TECHNIQUE FOR PASSIVE DUST CONTROL

Efraín Bozo Godoy
Gonzalo Bozo Nalli

May 2024

TECHNIQUE FOR PASSIVE DUST CONTROL

Table of Contents

1.0 INTRODUCTION

Passive dust control in transfers between conveyors is crucial to significantly reduce the flow of contaminated air into the skirtboard. This document presents a specific technique for passive dust control, using exclusive designs developed by Proconm. The efficient implementation of this technique allows fugitive dust to minimize, without consuming energy, protecting people's health and the environment.

2.0 DEFINITION

Passive Control. Passive dust control is a technique that allows for reducing emissions of particulate matter released into the environment or fugitive dust without consuming energy. It involves confining and/or sealing the storage and transportation location of the material,

Active control. Active dust control is a technique that allows for reducing emissions of particulate matter released into the environment or fugitive dust with energy consumption. The most well-known methods are extraction and suppression systems.

Mixed control. It is a combination of passive system with an active system. Most existing control systems are mixed.

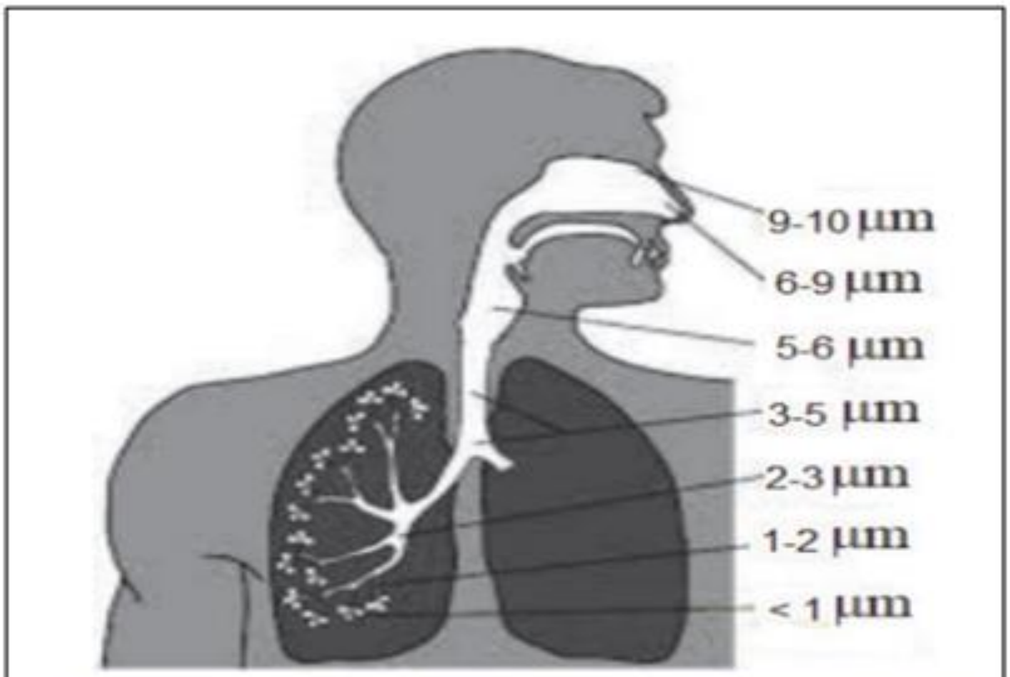
3.0 SCOPE OF APPLICATION

The scope of application is the transportation and storage of bulk solid material that has the potential to emit dust or particulate matter affecting human health and the environment.

4.0 DEFINITIONS OF DUST AND PARTICULATE MATTER

Dust is the dispersion of solid particles in the environment.

PM10 is the inhalable fraction and refers to particles less than 10 microns, non-sedimentable and that do not reach the lungs.



Particle sizes in the respiratory system

Figure 1. The smaller the particle size, the greater the health risk.

PM5 is the respirable fraction, it is the particulate matter that reaches the lungs.

Silicogen dust is PM5 with 1% or more free crystalline silica or silicon dioxide (SiO_2). It can cause silicosis, cancer or accentuate other diseases.

PM2.5 is the fine respirable fraction, particles smaller than 2.5 microns, which reach the smallest airways of the lungs, the alveoli; therefore, it poses a greater risk.

TSP or PM100 is the total dust formed by particles with a size between 10 and 100 microns. Depending on its size and wind speed, it can settle meters or kilometers away from the emission source, affecting nearby or distant areas.

Visible dust. Visible dust. Particle larger than about forty µm is visible to the human eye. For reference, the thickness of human hair measures eighty µm.

5.0 TERMINAL VELOCITY OR LIMIT

Terminal velocity or limit is the maximum speed reached by an object moving through the air under the influence of gravity. In other words, it occurs when acceleration is zero or when air resistance equals gravity.

