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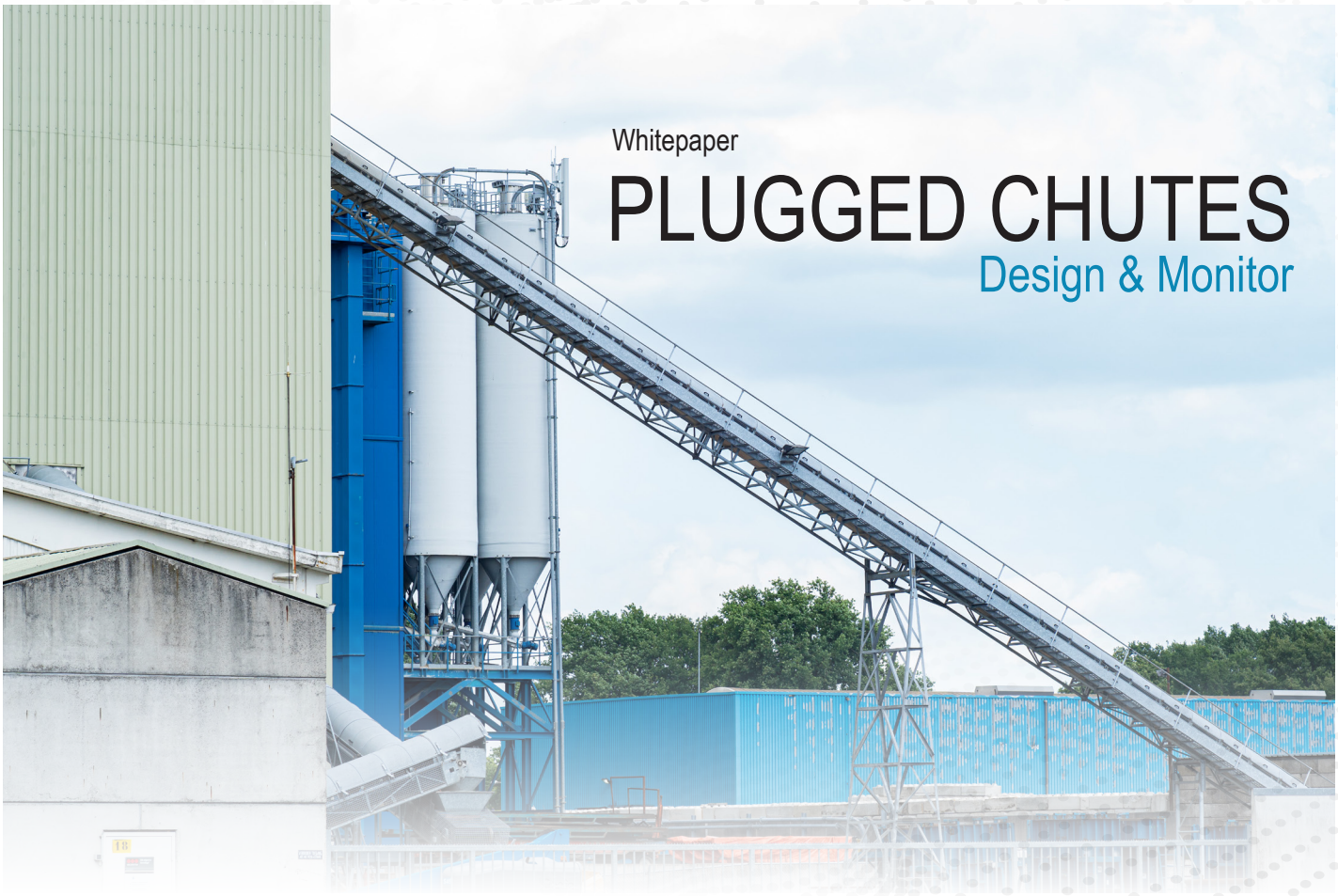

Whitepaper

PLUGGED CHUTES

Design & Monitor

Temperatures drop. Moisture rises. Chutes plug.

