Dry Fog Dust Suppression Systems

Presented by: Dust Solutions, Inc.
Richard Posner, President

Industry Challenges

- Maximize value of material mined or used in plants
  - Reduce material losses
  - Prevent moisture addition to product (typically)
  - Reduce maintenance and downtime
  - Cost reductions on processing without production impact
- Potential for environmental impact
  - Controlling fugitive dust during loading, unloading and processing
  - Controlling particle uptake from material stockpiles
  - Reducing respirable PM10 and PM2.5 particles for employee and worker safety and health

PM10 and PM2.5

- PM10 refers to particulate matter 10um and below.
  - Highly regulated globally in mines and power plants.
  - This type of dust can easily reach the lungs without being blocked by the nasal passage or mucus membranes.
- PM2.5 refers to particulate matter 2.5um and below.
  - Less regulated globally, but even more dangerous due to the ability to bypass the mucus membranes and nasal passage filters completely.
  - Sources of particles include crushing or grinding operations.
  - May be formed in the air from the chemical change of gases. They are indirectly formed when gases from burning fuels react with sunlight and water vapor.

Respirable Dust vs Visible Dust (Inhalable)

Human Hair
89 microns
0.089 mm

Inhalable Dust
< 100 microns
0.1 mm

Respirable Dust
< 10 microns
0.01 mm

- Visible dust, also known as inhalable dust can be up to 100 micron in size. Inhalable dust enters the nose or mouth during breathing and can settle anywhere in the respiratory tract.
- Respirable dust is too small to be seen with the eye, typically particles 10 micron or smaller, including PM10 and PM2.5
  - Respirable particles have the potential to penetrate the nose and upper respiratory systems and settle and deposit on the lungs.
  - Chronic exposure to respirable dust particles has the potential to impair many cellular functions throughout the body.

Dangerous Aspects of Dust

- Quartz particles
  - Can cause fibrous or scar tissue formation in the lungs, which reduce the lung's ability to extract oxygen from the air
  - Possible causes of lung cancer
- Silica in the dust
  - OSHA limit of 2.4 mg/m^3 exposure (with 5% SiO_2)
  - Cause of pneumoconiosis, chronic obstructive pulmonary disease, and silicosis
- General Dust
  - Irritation, sneezing, general respiratory problems like bronchitis
- Explosion and fire hazards

Effects of Dust

- Impacts on neighboring areas and local communities
- Impact on employees and general health of the workers
- Material loss
- Overall hazards in build up areas

Reduction Methods for Respirable Dust

- Dust Suppression
  - Water Sprays
  - Chemical Systems
  - Dry Fog
- Dust Collection
- Masks for workers
- Cleaning of areas

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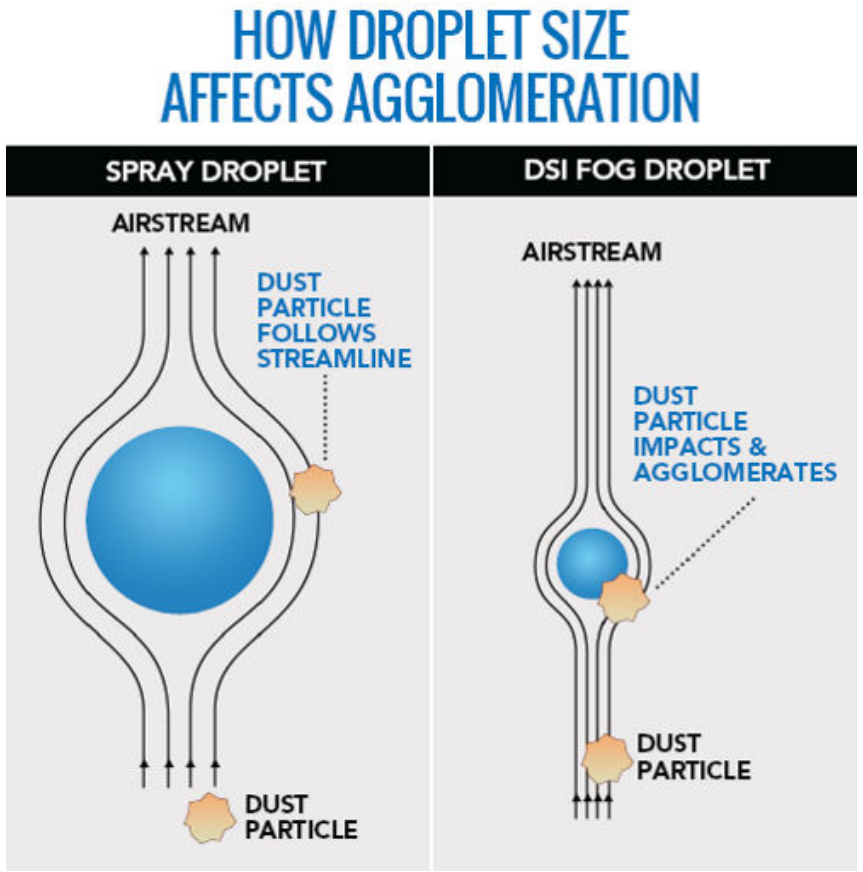
PRINCIPLES OF OPERATION

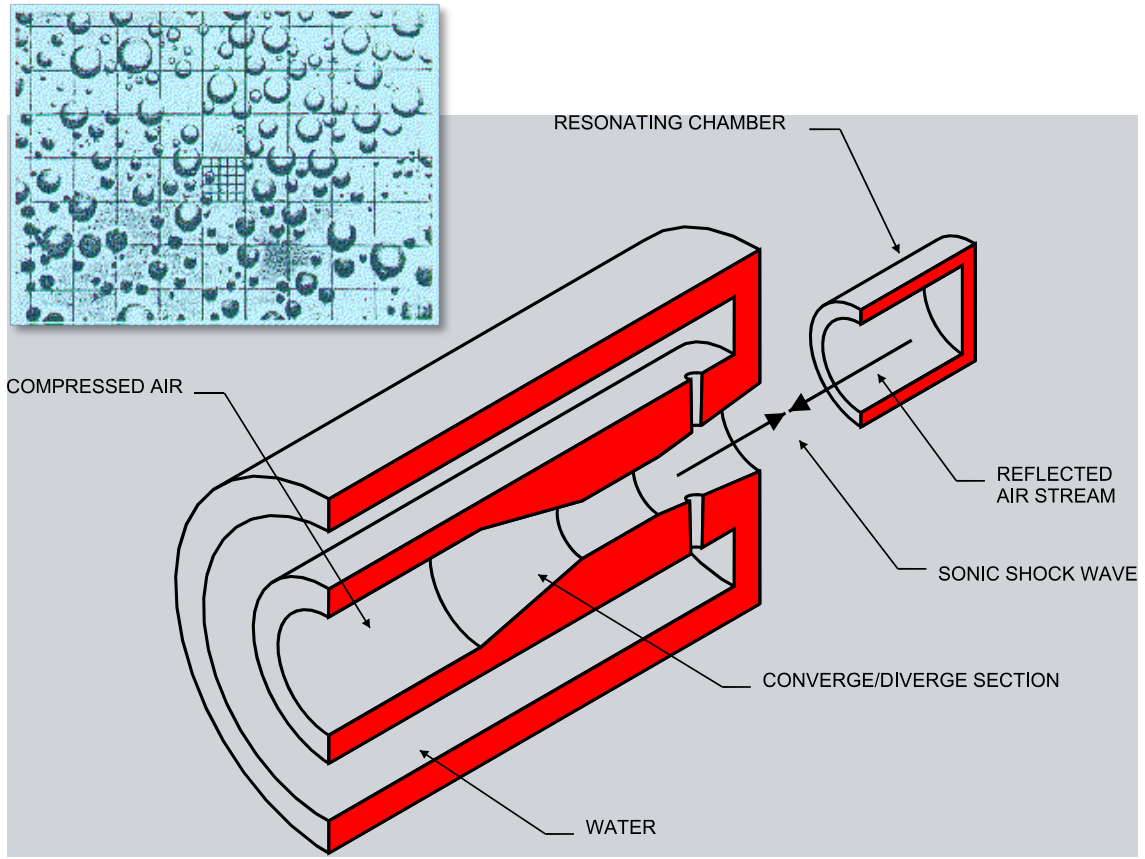
Dry Fog Dust Suppression Systems

- Droplet sizes less than 10µm to properly agglomerate with the dust
- Gravity forces dust back down into the process
- Enough water droplets of the same size need to be created at the same rate as the dust particles
- Both the dust particles and water droplets need to be contained in the same area