To obtain the Terminal Velocity (TV) by particle size for turbulent flow, an accurate method is this graph published by COMET [1], built with the Zender predictive model [2].

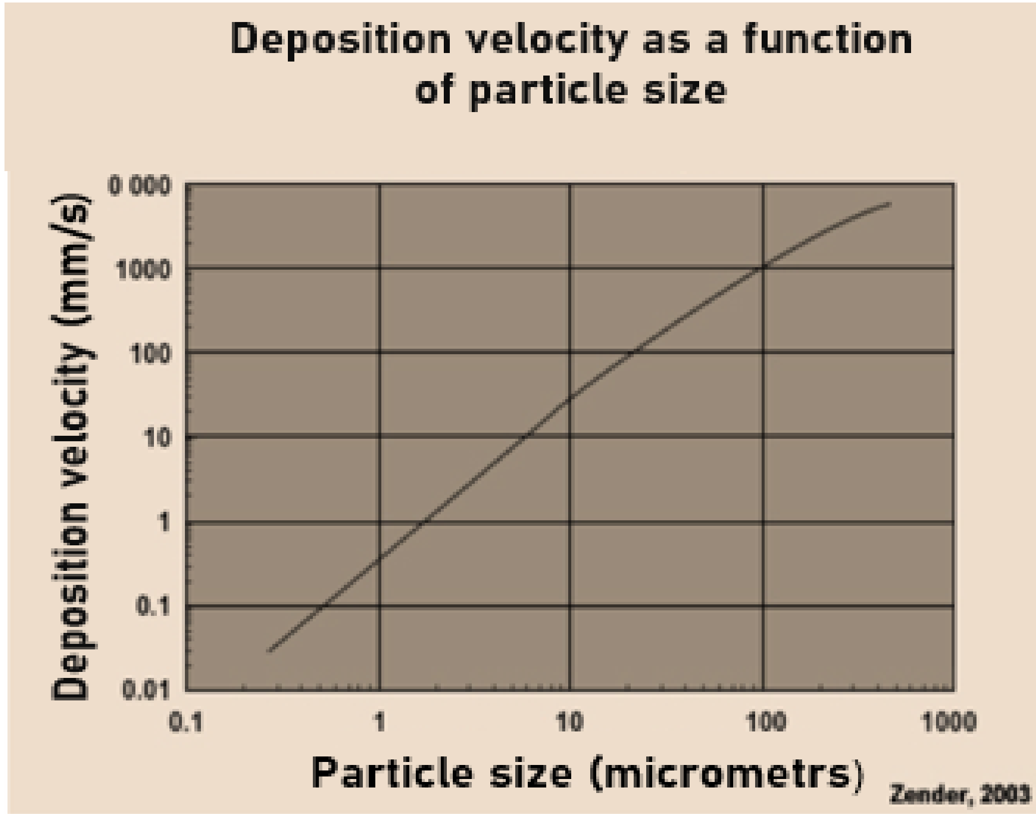


Figure 2. COMET diagram for terminal velocities.

This graph shows that a 10-micron particle requires a speed of 0.03 m/s (0.11 km/h) to remain suspended. For this reason, the PM10 fraction does not settle.

6.0 AIR MOVEMENT

6.1 General

Understanding air movement in relation the material flow is crucial to controlling and minimizing fugitive dust (escaping into the environment). There are three sources of air movement that may be present in a transfer:

- Displaced Air
- Air generated or introduced.
- Induced Air

6.2 Displaced Air

The displaced air is the principle of Archimedes applied to flow. This means:

$$Q_{dis} = \frac{0{,}277R}{\rho}$$

Q_{dis}: Displaced air, m³/s

R: Material flow, t/h

ρ: Apparent density, kg/m³/h

Displaced air is present primarily in hoppers and stockpiles confined. When the level of material inside the hopper rises, the air must come out clean or filtered so as not to contaminate the environment. Consequently, when the level of the material drops there must be an entry of air from the outside.

6.3 Generated or Introduced Air

This air generated by crushers due to differences in density or size, and by the fan effect in the case of the gyratory crusher. Field observations show that this fan effect recirculates the air in the truck unloading area. Air from dust suppression systems is air introduced from the outside.

6.4 Induced Air

The induced air is present in all material transfer.

According to the NIOSH standard [3] and the Martin Engineering publication [4], the induced air represents the physical phenomenon that occurs during the free-fall of bulk material. That is, the falling material opens, leaving gaps with negative pressure or vacuum in the space it previously occupied, the surrounding air attracted to that vacuum and fills it, this is known as absorbed air, Qab. When the bulk material impacts, it releases all this air entrained during the trajectory, which we define as induced air.

