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Most conveyors handling bulk materials have some amount of material loss from spillage, leakage, dust and carryback emissions, collectively called fugitive materials. The root causes are often obvious but rarely addressed. Rather, the standard approach is to treat the symptoms. The consequences of failing to control fugitive materials include unplanned downtime, excessive cleaning costs, regulatory actions, poor public relations and safety incidents. Addressing the issues with workable long-term solutions improves availability, housekeeping and safety, ultimately enhancing the company's cash flow.

TEXT **Todd Swinderman,** CEO Emeritus / Martin Engineering

New designs in skirtboards allow for double skirting that fluctuates with the belt for a better seal Martin Engineering 2024

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How to effectively use skirtboards and curtains for dust control

Reducing visible dust emissions (usually defined as ≥ 40 μm) from conveyors is typically a primary goal, partly because it attracts the attention of workers, neighbors and inspectors. Quite often the use of respirators is seen as an acceptable alternative, but a closer evaluation will show respirators reduce productivity by as much as 19%, and prolonged use can affect cognitive and sensory abilities significantly.[1] These decreases in productivity alone can justify improvements to conveyor dust containment to reduce emissions.

Skirtboards

The skirtboard enclosure is essentially a low-efficiency settling chamber. The basic concept is that a dust particle will settle out of a laminar air stream based on the speed of the air flow, Vair, and the terminal velocity, Vt, of the dust particle. [Figure 1]

There are many rules of thumb, along with traditional and industry-based practices for skirtboard sizing and dust curtain placement in an attempt to contain the dust in the skirtboard enclosure. Most of these practices are without proof of performance other than, "That's the way we've always done it."

Current practice for conveyor skirtboard enclosures is to design for Vair ≤ 1.0 m/s by increasing the height of the enclosure. Two common rules of thumb for the enclosure length are two times belt width or 0.6 m for every 1.0 m/s in belt speed. It is interesting to note that if H is increased, the distance (L) that the average dust particle must travel also increases. A detailed design study of air flow and particulate settling was performed using flow simulation software.

A "standard conveyor" was established as the baseline for the study. The standard conveyor is a 1200 mm wide belt with a 35-degree trough angle, traveling at 2.0 m/s. A generic material was used to produce the baseline data, with a bulk density of 1442 kg/m^3 and a nominal 50 mm minus particle size distribution with a 20-degree surcharge. The discharge chute was sized based on a material volume equal to or less than 40% of the chute cross section. A drop height of 3 m, an open area of 0.9 m², an average particle size of 25 mm and bulk flow of 1680 mtph were used to calculate the induced air volume.

Several variables were investigated to simplify the analysis. The complete conveyor with discharge and receiving belts was modeled and, while there were significant regions of recirculation in the upper discharge section, the air flow in the chute was reasonably consistent. So, the chute was simplified to that shown in Figure 3, with the air volume and dust particles injected into the last 2 m of the chute.

The combination of variables studied are given in Table 1. Both external and internal analyses were conducted, with complete moving discharge and receiving conveyors. The bulk material surface was set to absorb particles and the walls set to reflect particles. The effectiveness of the enclosure variations was determined by counting the number of each size particles that escaped the end of the enclosure compared to the number injected.

The results of the external analysis indicated that escaped dust particles increased in speed, as the air current is affected by traveling around the belt and the discharge pulley. This phenomenon is known as the Magnus Effect and emphasizes the need for effective belt cleaning as close to the discharge as possible. A space of 1 mm between the bottom of the skirtboard and the belt was used to simulate leakage.

Curtain designs

Several experienced maintenance technicians were surveyed and their preferred curtain arrangements modeled. In addition, multiple curtain designs and placement schemes were studied, including staggered, slit, curved, angled, with and without slits, with holes and no curtains. Several unconventional skirtboard enclosures were modeled in an attempt to create recirculation in the enclosure and improve dust settling. The optimum design for the standard conveyor was determined to be a conventional enclosure with a height of 600 mm a length of 3.6 m and three dust curtains placed in defined locations. [See Figure 6.]

Worn exit curtains were also modeled, and as the spacing above the load increased, the dust settling performance deteriorated. The use of a single curtain right at the exit proved problematic in all cases, acting to speed up the exit air flow even further when close to the belt and re-entraining dust in the exiting air stream, while being ineffective in creating recirculation within the enclosure. When the curtain placed at the exit was worn too much, it was as if there was no curtain at all. A curtain placed right at the exit and adjusted close to the load creates another fugitive material problem, sometimes called the popcorn effect, where the curtain causes spillage by knocking material off the belt.