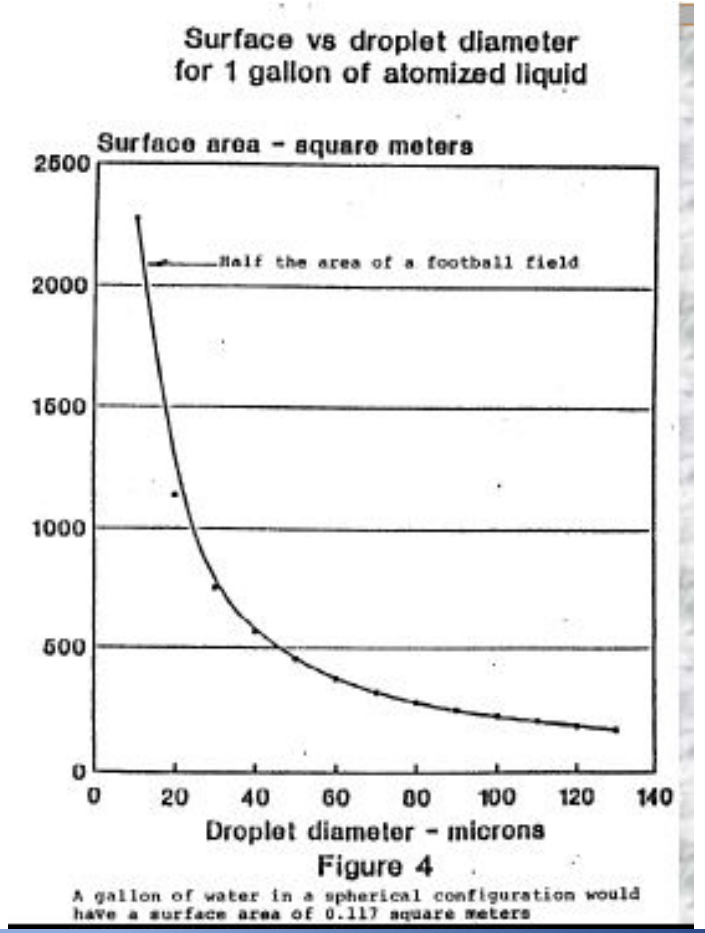
DSI Fogging Nozzle

- Nozzle is stainless steel with no moving parts
- Creates a dense 1-10µm droplet fog
- Uses ultrasonic technology that creates a shock wave at a high frequency to atomize the water droplets

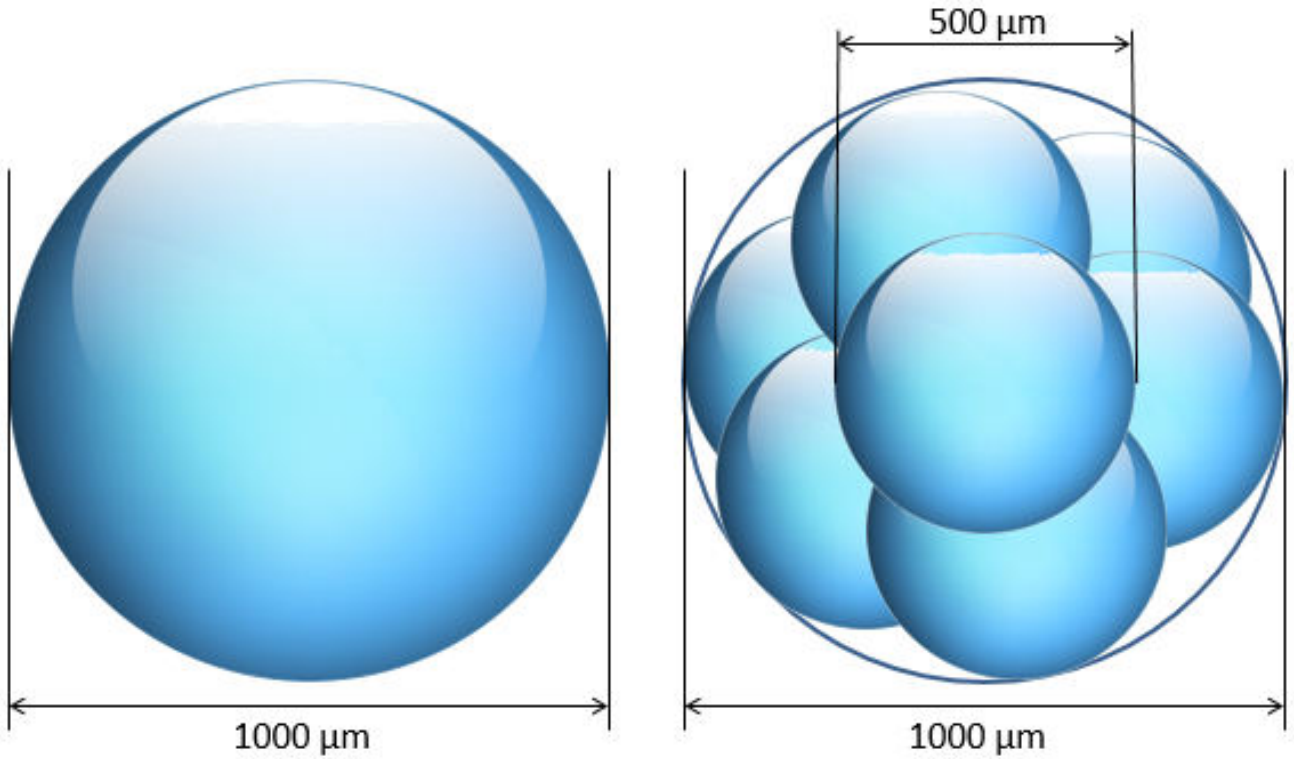


Fog Droplet Surface Diameter

- Droplet size versus surface area for 1 gallon of atomized water
- Our nozzle can cover half the size of a football field in fog with a single gallon of atomized water