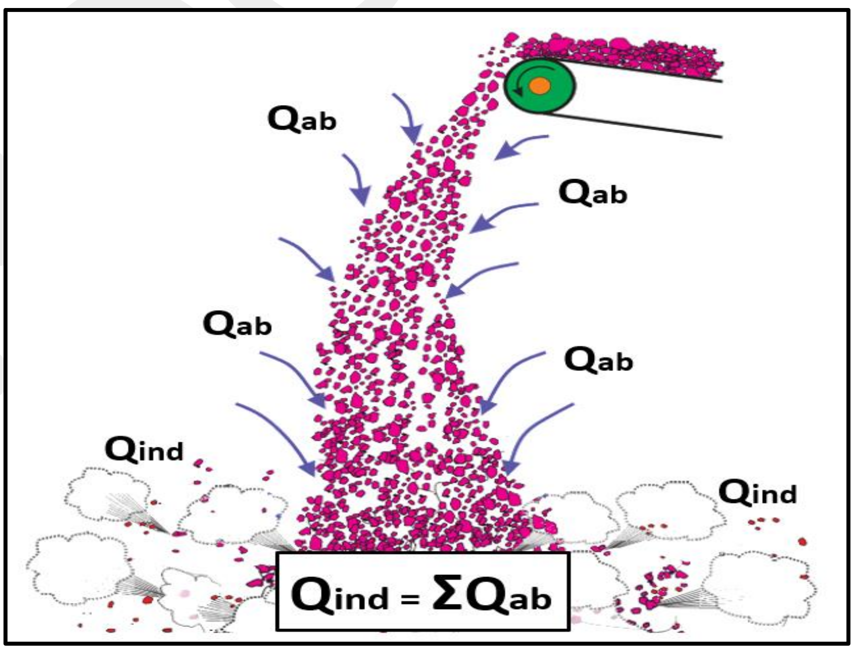


Figure 3. Scheme of the NIOSH Standard for induced air [3].

Anderson's equation [5] for induced air or air extraction in a confined environment is:

$$Q_i = kA_u\sqrt[3]{\frac{RS^2}{D}}$$

Q_i: Induced air flow and extraction of Anderson, m^3/s

K: Conversion factor = 0,078

Au: Open areas at top of chute or induced area, m^2

R: Material Flow, t/h

S: Free-fall height of the material, m

D: Average diameter of the material (P50), m

To decrease the air to extract, the only variable that can controlled in this equation is the induced area. That is, reducing the induced area means reducing the air to extract and reducing fugitive dust. This is passive dust control.

Anderson's equation is a simplification of the equation of Richard Dennis [6], who used a longitudinally sealed tray as a receiving tape, with no possibility of air escape from the back. Passive dust control therefore includes efficient sealing of the skirtboard longitudinally and transversely at the rear.

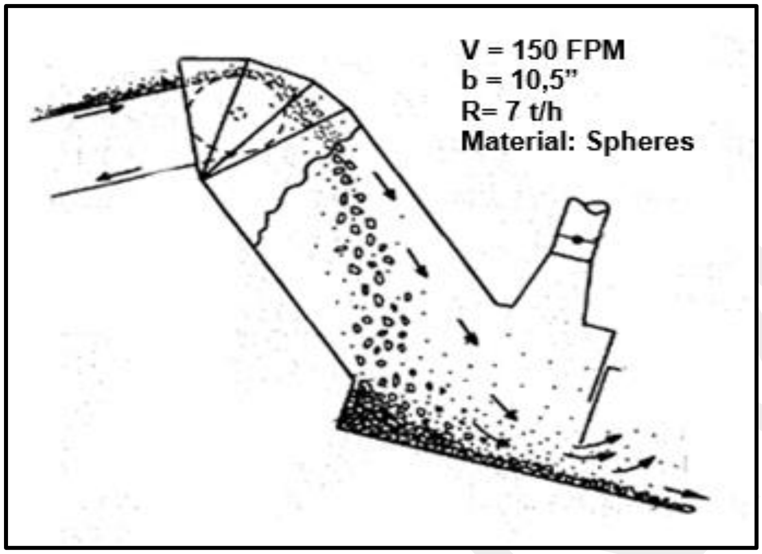


Figure 4. Model used by Richard Dennis [6]

7.0 TECHNIQUE FOR PASSIVE DUST CONTROL

7.1 Transfer between Conveyor Belts

General. In a transfer between conveyors, displaced air is present only in the seconds it takes for the material to fill the skirt area of the receiving belt. Consequently, in this type of transfer only induced the air is present.

The passive control technique aims to seal the top and bottom of the duct to facilitate the recirculation of induced air.

For recirculation to occur, it is not enough to seal, but the conduit and skirtboard must designed to eliminate any risk of clogging or jamming.

