DRY BULK®

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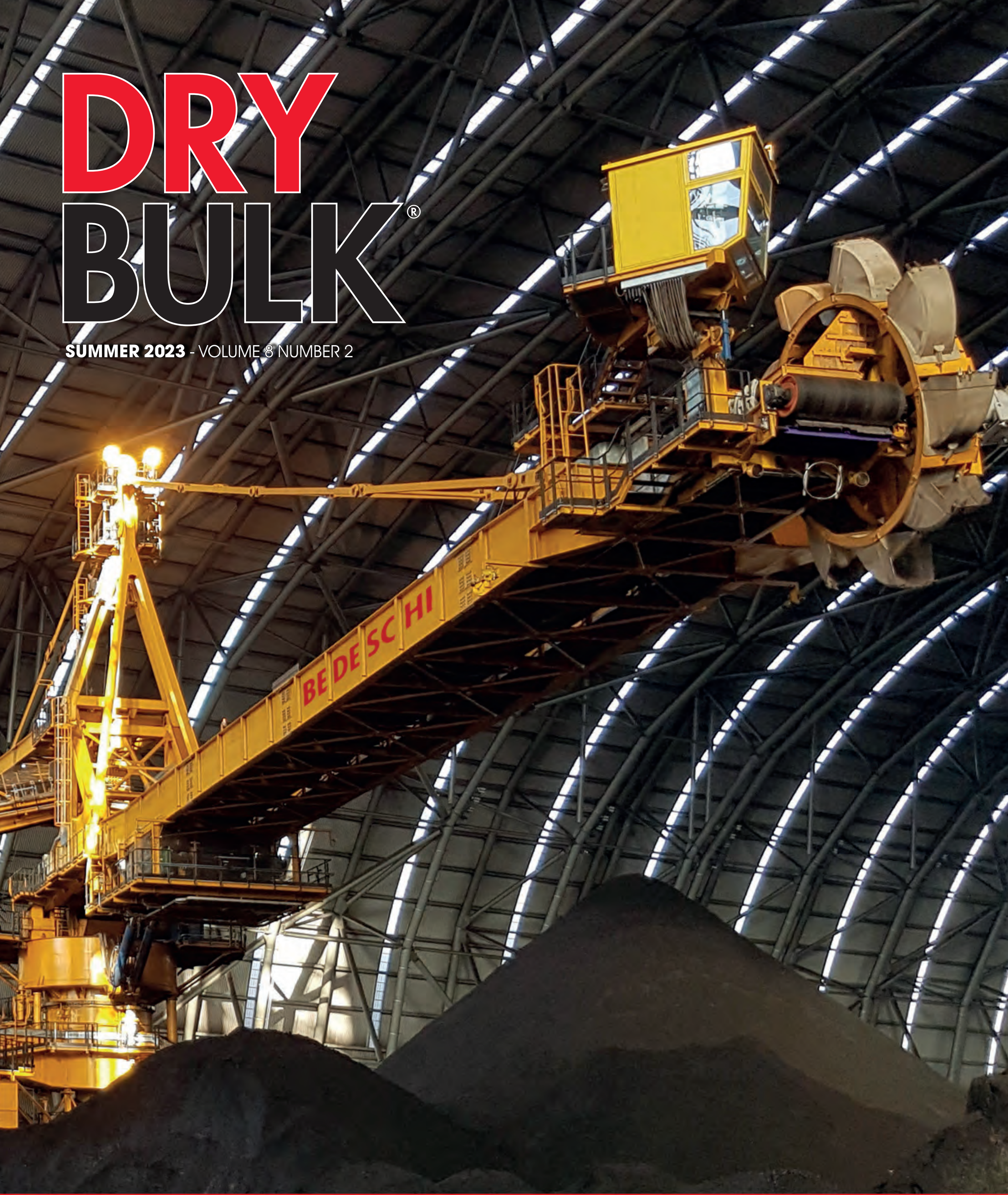
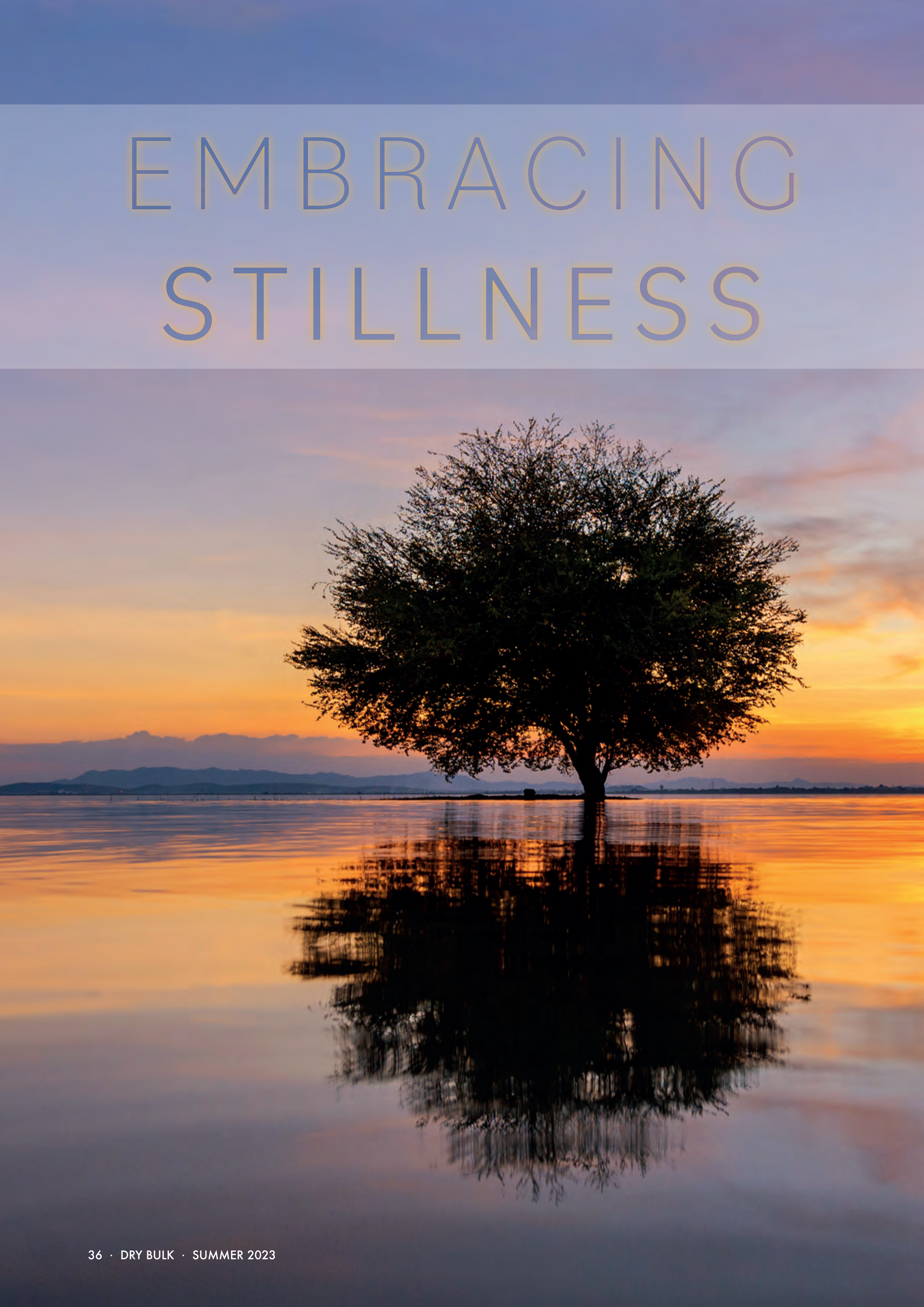