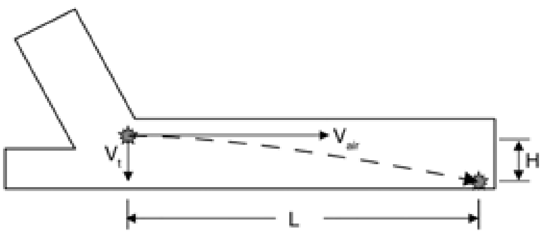
Results

Particle density

Solid density had little effect on the settling of nuisance dust particles from 100 to 25 µm. In every case 100% of the 100 and 40 µm particles settled almost immediately. As the bulk density increased, there was a moderate reduction in respirable dust emissions.

Discharge chute and tailbox

The junction between the discharge chute and the skirtboards was found to be an important design



1 Theoretical dust particle settling distance "L" in skirtboard enclosure
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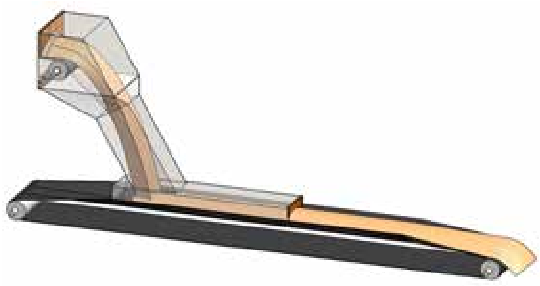

2 Model of complete standard conveyor receiving and discharge for external analysis
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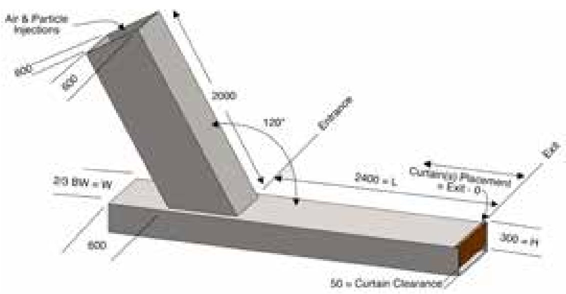

3 The standard conveyor used for baseline internal analysis
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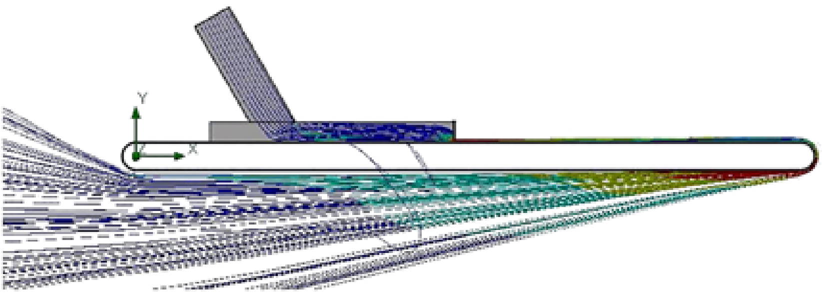

4 Typical external analysis results - dust particle trajectories
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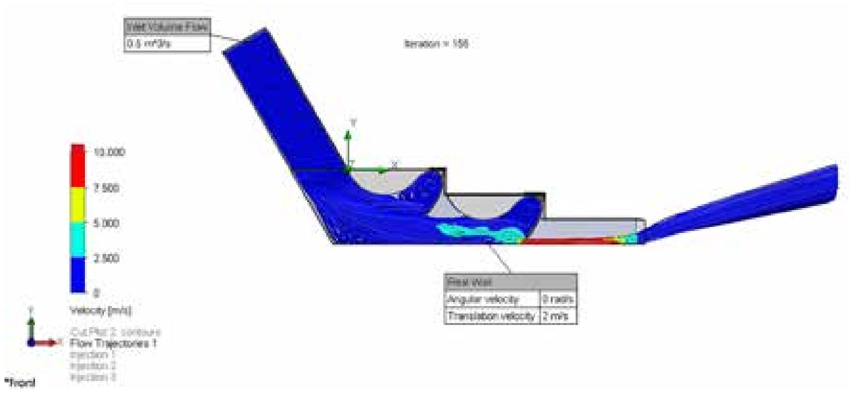