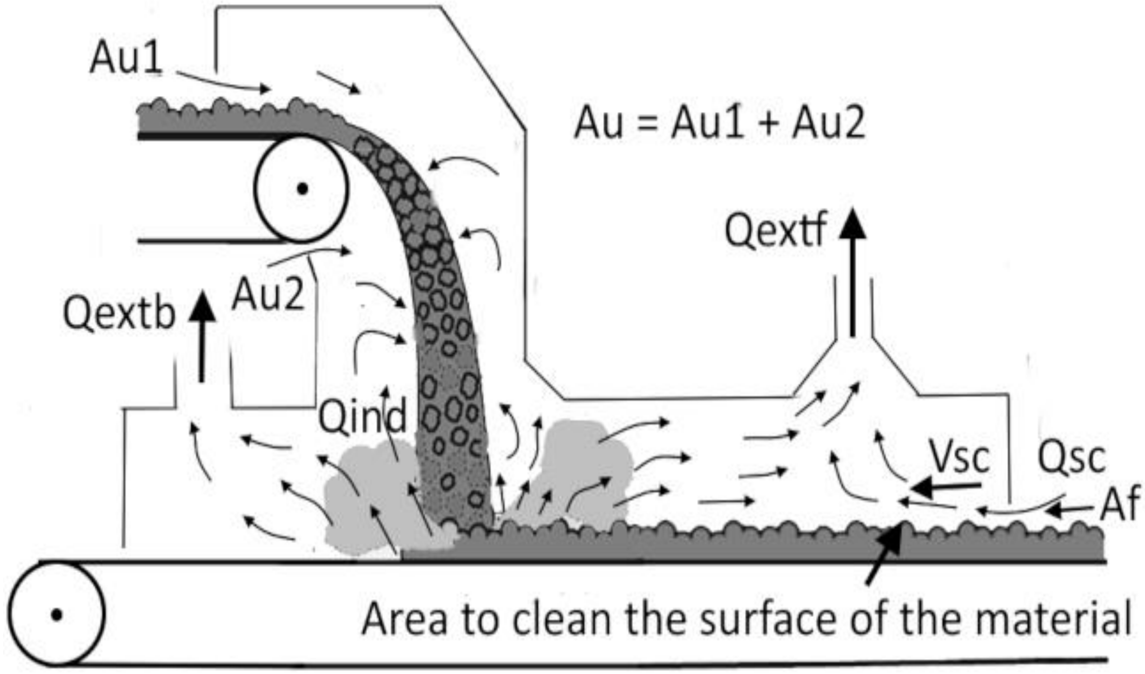


Figure 5. Passive control involves facilitating the recirculation or induced air.

Longitudinal Seal. Since 2015, has patented a type of longitudinal seal [7] that fulfills two important principles:

1. The material should not press the seal.
2. There should be no risk of jams or permanent blockages between the conveyor belt and the skirtboard.

At a CEMA Committee meeting held in 2017 [8], the same postulates already registered by Proconm. A more advanced seal with this same concept allows to place the wear plate by the outside, making inspection and replacement easier, as shown in the image below:

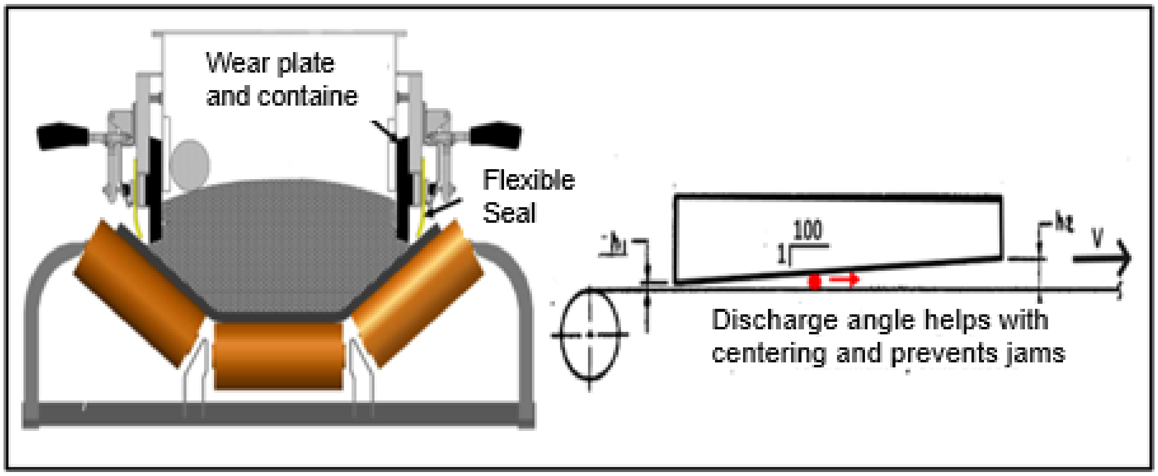


Figure 6. Longitudinal seal for primary and secondary ore.