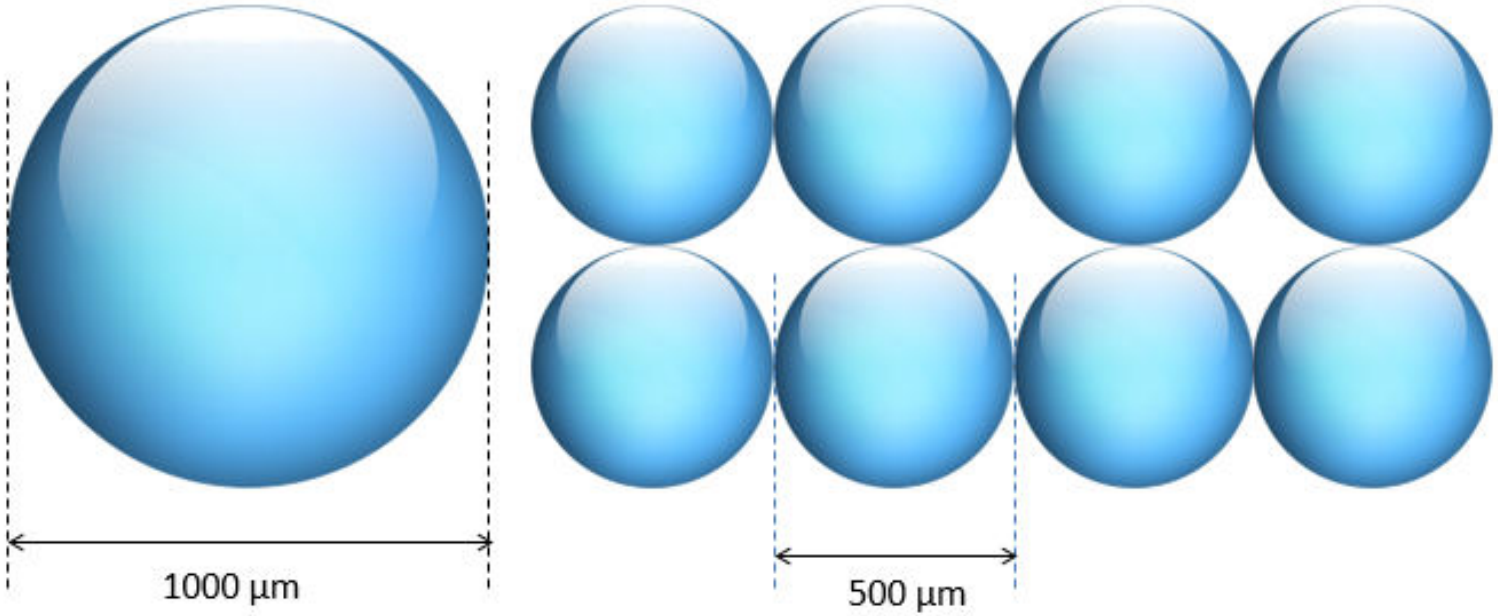
Fog Droplet Surface Diameter



$$A = 4\pi r^2$$

$$V = \frac{4}{3}\pi r^3$$

Fog Droplet Surface Diameter

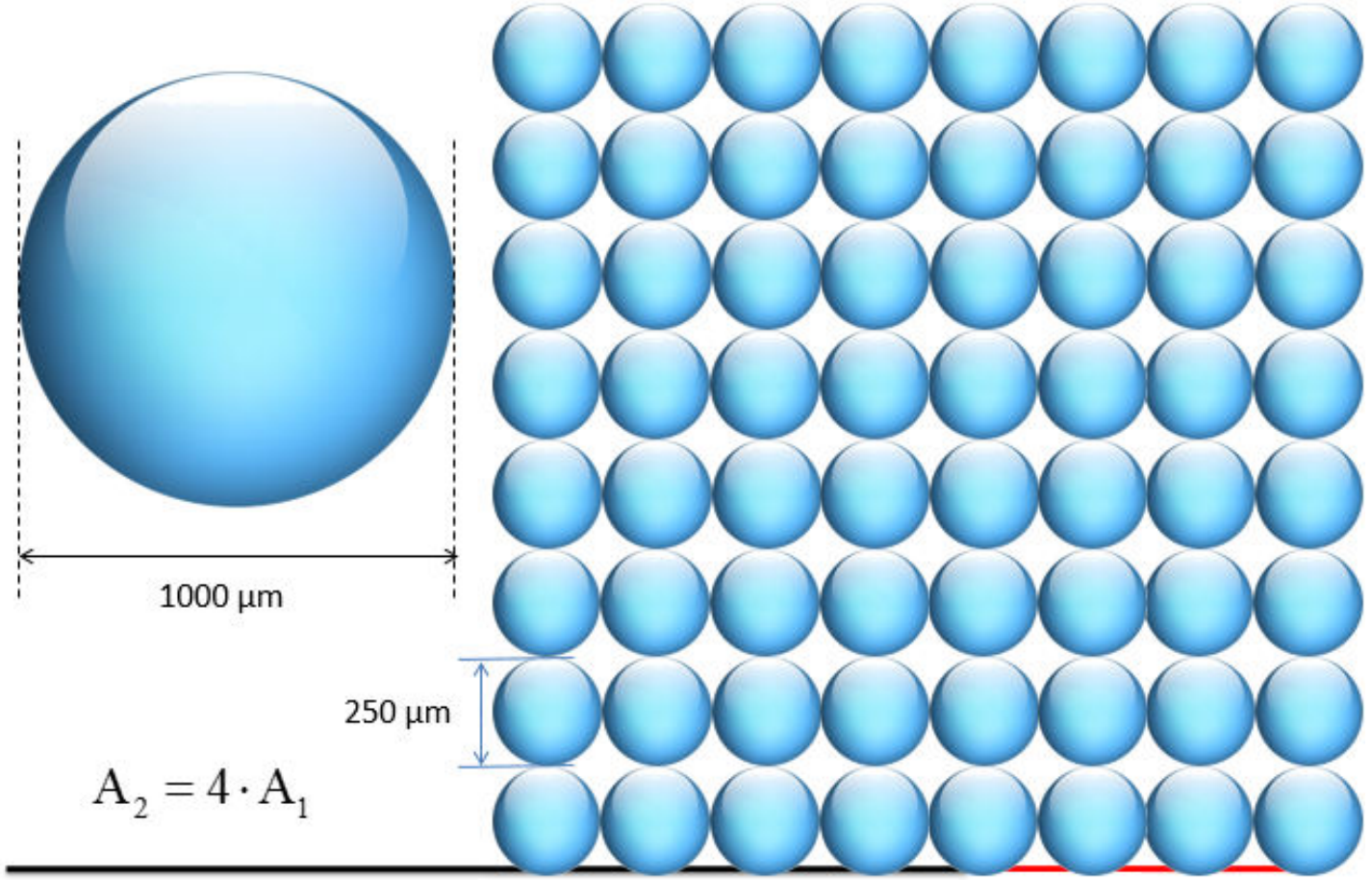


$$A_1 = 4\pi r_1^2$$
$$A_1 = 4\pi(500)^2$$

$$A_2 = 8 \cdot 4\pi r_2^2$$
$$A_2 = 8 \cdot 4\pi(250)^2$$

$$A_2 = 2 \cdot A_1$$

Fog Droplet Surface Diameter

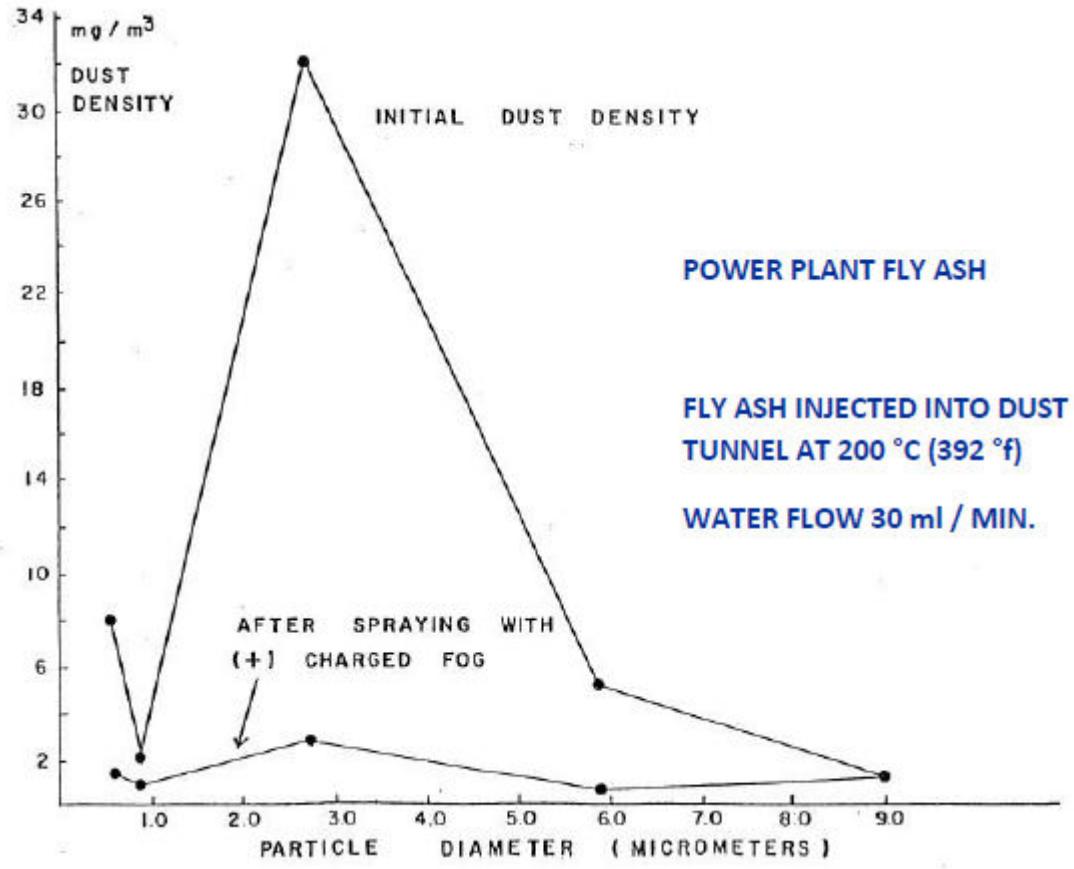


Fog Droplet Surface Diameter

Number of Divisions	Diameter of the droplet (m)	Number of droplets	Volume of the droplet (m3)	Area of the droplet (m2)	Total Volume of the droplets (m3)	Total Area of the droplets (m2)
0	1.93E-01	1	0.00378541	0.117461	0.0037854	0.117461
1	9.67E-02	8	0.00047318	0.029365	0.0037854	0.234922
2	4.83E-02	64	5.9147E-05	0.007341	0.0037854	0.469843
3	2.42E-02	512	7.3934E-06	0.001835	0.0037854	0.939686
4	1.21E-02	4096	9.2417E-07	0.000459	0.0037854	1.879372
5	6.04E-03	32768	1.1552E-07	0.000115	0.0037854	3.758745
6	3.02E-03	262144	1.444E-08	2.87E-05	0.0037854	7.51749
7	1.51E-03	2097152	1.805E-09	7.17E-06	0.0037854	15.03498
8	7.55E-04	16777216	2.2563E-10	1.79E-06	0.0037854	30.06996
9	3.78E-04	1.34E+08	2.8204E-11	4.48E-07	0.0037854	60.13992
10	1.89E-04	1.07E+09	3.5254E-12	1.12E-07	0.0037854	120.2798
11	9.44E-05	8.59E+09	4.4068E-13	2.8E-08	0.0037854	240.5597
12	4.72E-05	6.87E+10	5.5085E-14	7E-09	0.0037854	481.1194
13	2.36E-05	5.5E+11	6.8856E-15	1.75E-09	0.0037854	962.2387
14	1.18E-05	4.4E+12	8.607E-16	4.38E-10	0.0037854	1924.477
15	5.90E-06	3.52E+13	1.0759E-16	1.09E-10	0.0037854	3848.955