5 **Example of one of the unconventional chute designs analyzed**
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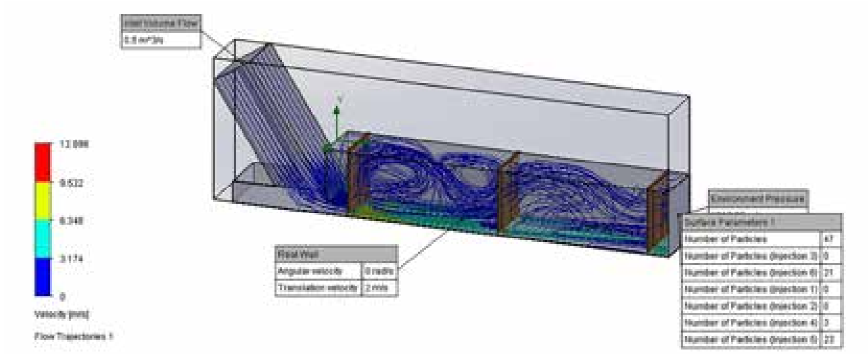

6 **Typical recirculation air flow results with 3 curtains**
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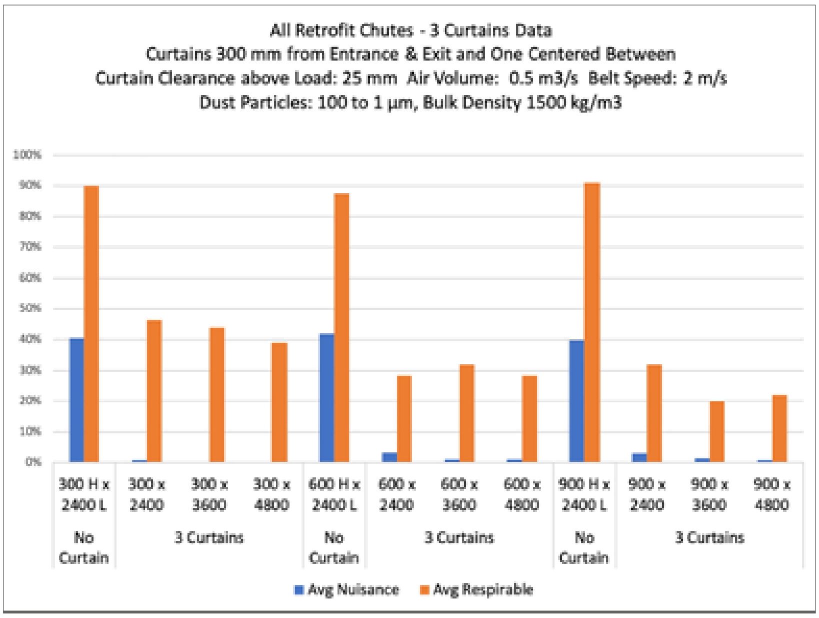
detail for creating recirculation. Making the width of the discharge chute narrower than the width of the skirtboard helps to fold the air flow going into the first curtain, and that encourages distribution of the air flow toward the top of the enclosure, rather than along the surface of the material. The retrofit and mitered junctions were significantly more effective than a simple butt connection and 300 mm height as shown in the standard conveyor [Figure 3].



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7 **Summary of results – Percent of dust particles exiting the enclosures**

The tail box had little effect on dust emissions out of the exit end of the skirtboards. In most configurations, the height of the tail box was set at 300 mm. The tail box length was set at 600 mm to match the typical 600 mm idler spacing used in the load zone by most conveyor manufacturers and engineers.

Length of skirtboard

It was found that for most situations a 3600 mm long skirtboard produced the best results. Increasing the length to 4800 mm and height to 900 mm had some marginal effect, but may not be worth the extra investment.

Height of skirtboard

An enclosure height beyond 600 mm for the standard conveyor with a single exit curtain did reduce nuisance emissions but tended to increase respirable dust discharge, because the average settling path was greater with the higher enclosure.

Air flow

As would be expected, the average air velocity through the skirtboards was directly proportional to the induced air flow and cross-sectional area. Average velocities in the skirtboards due to induced air ranged from 0.8 to 2.8 m/s. Belt speed has a minor effect on the average velocities. The maximum air velocities were almost always found where the air flows under the skirtboard curtains. These high air speeds kept the respirable dust suspended, so reducing induced air into the chute is also important in improving performance.