Transverse Seal. Most existing seals for sealing transversely on the material are ineffective; they do not achieve a minimum of airtightness.

Figure 7. Existing type of transverse seal.

There are seals that approximate a real solution, as they seal over the material.

Figure 8. Existing transverse seal that goes over the material.

The proposed seal goes over the material, with the following characteristics:

- With double seal forming an air chamber
- With pivots to prevent deterioration
- Flexible to reduce friction and adjust to the material.

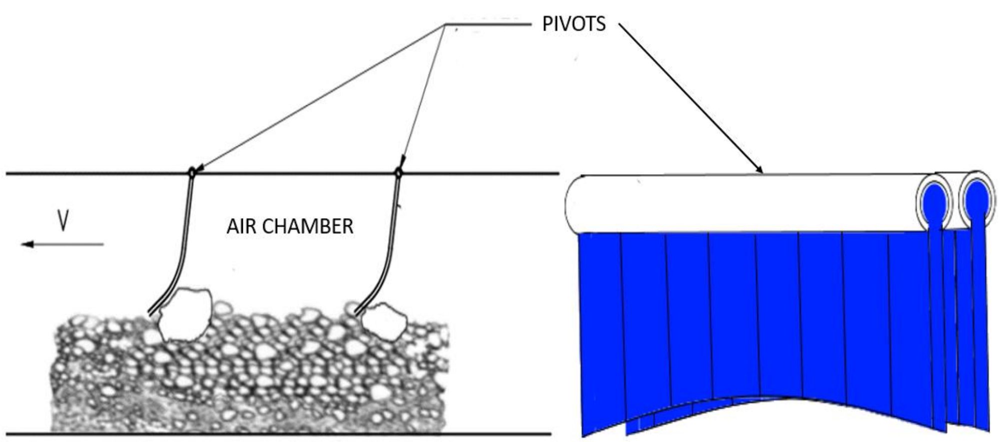


Figure 9. Flexible polyurethane transverse seal with pivots.

Cleaner Seal. The sealing between the belt return and the chute is complicated by the oscillation and deformation of the belt. Proconm' s proposal addresses these issues. An adjustable seal made of flexible polyurethane, field-tested, which also acts as a secondary or tertiary cleaner.

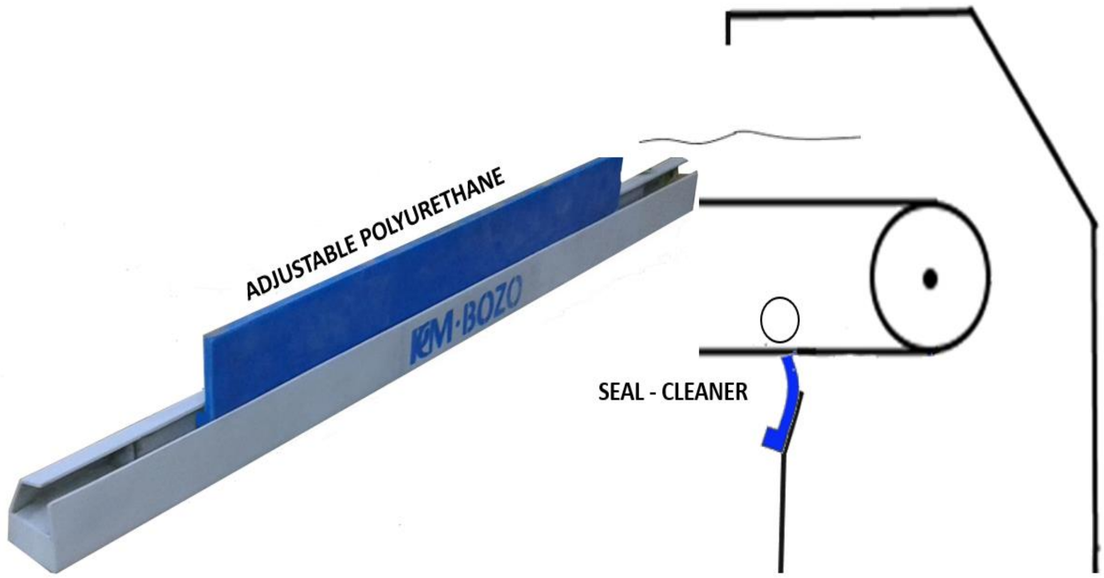


Figure 10. Seal – Cleaner adjustable and made of flexible polyurethane.

7.2 Truck Unloading

Induced Air. The area where trucks unload does not have a mathematical model for the calculation or estimation of induced air. This is because the discharge angle and flow are variable. Proconm has developed an approximate equation based on average values and times.

Displaced Air. The displaced air is the most important, according to measurements in site, the ratio of the flow that increases the level due to truck unloading versus the flow that decreases due to crusher operation is 20:1.