Charged Fog Effect

- Fog leaves the nozzle with a slight positive charge
- Most dust particles generated carry a negative charge, providing an even stronger chance of agglomeration



DSI Nozzle Specifications

	DSN-3	DSN-6	DSN-10	DSN-12
Nominal Flow Rate	3.5 GPH (13.25 LPH)	7.8 GPH (29.52 LPH)	10.8 GPH (40.88 LPH)	13.5 GPH (51.1 LPH)
Air Consumption	3 SCFM (5.1 m^3/h)	7.5 SCFM (12.7 m^3/h)	9.5 SCFM (16.1 m^3/h)	12.5 SCFM (21.2 m^3/h)
Air Orifice Diameter	.052” (1.3mm)	.078” (1.98mm)	.086” (2.18mm)	.111” (2.82mm)
Applications	Transfer Points with low fines or small width conveyors	Transfer Points with high fines, small hoppers, protected dumping areas	Large unconfined dumping areas, ship and cargo loading, large hoppers	Large truck dumps, primary crusher applications

Fog Containment

Advantages of the DSI system

- Does not wet the product
- Adds no chemicals or reactive agents
- No disposal costs
- Low operational and maintenance costs
- No freezing problems
- No product contamination
- Easy to install
- Rugged for harsh environments

Rollover Railcar Loading / Unloading

Railcar Loading / Unloading Video

Truck Dumps

Before Dry Fog

After Dry Fog

Truck Dumps

Hopper Loading / Unloading

DSI
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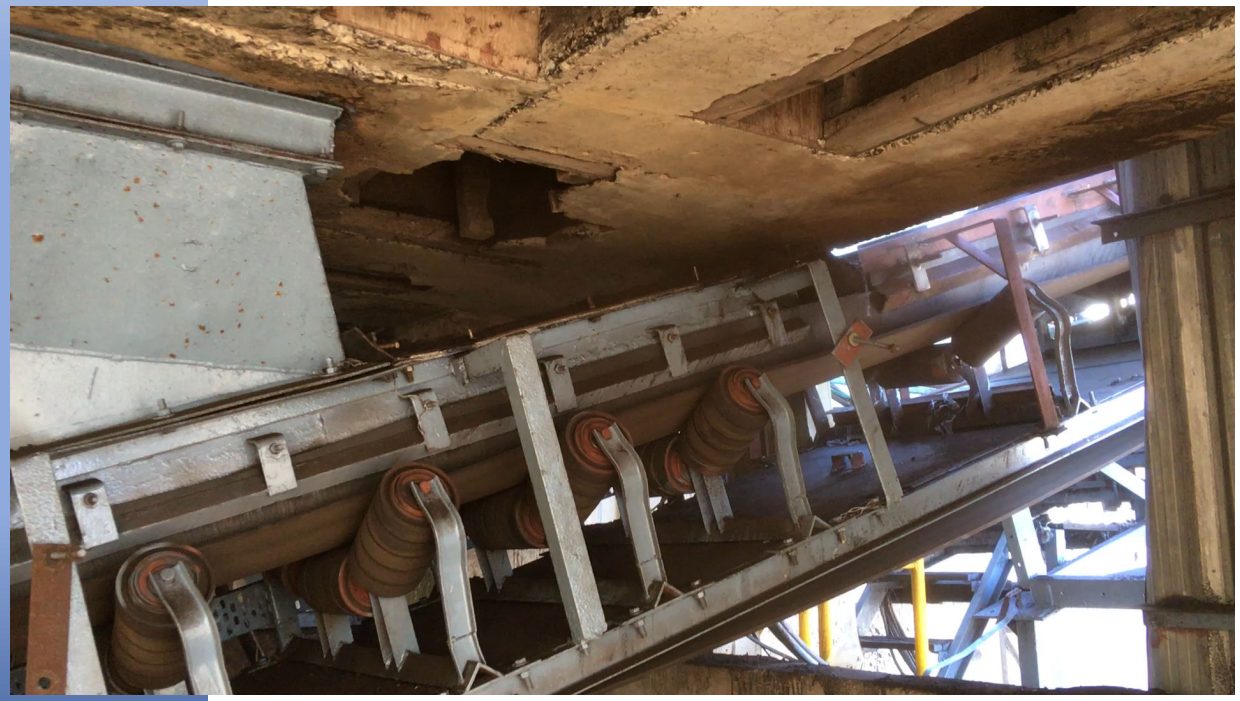
Ship-unloading Screw Conveyor

