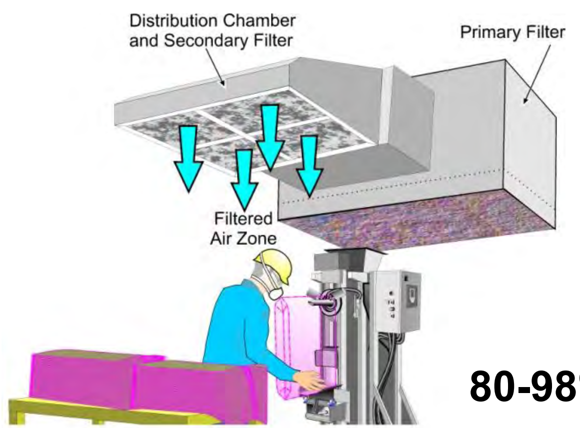


35-65%



65-99%





80-98%

Disclaimer

The findings and conclusions in this presentation are those of the authors and do not necessarily represent the views of NIOSH. Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH). In addition, citations to Web sites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these Web sites. All Web addresses referenced in this presentation were accessible as of the date the presentation was originally delivered.

Andy Cecala

Dust Control, Ventilation, and Toxic Substances Branch

Pittsburgh, Pittsburgh

Phone: 412-386-6677

E-mail: acecala@cdc.gov or aic1@cdc.gov