Mixed Confinement. Mixed confinement is the most efficient for this place. This means adding to passive confinement an active confinement based on a water curtain, water-air, or air. This active confinement process does not last more than 30 seconds.

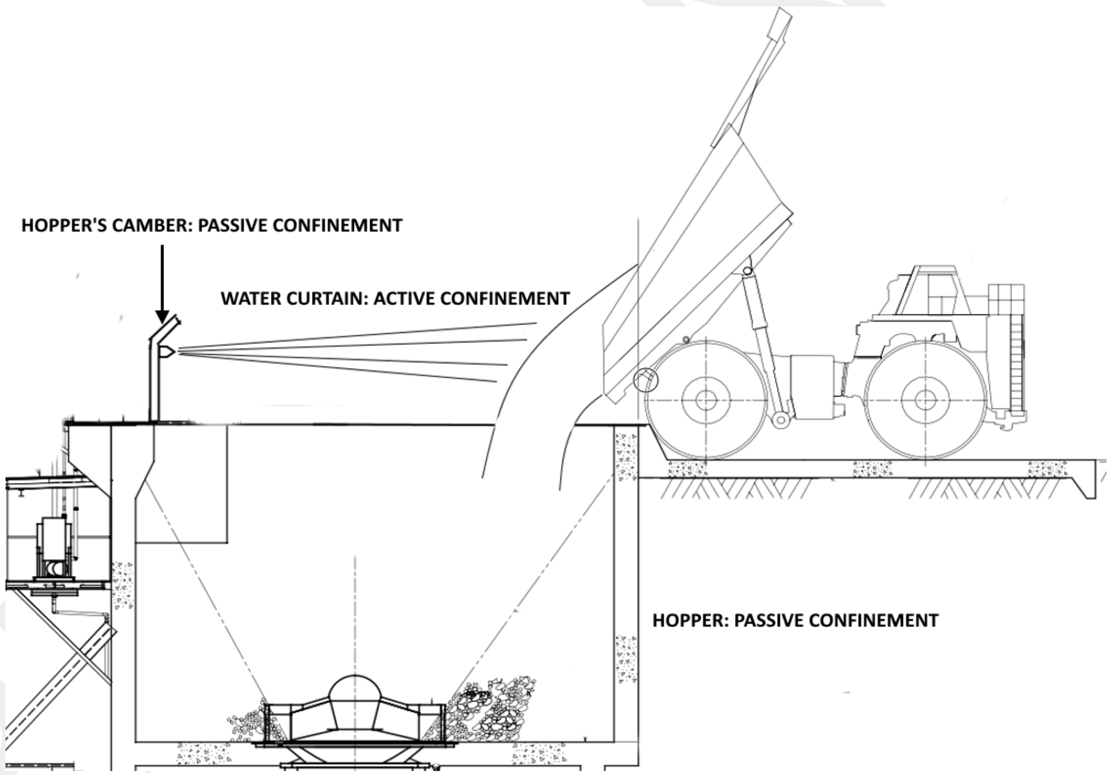


Figure 11. Diagram of truck unloading confinement.

Passive Confinement. In a location without a building or cover, passive confinement consists of the hopper, the hopper cannot, and windfences.

Windfences. Windfences are large metal structures with porous screens intended to reduce atmospheric dust by decreasing wind speed by 50% in large areas and by 80% in localized areas. The location, type, and height of windfences barriers should supported by a wind study.