Conveyor Transfer Points Video

Conveyor Transfer Points Video



Truck Loading / Fly Ash Handling

Truck Loading / Fly Ash Handling

Reclaimer

Without Fog

With Fog

Reclaimer

Stacker

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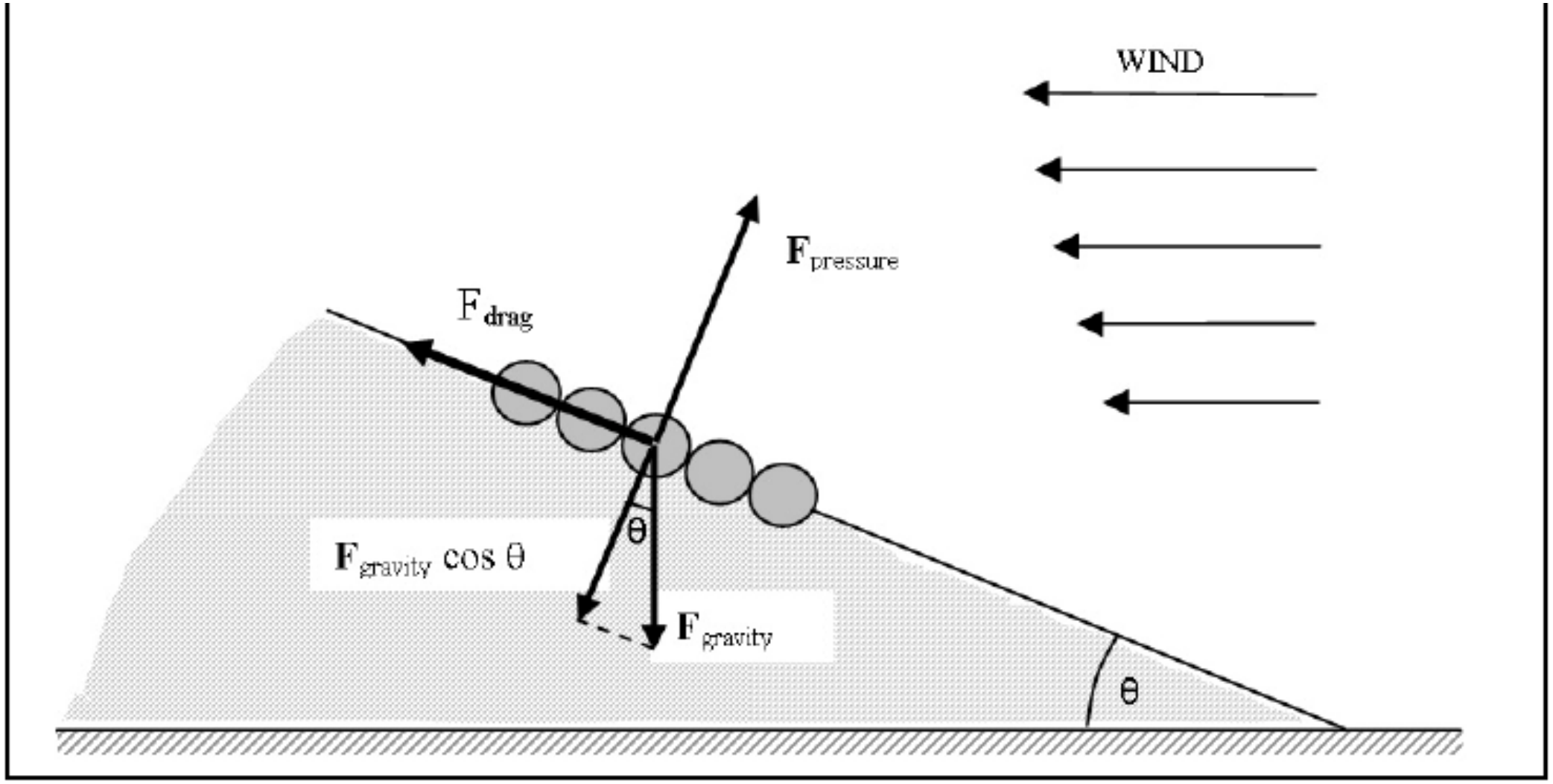
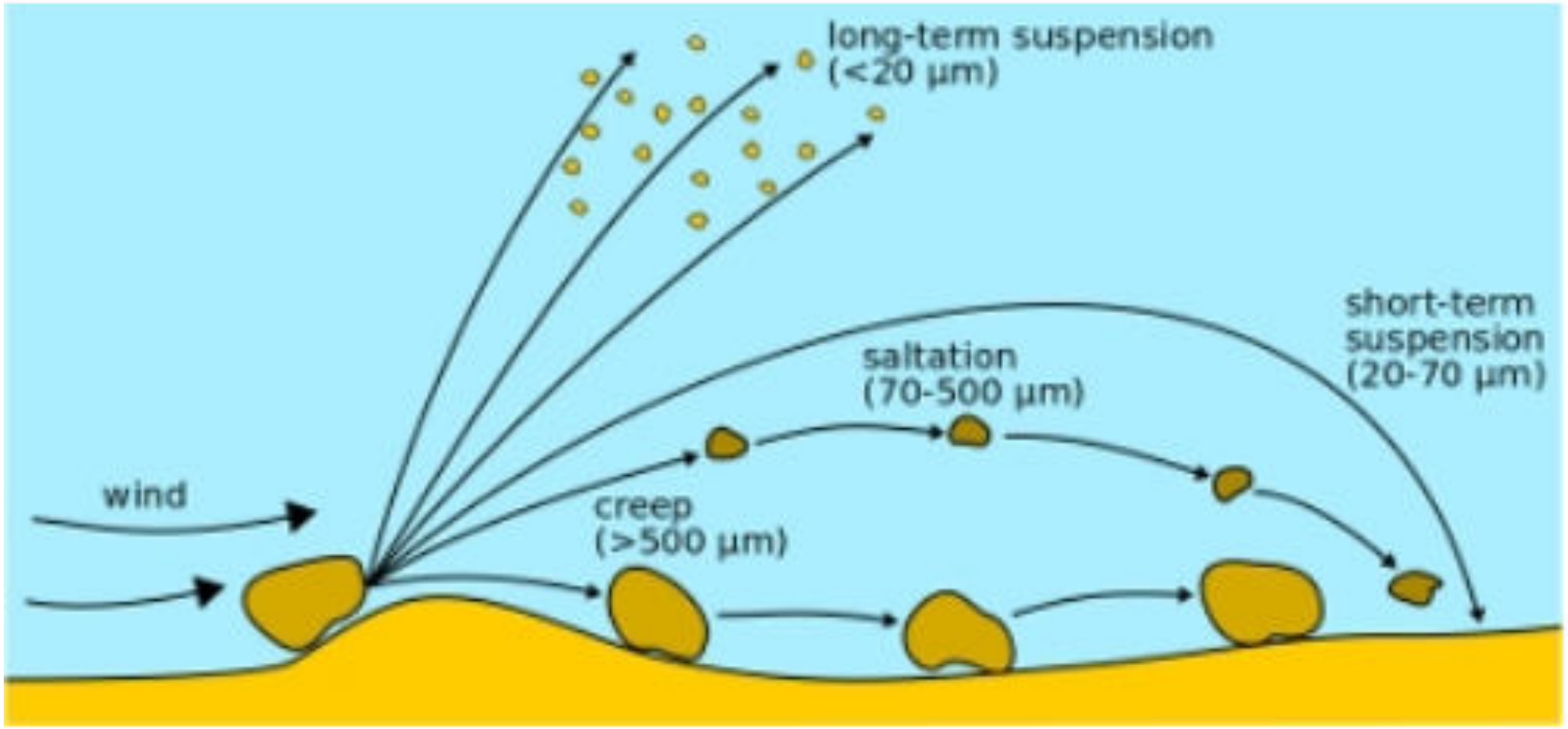
INTRO TO WIND FENCE SYSTEMS