EMBRACING STILLNESS



Todd Swinderman, Martin Engineering, USA, considers passive dust control in conveyor loading zones.

Historically, transfer points have been designed primarily for material throughput and secondarily for fugitive material control. However, dust control and spillage have come to the forefront as serious workplace safety issues, and have also been linked to a greater cost of operation from cleanup and equipment fouling. This makes addressing dust and spillage through engineered transfer chute design both critical and practical.

The testing and application of 'passive dust control measures' in a wide range of bulk handling applications using dust curtains and skirting have proven to be an effective control measure for dust. However, this equipment needs to be installed correctly and strategically to maximise results and the return on investment.

When redesigning a dust control enclosure at a conveyor belt transfer point, skirtboard extensions (wear liners, polyurethane skirting, clamps, etc.) to seal the environment and the placement of dust curtains to control airflow are essential. Most engineering firms use the American Conference of Governmental Industrial Hygienists (ACGIH) Industrial Ventilation Handbook design criteria for active dust control (dust machines, dust bags, sprayers, etc.). The design rules for skirtboard extensions are based primarily on lump size and the length necessary for the bulk material to settle down into a stable profile.

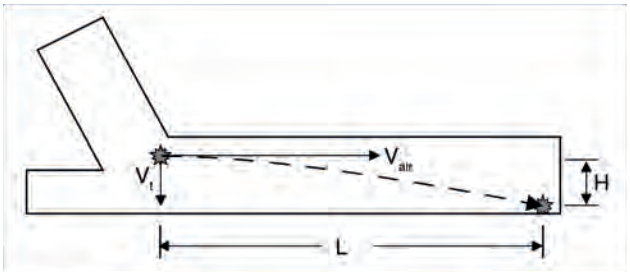


Figure 1. Dust particle trajectory.

Figure 2. Basic chute configurations.

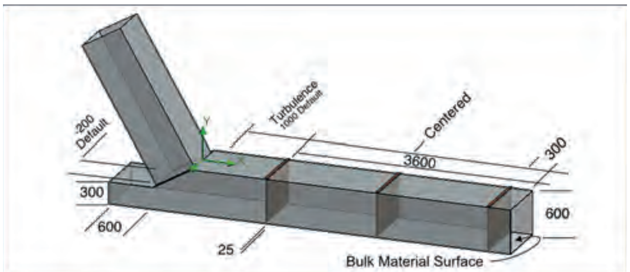


Figure 3. Preferred chute configuration.