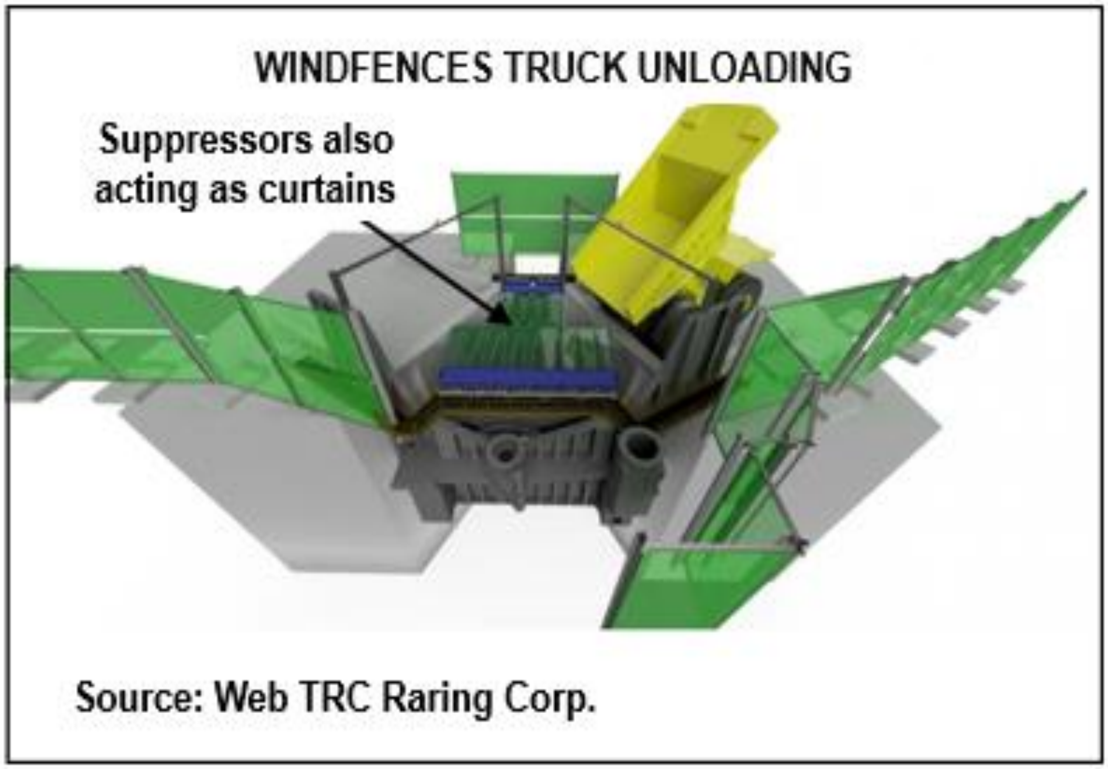


Figure 12. Diagram with location of TRC Raring Windfences.

7.3 Conveyor Belts

Passive Confinement. Particles released from the material on the surface of the belt, and their size depends on the belt speed. PM10 goes into the environment. It is necessary to consider a hermetic cover or a tubular belt as passive control.

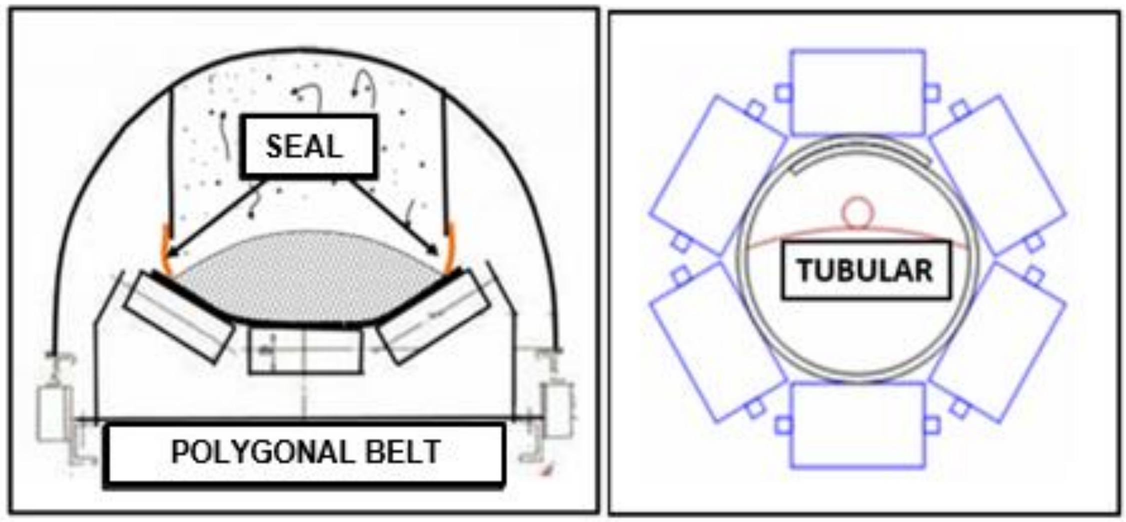


Figure 13. Passive dust control options.

7.1 Hopper

General. In a hopper or stockpile of confined ore with material entering from the top and exiting from the bottom simultaneously, induced air recirculates inside, and only displaced air exists, which exits the hopper when the level rises or enters the hopper when the material level inside decreases. These rises and falls in level is the fluctuation factor (FF) in the hopper.

Passive control. The old Reverse Air Jet Collector type [9] meets the defined requirements, as do the dust bags described in the Foundations [8]. with mechanical cleaning or compressed air cleaning [9].

.