Forces that Act Upon Dust Particles

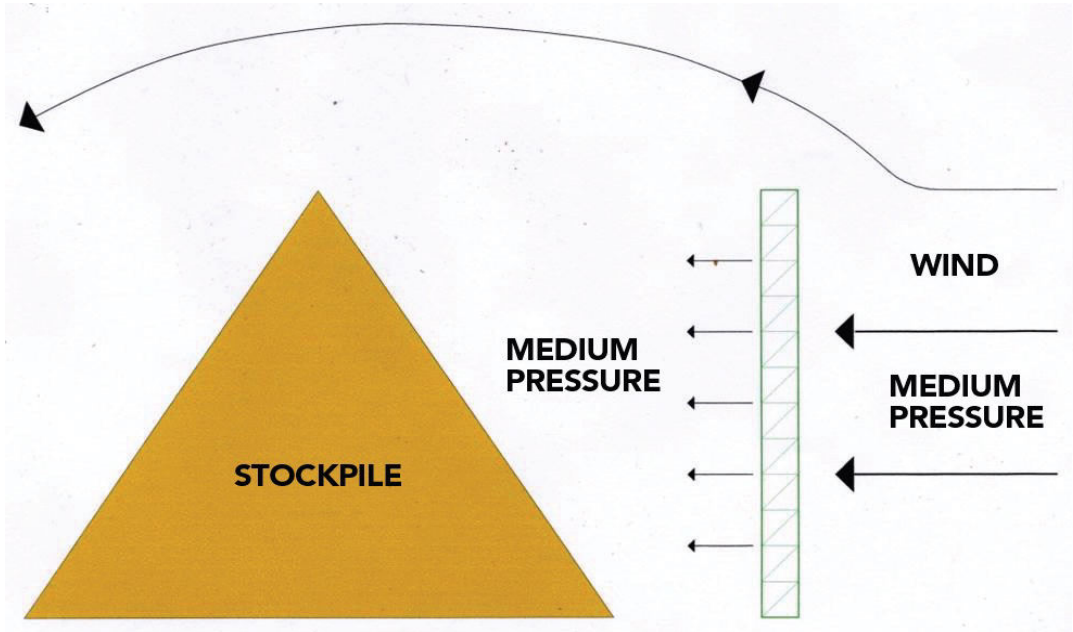


Particle Uptake from Stockpiles

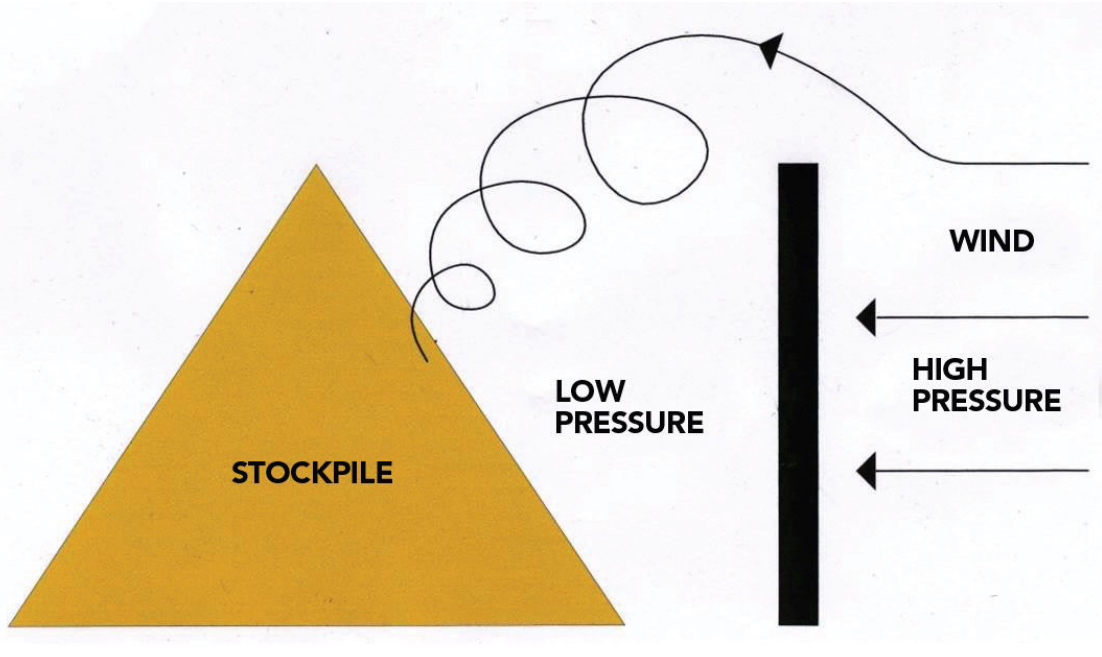


Effect of Wind Fence vs. Solid Wall

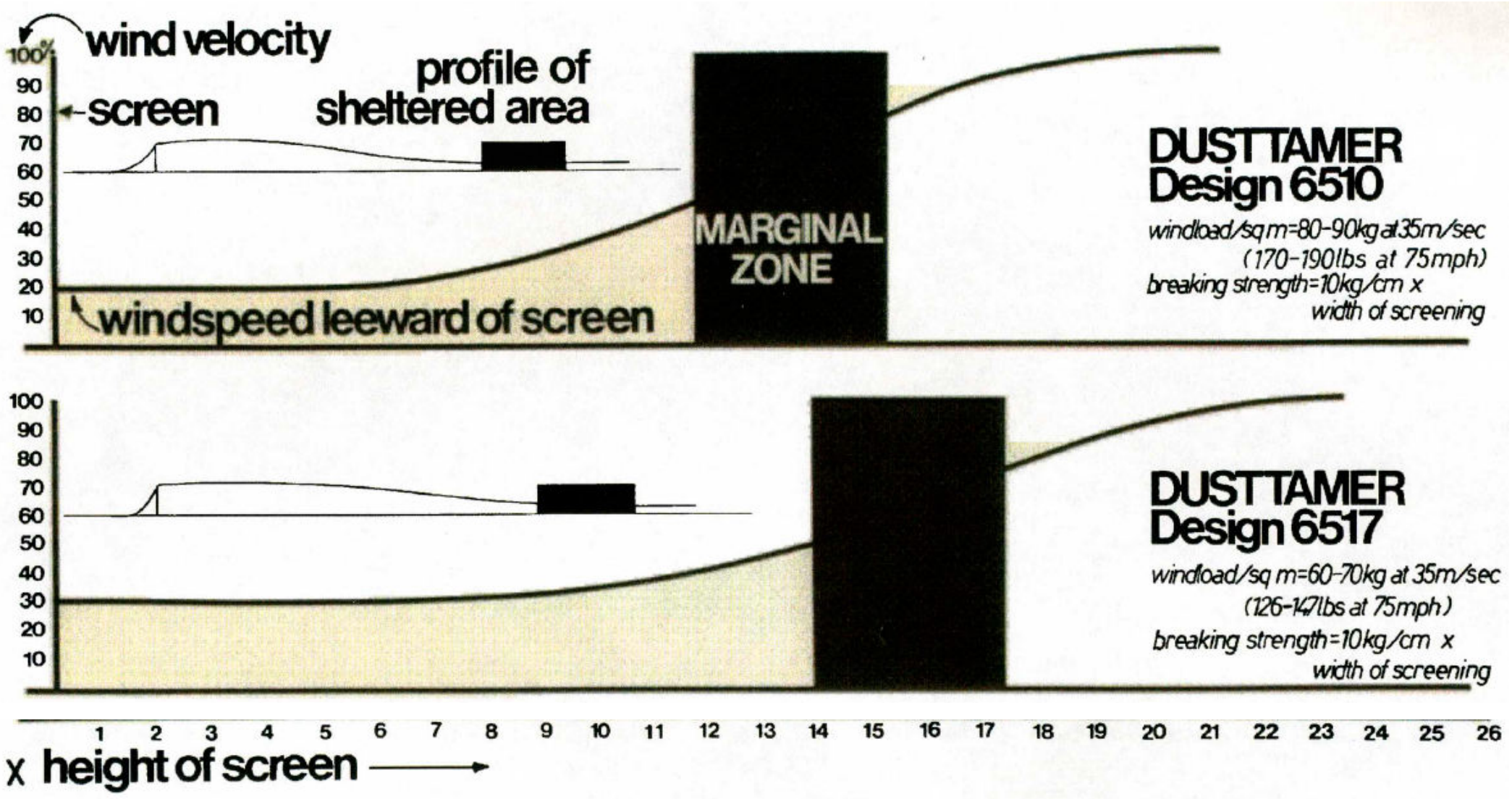
EFFECT OF WIND WITH DSI FENCE



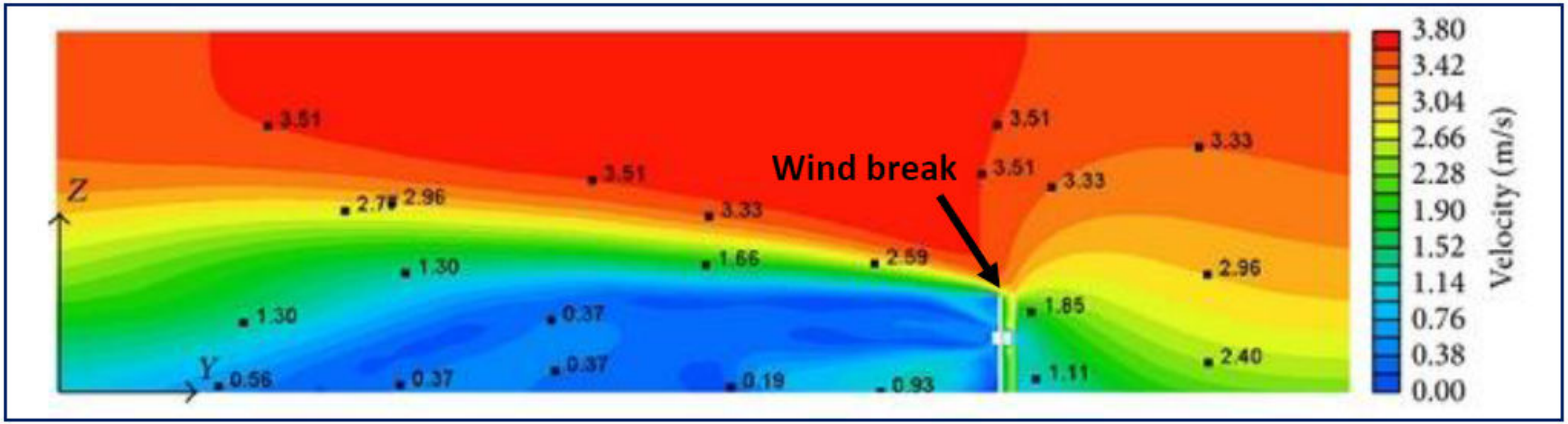
EFFECT OF WIND WITH SOLID WALL



Protection Zones



Wind Break Modeling



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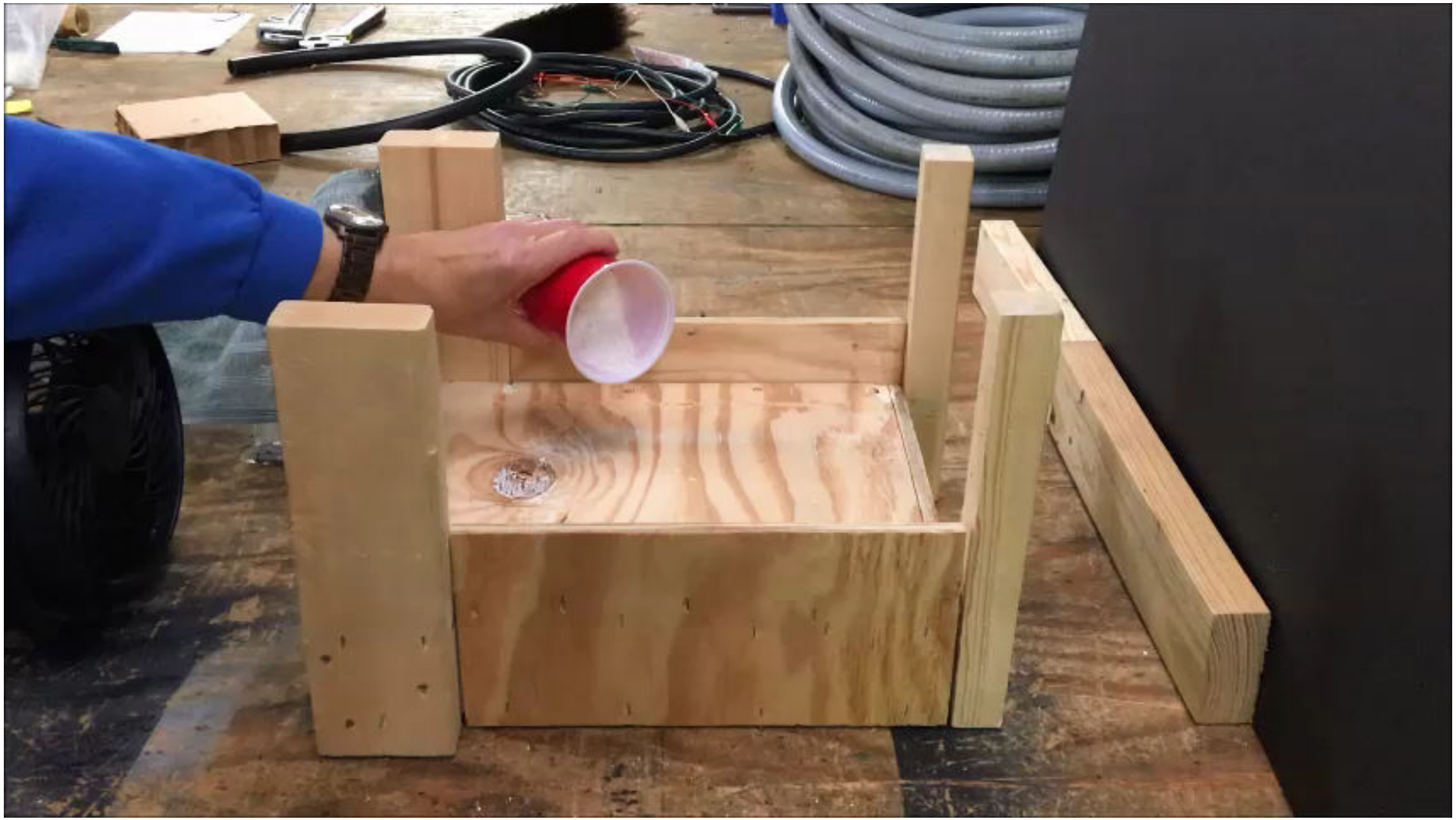
Wind Fence Video