Curtains

The best results were obtained with three or more curtains. The design of the slits in the curtains is important to allow air to pass through, allowing the airflow paths to fill the entire chamber and not just flow at high speeds under the curtains. It was found that the individual flaps should be about 50 mm wide, with slits at least 5 mm wide and the curtains extending the full width of the enclosure.

Preferred embodiments

The best value for the cost of the skirtboard enclosure and its effectiveness is judged as skirtboards 600 mm high and 3600 mm long and 3 full width slit curtains using either the retrofit or mitered discharge chute-to-skirtboard connection.

Design recommendations

» Discharge chute width across skirtboards 200 mm < width between skirtboards.
» Skirtboard outside width based on horizontal dimension of free belt edge for sealing and belt wander edge allowance ≥ 115 mm per side (Foundations™ method).[1]

- Skirtboard height ≥ 600 mm.
- Inlet to skirtboards air volume flow ≤ 0.50 m^3/s.
- Length of skirtboards for material loading turbulence ≥ 1000 mm when required.
- Length of skirtboards for dust settlement ≥ 3600 mm plus extra allowance for loading turbulence if necessary.
- Skirtboard dust curtains:
- Entrance (1st) curtain 300 mm past end of extra allowance for material turbulence and distributing air flow.
- 2nd (middle) curtain centered between entrance and exit curtains.
- Exit (3rd) curtain 300 mm from end of skirtboards.
- Curtain clearance above the bulk material: 25 mm preferred, 50 mm max.
- Curtain flaps: ~ 50 mm wide strips separated by slots ≥ 5 mm.

Conclusion

While some improvement is seen with increased skirtboard height and length, it is doubtful that it can be economically justified on the reduction of respirable dust alone. A return on investment for control of nuisance dust for new and retrofit designs can be based on reducing cleaning labor, increased equipment life and/or elimination of dust collection. If the improvements reduce the TWA of respirable dust emissions to the point where engineering or administrative controls could be less stringent, then a financial case could also be made based on improvements in labor productivity.[2]

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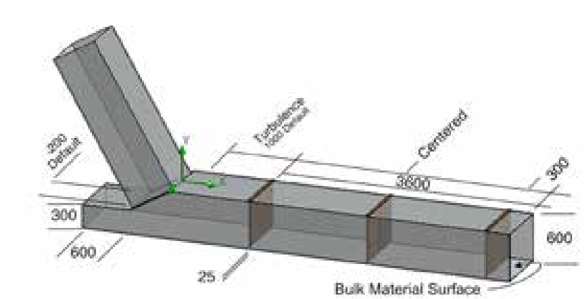

8 **Recommended mitered skirtboard enclosure for new construction**
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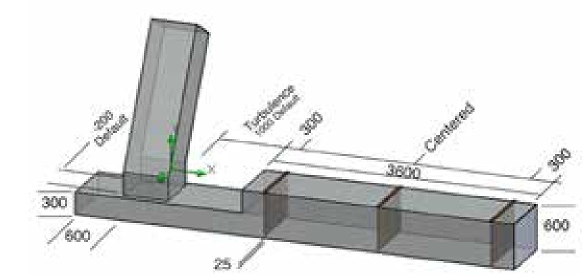

9 **Recommended skirtboard enclosure for retrofit or angle transfer**
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1 **Variables used in the particle study**

Parameters	Standard conveyor	Experiment variables
Belt speed (m/s)	2.0	2.0 to 8.0
Belt width	1200	600, 1200 & 1800
Bulk material solid density kg/m3	1500	750, 1500 & 3000
Air flow (m3/s)	0.5	0.25, 0.5 & 0.75
Curtain placements	1 @ Exit	1 to 6 curtains, at various spacings
Curtain clearance (mm)	50	0 to 150 above load
Skirtboard height (mm)	300	300, 600 & 900
Skirtboard length (mm)	2400	2400, 3600 and 4800
Wall roughness (mm)	1	0 to 100
Chute to skirtboard	Standard Inline	Mitered, full width & 90°
Tail box length: 600 mm	300 High	300, 600 & 900 High
Dust particle diameter (µm)	All configurations modeled with 100, 50, 40, 25, 10 and 1 µm dust particles	

REFERENCES

[1] Foundations, The Practical Resource for Cleaner, Safer, More Productive Dust & Material Control, Martin Engineering, 4th edition, copyright 2009.
[2] Foundations for Conveyor Safety, The Global Best Practices Resource for Safer Bulk Material Handling, 1st edition, copyright 2016.