MoMost operations handling bulk solids experience plugged chutes. It's expensive. A plugged bin or chute cost one facility $50,000 a day in lost production and labor, according to Sukup Manufacturing. In mining, blocked chutes are responsible for about 60% of conveyor-related accidents, according to the Australasian Mine Safety Journal.

Chutes are used to control direction of material, flow stream, spillage, dust and environmental pollution, production degradation, retard or control flow, and surge control. (ckit.co.za, 2023)

Cost is a factor for designing a bulk material handling system to accommodate different materials, according to Rich Tavis, BinMaster Representative, Southeast Region.

"I work with a company that purchased an agricultural facility and used it for minerals processing," Tavis said. "They don't want to invest in new silos, conveyors, and chutes, so they adapt and utilize sensors to monitor bulk material flow."

High-tech sensors indicate flow and no-flow material conditions to alert operators before, or shortly after, a plug occurs

Sensor	Technology	Applied
Flow Detect 2000	Low-power microwave measures beat frequency (Doppler effect)	Detects material in flow, or no flow conditions. Detects clogs or trickles of flow
PROCAP FL	Capacitance probe, flat-faced, non-intrusive	Detects presence or absence of material
BMRX & MAXIMA Rotaries	Mounted away from flow stream, rotary paddle stops when material backs up	Installed in a y-pipe and sends alert when material backs up in chute.
VR-21 Vibrating Probe	Reliable despite changes in dielectric constant, humidity or density as low as 1.25 lb/cu.ft.	Blade vibrates until dampened by material triggering an alert. Installed in a y-pipe and sends alert when material backs up

Plugin
binmaster.com

KEYWORDS
chute sensor, bulk inventory, plugged chute, conveyor
OBJECTIVE
Learn to detect low-flow, no-flow in silo and bin chutes.
CONSIDER
Manual bulk measurement is risky, production stops and material spillage costly, and labor short.
ONLINE
https://www.binmaster.com/products
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https://www.binmaster.com/support/sales/contact-form

Expert Shares Years of Sensor Experience

Everything varies. Silo height. Material density. Conveyor size and speed. The best way to configure sensors and software for chutes is to lean on experience. Tavis, for example, has configured systems for more than 20 years.


Rich Tavis

"Often, cement plants use kilns that have massive "walking floors". They are basically metal belts that carry fuel through a long tunnel that looks like the "flames of hell." Cool to see, but I wouldn't want to visit," Tavis said. "They burned wood, tires, and other waste materials as fuel. It's an environmentally friendly way to avoid more landfill." Tavis said sensors helped monitor a chute that carries ash to the end of the process. Un-burnt chunks could cause problems and plug the chute at the end of the belt, he said.

The Science of Chutes

Engineered material flow is an intentional plan of how materials will move through a process. It requires an understanding of every moment bulk material moves through a facility. Studying the science of chutes can prevent problems. Looking at bulk material through the lens of engineered flow, an operation can see benefits with reduced dust, plugging, buildup, and load impact. Degradation of materials also lessens as load control is improved (bulk-online.com, n.d.).

The keys are speed, direction of flow and material characteristics. As chutes are designed, consideration should be paid to the way material steers through changing surfaces as well as the material's friction values. Special consideration should be given to materials that are hygroscopic. Tweaking surfaces can help minimize dust and relieve a center load. The goal in most material is "fluid-like" flow versus clumps bouncing off each other like billiard balls (hubspot.net, 2023).

Chutes should account for capacity, conveying distance, product distribution, and abrasion resistance of chute materials (ckit.co.za, 2023).

Another factor is continuity of flow, which can be measured with a relatively inexpensive test of friction coefficients and adhesion. Friction between material and the chute is not constant. It increases with reduced depth of flow in the chute and other changes in moisture.