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DUSTTAMER WINDFENCE SYSTEM
APPLICATIONS

Coal Pile Applications

Screen Install on Truss Type Support Structure

100 ft. / 30 m tall Coal Pile Wind Fence

100 ft. / 30 m tall Coal Pile Wind Fence

Xcel Energy Newsletter

Comanche Wind Fence

No high-emission events recorded since fence was installed

A 10-story-tall wind fence now wraps part of the coal yard at Comanche Generating Station – a major component of an integrated fugitive dust control plan at the Pueblo, Colo., plant.

The unique project got under way last spring to help combat a reoccurring problem of dust blowing from coal-handling operations and off plant property. Comanche Station receives up to 8 million tons of coal a year, and its coal pile occupies 10 acres and sits in an open, exposed area that frequently experiences windy conditions.

Since the installation of the massive 1,700-foot-long fence – nearly a third of a mile – no excess dust emissions have occurred, said Fred Prutch, plant director at Comanche. The air-particle monitor onsite, which measures the amount of dust in the air, has recorded no high-emission events since the fence was installed.

Prior to installing the wind fence, the plant took other steps to suppress coal dust, including enclosing coal-unloading operations, spraying the coal with water and dust-suppression chemicals, sealing the inactive coal pile, and minimizing coal handling during high winds. All of these measures were part of the plant's integrated fugitive dust control plan, he said.

"Wind fencing had been proven to control fugitive dust under similar conditions at other facilities around the country, so it was chosen as the most effective solution for Comanche, as well," Prutch said. "The results so far have been promising, and we expect continued improved air quality, which is good for the environment and our neighbors near the plant."

The fence is made of a mesh screen, and the project cost about $4 million. The factory-tested fence is estimated to last 20 years, according to the manufacturer. It was constructed around the coal pile to reduce the speed of the wind blowing through the coal yard.

The fence is situated upwind of the coal pile in the path of the prevailing wind direction. It acts as a barrier to the wind, reducing wind speed by 50 percent, which decreases the amount of fugitive dust that is blown from the coal yard. Winds from the southwest can be particularly troublesome for the plant's dust-mitigation efforts, especially during windy periods that occur in the spring and fall months.

"We recognized the need for additional dust control measures at the plant," said Gary Magno, manager of Environmental Services. "It is part of our ongoing air-compliance obligation and responsibility as a good neighbor."

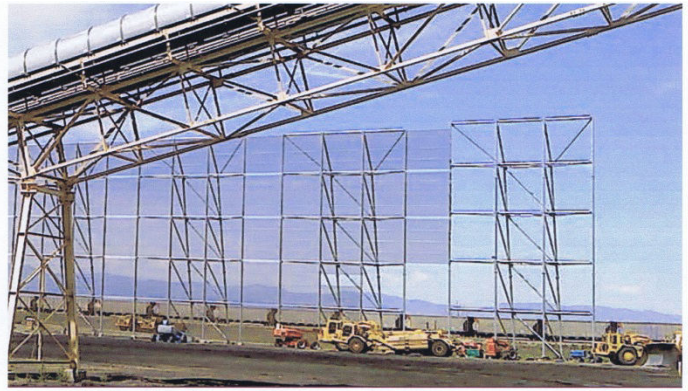
The fence was the most unobtrusive, effective and economical solution, he said. The Colorado Air Pollution Control Division agreed and included the installation of the wind fence in the company's site air quality permit.

As part of the Comanche Unit Three project, which added a new unit at the facility, the company was required to install an air-monitoring system to measure particulate matter. The monitor, located along the plant's eastern fence line, measures particulate matter concentrations in the air. All episodes of elevated emissions prior to the installation of the fence were associated with high wind events, he said, ranging from 25 to 50 miles per hour.

"We worked with Comanche and Engineering and Construction, and sought ways to reduce dust emissions from coal handling and storage operations, including installing a wind fence," Magno said.

The fence is not your typical variety and is made of an engineered fabric that knocks down the wind. While this type of fencing is installed in other locations across the country, Comanche's wind fence is the first of this magnitude, he added.

"We'd like to send kudos to the folks at the plant, who have stayed on top of the fugitive-dust issue and completed a number of different mitigation efforts," he said. "It's been a big challenge for everyone involved."



COMANCHE FENCE

The new factory-tested fence at Comanche Generating Station in Pueblo, Colo., is made of a mesh screen and is estimated to last 20 years. It was constructed around the coal pile to reduce the speed of the wind blowing through the coal yard and is situated upwind of the coal pile in the path of the prevailing wind direction.