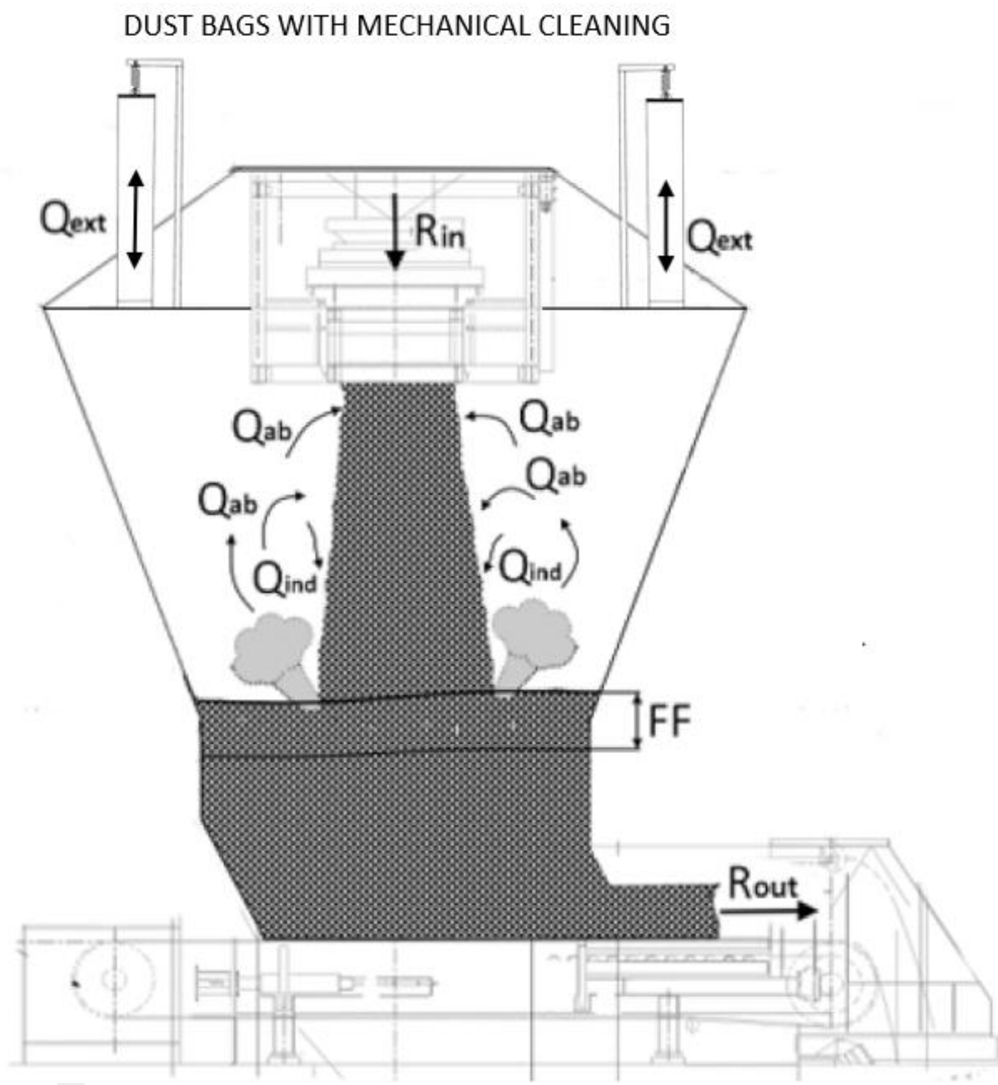


Figure 14. Hopper with dust bags with mechanical cleaning.

8.0 REFERENCES

[1] El Polvo Atmosférico. Publicado por COMET, Cooperative Program for Operational Meteorology, Education and Training de USA.

[2] Mineral Dust Entrainment and Deposition (DEAD) Model: Description and 1990s Dust Climatology. Publicado el 2003 en el Journal of Geophysical Research por: Charles S. Zender, Huisheng Bian, and David Newman

[3] Dust Control Handbook for Industrial Minerals Mining and Processing. Publicado por la norma NIOSH.

[4] Daniel Marshall and Greg Boggis, "Facts Concerning Dust and Air", Martin Engineering

[5] D. M. Anderson, "Dust control design by the air induction technique," Ind. Med. Surgery 33: 68 (1964)

[6] Richard Dennis & David V. Bubenick, "Fugitive Emissions Control for Solid Materials Handling Operations", Journal of the Air Pollution Control Association: (1983)

Control de Emisiones Fugitivas Dennis

[7] SEAA: Sistema de Encerramiento Anti-Atascos para Gualderas. Invento desarrollado por Proconm para resolver problema de atascos entre la cinta y la gualdera. Con patente registrada el año 2020

Sistema de Encerramiento Anti-Atascos

[8] Agenda of the CEMA Engineering Conference Bulk Conveyor Accessories Committee Meeting. Publicado por CEMA el año 2017.

Bulk-Accessories-Committee-Meeting-Agenda-Set.pdf

[9] Limpiador y Sellador desarrollado por Proconm para el control pasivo del polvo. Con patente registrada el año 2018.

Limpiador y Sellador. Innovación Chilena

[10] Martin Engineering. Foundations the Practical Resource for Total Dust & Material Control, Fourth Edition (2009).

[11] Charles E. Billings, Richard Dennis & Leslie Silverman, “Performance of Three Types of Fabric Dust Collectors”, Harvard University School of Public Health: 1954