Putting it all together

Plugged chutes can be somewhat mitigated with good design, but like every bulk material process, sensors with automated alerts should always be used to monitor, tweak and ultimately to ensure that material flows smooth as sand through an hourglass.

Causes of Chute Plugs

Problem	Symptom
Moisture	Moisture causes sidewall buildup. (Agrawal & Kazi, 2019)
Compaction	Material compaction due to vibration or time sitting in a hopper. For example, minerals sitting in a hopper bottom overnight may not flow the next morning when a slide gate or airlock is opened due to settling/material compaction
Particle size or shape	Particle size or shape always affects material flow.
Interlocking Material	Particles interlocking, such as wood chips, fiberglass fibers. For example, a sawdust bin in a mill gets an influx of "hog fuel" (bark chunks) or planer shavings (long strips of wood from a planer). These material interlock and bridge in a hopper or chute.
Up, Down-Stream Equipment	Failure of upstream or downstream equipment. For example, an airline to a pneumatic slide gate springs a leak and fails closed, starving feed to a furnace.
Material Makeup	Abrasive and heavy material causes sensors to quickly wear or bend
Material Buildup	Over time, material accumulates and builds up in chutes, reducing the effective cross-sectional area of the chute and causing blockages (McCarthy, 2019).
Foreign Objects	Foreign objects such as rocks or tools can enter the chute and become lodged, causing a blockage (Kramer & Walters, 2015).
Equipment Failure	Equipment such as valves, feeders, or screens malfunction and cause material to back up and block the chute (Schmidt, 2017).
Chute Design	Poor chute design, including incorrect angles or dimensions, cause material to flow unevenly and result in blockages (Tylczak et al., 2018). For example, a hopper bottom silo designed for plastic pellets gets sold to a bakery. The hopper bottom isn't steep enough for flour or sugar, so they deal with constant flow issues.

Chute Design Problems

- Traditionally-designed with box shape to avoid fabrication expense
- Designed based on angle of repose and are prone to blockage
- Flow and downward energy of material causes wear on metal walls
- Material moves causing extra dust
- Two conveyors running simultaneously cause material velocity to increase and belts to become overloaded.
- Plugged or blocked chutes create spillage when a belt restarts
- A conveyor system should be designed to handle when a system shuts down. Under normal stops, chutes should not plug. This might be accomplished by stopping the system sequentially starting with the most upstream belt, allowing each step to purge itself of materials before stopping.

• 90% of mining dust is caused by storage and transfer of bulk solids (pure.unileoben,ac.at, 2023)

Mining	In 2016, a plugged chute incident at a coal handling facility in Australia resulted in a large spill of coal and forced the facility to shut down for several days. Around 25% of workplace accidents in the manufacturing industry are caused by blocked or poorly maintained machinery, including chutes. (Source: EHS Today) Over 50% of power outages at coal-fired power plants are caused by blockages in coal chutes and other related equipment. (Source: Power Engineering)
Concrete	In 2019, a blocked chute at a concrete plant in the United States caused a delay in the pouring of concrete and required workers to manually clear the blockage. In the cement industry, chute blockages are a common cause of kiln downtime and can cost the industry up to $10 million per year. (Source: Global Cement)
Plastics	In 2020, a plugged chute incident occurred at a plastics manufacturing facility in the United States, causing a delay in production and requiring workers to manually clear the blockage. The average cost of downtime for an unplanned outage in a processing plant is $260,000 per hour. Blocked chutes are a common cause of unplanned outages. (Source: Plant Services).
Food	In 2013, a plugged chute caused a massive explosion at a grain elevator in Kansas, killing six workers and injuring two others. Approximately 60% of grain handling facility experienced a plugged chute or bin in 2018 (NDSU Extension, 2018). In 2010, 31 people died from 53 grain entrapments recorded in the U.S. (National Safety Council, 2013).

Chute Flow Detection by BinMaster

Flow Detect 2000


ProCap


BMRX, MAXIMA Rotary


Vibrating probes