Coal Stockpiles

Coal Stockpiles

Coal Stockpiles

Gypsum Piles

Gypsum Piles

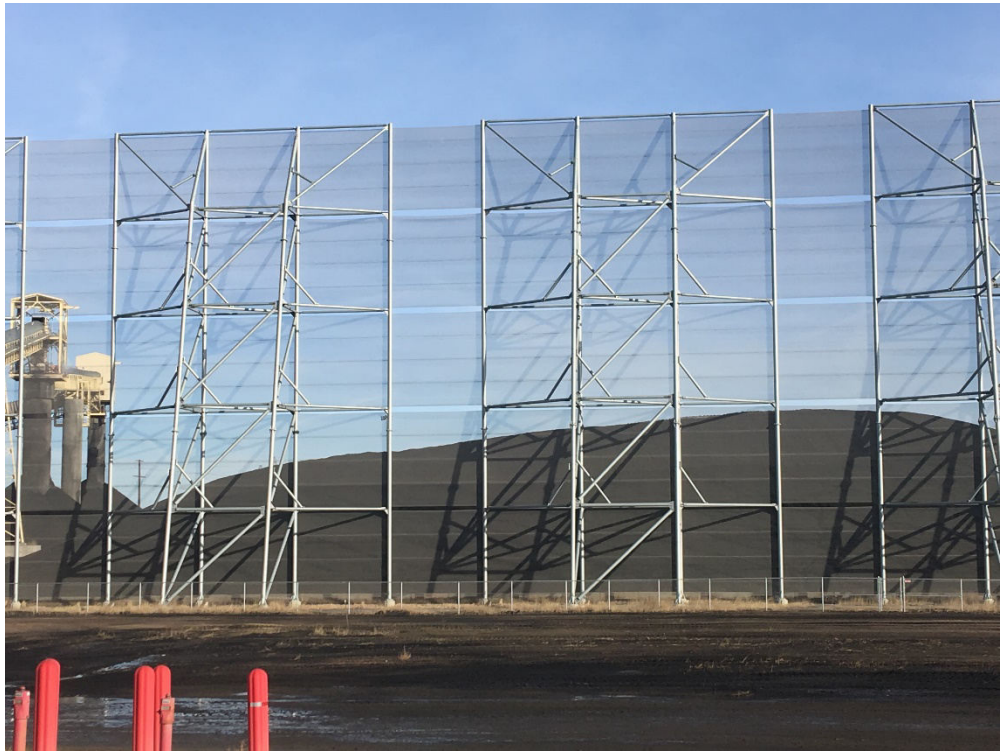
Wind Fence Durability

2003 Installed

2015 Installed

Wind Fence Durability

2011 Installed



2016 Installed

Fence for Conveyor Crosswind Protection

Applications continued…

Transformer Station Wind Fence

Dry Lake Bed Owens Lake

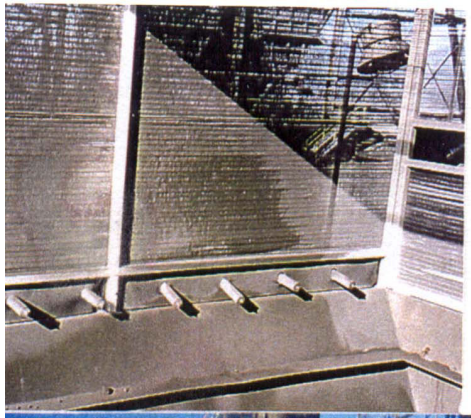
Tailings Pond

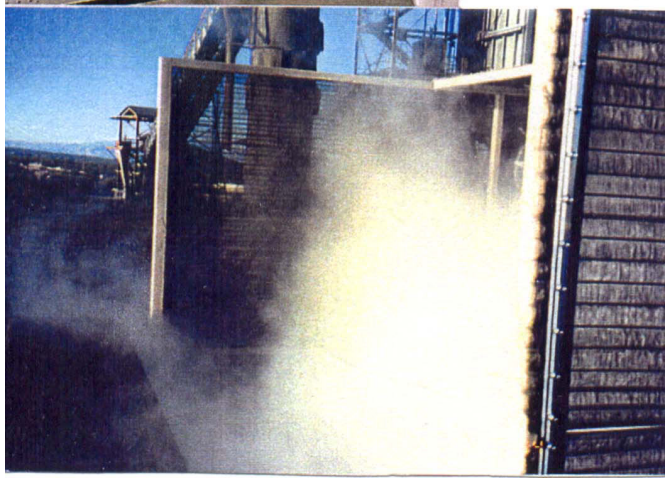
Applications continued…

Gypsum Pile

Biomass (Wood Chip) Pile

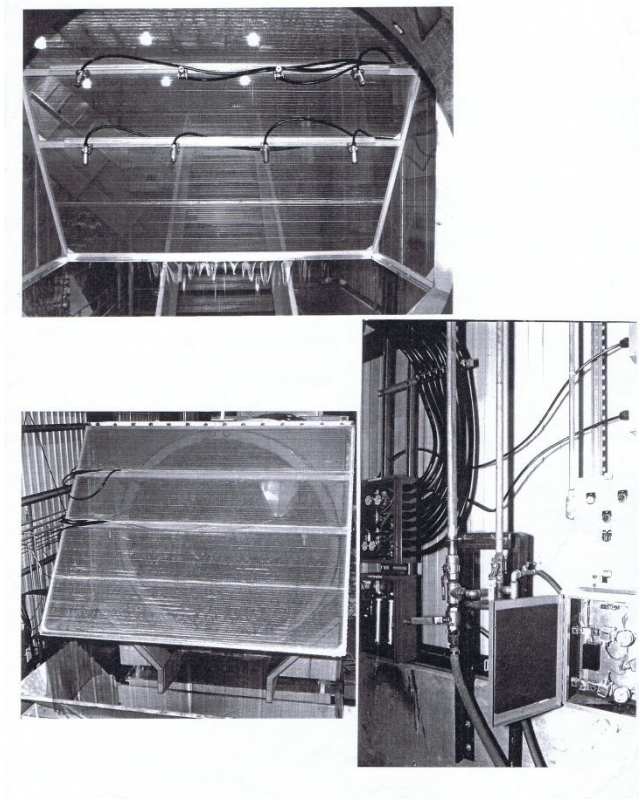
DustTamer will help contain Fog in the Dump Pocket, resisting ambient crosswinds





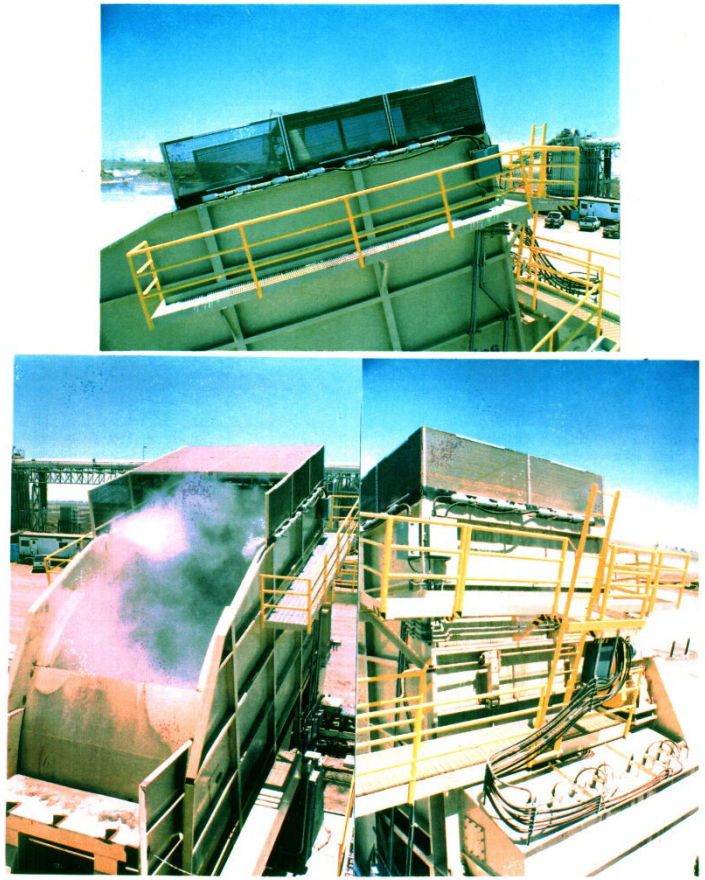
Applications continued…

For Trommel Fog Containment



Truck Tipper Crosswind Protection

Screen to enclose Hoppers with Dry Fog



Hoppers

Applications continued…

Aggregate Pile

Railcar Unloader

Wind Screen For Buildings

Rail Load out Building

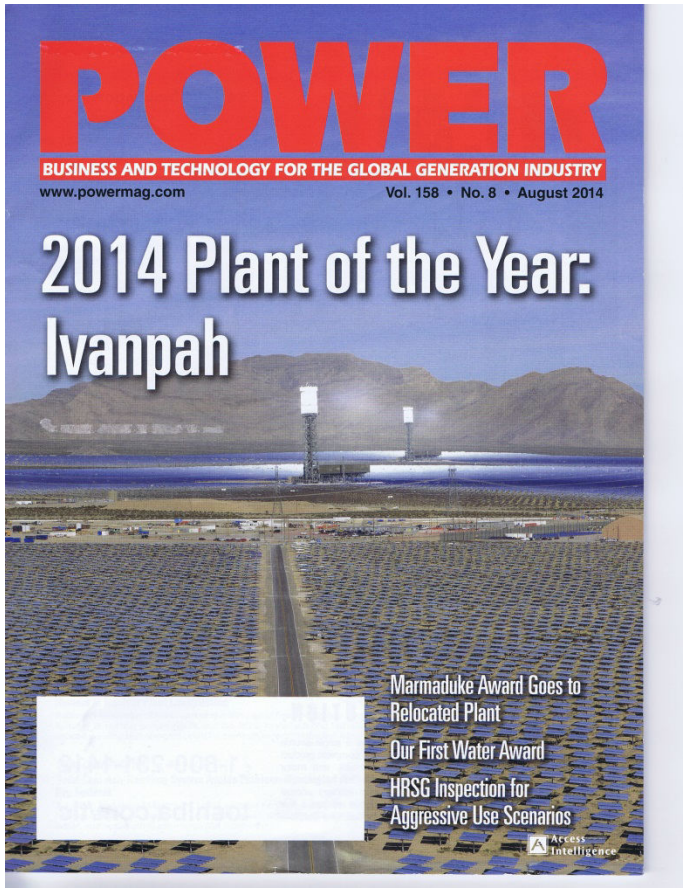
Crusher Building and Transfer Tower Siding

Applications continued…

Solar Array Wind and Dust Protection

Solar Panels Destroyed by Wind

Bechtel Ivanpah Solar Project



Fence for Solar Array Staging Area for Bechtel Construction

Air Cooled Condensers