Figure 4. The proper skirtboard extensions and curtain placement drastically reduce dust emissions.

By understanding the environment inside the transfer point and how the structural components work together during operation, dust and spillage can be mitigated and the external environment will improve.

Dust dynamics

Air is very compressible and will find the path of least resistance. With current enclosure designs, the air is sped up significantly to flow under or around a single exit dust curtain with narrow slits, resulting in re-entraining the dust particles in the exhaust. Therefore, it is necessary to create recirculation regions inside a transfer point to improve dust settling.

The basic concept is the trajectory of a dust particle can be modeled based on the terminal velocity (V_t) of the dust particle settling in still air and the velocity of the airflow in the transfer point (V_{air}). The result of these two velocities using the enclosure height (H) as the vertical drop distance indicates the length (L) necessary to settle the dust particle. If the terminal velocity of the particle is very small and the transfer point air speed is relatively large, the settling distance can be quite long (Figure 1).

Using the commonly applied Stoke's Law, a 10 μm (micrometer) respirable limestone dust particle in an air stream traveling 1 m/s (3.2 ft/s) is predicted to take 75 m (246 ft) to settle by gravity alone. This makes a well-designed enclosure with the proper height, seal, and air control with curtains essential to controlling dust.

Preferred embodiments

When reducing dust emissions, field tests have shown the difference in performance for longer and taller skirtboards of 4800 mm (15 ft) long and 900 mm (3 ft) high, compared to 3600 mm (~12 ft) long and 600 mm high is negligible. It was the placement of dust curtains that had the greatest impact on dust settling.

In both transfer point sizes, enclosures with three curtains spaced 300 mm (~1 ft) apart from the entrance and exit and one in the centre offered superior performance as compared to one dust curtain at the end. The best value for the cost of the skirtboard enclosure and its effectiveness is 600 mm high and 3600 mm long, using either the retrofit or mitered discharge chute-to-skirtboard connection (Figure 2).

The junction between the discharge chute and the skirtboards was found to be an important design detail for creating recirculation. Most conveyor engineers and manufacturers use 300 mm high skirtboards, because this height is about the minimum for installing a sealing system and wearliners.

In most of the models, the discharge chute was 200 mm (7.78 in.) narrower than the skirtboards. Making the width of the discharge chute narrower than the width of the skirtboard helps to fold the airflow going into the first curtain, and that encourages the distribution of the airflow toward the top of the enclosure rather than along the surface of the bulk material. Extending the head chute back to the first full troughing idler on the carrying side and using two curtains plus sealing the area between the top and bottom runs is critical in reducing induced airflow.

Height of the tail box

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. Very little airflow or pressure increase was observed in the tailbox for most configurations, so its main function should be considered reducing roll back of material and creating a means to effectively seal past the corner of the loading chute.

Consider air flow

In field tests, three different airflow volumes of 0.25, 0.50, and 0.75 m^3/s (0.82, 1.64, and 2.46 ft^3/s) were used to represent induced air. For reference, 0.50 m^3/s is about 28.3 cmm (1000 cfm). As would be expected, the average air velocity through the skirtboards was directly proportional to the induced airflow. The maximum air velocities in the skirtboard are almost always found where the air flows under the curtains. Air velocities of 30 m/s (98.4 ft/s) were common under the curtains, with up to 90 m/s (295 ft/s) observed. These high air speeds keep the respirable dust suspended, so lowering induced air into the chute is important for improving performance.

The length of the skirtboard had some effect on dust discharges for the standard conveyor with a single exit curtain. With three curtains spaced 25 mm (~1 in) above the belt, there was a similar reduction in the emission ratios but at a much lower percentage of particles escaping. Keeping the airflow (and therefore the flow of bulk material) consistent through the transfer is important to improving dust settling. Different baffle arrangements were tried to encourage recirculation within the discharge chute and the skirtboards, with little effect.

Time to arrange the curtains

Testing has shown that, in most cases, curtain strips were nominally 50 mm (~2 in.) wide with a gap between the strips of at least 5 mm was necessary to cause airflow through the curtain, rather than under it. While it varies by application, it appears that a gap of 10 to 15 mm (0.4 to 0.6 in.) produces the best combination of recirculation and keeping the average air speed inside the skirtboards more uniform and at a lower velocity.

When multiple curtains were tried, the best combination was with a curtain 300 – 450 mm (1 – 1.5 ft) from the beginning of the skirtboards, one curtain in the centre and an exit curtain 300 to 450 mm from the end of the enclosure. This pattern was found for all skirtboard lengths, heights, and belt widths. A minimum of two chambers created by the spaces between curtains was necessary to create recirculation patterns within the skirtboards.

Recirculation within the chambers created longer settling paths for the respirable dust, which improved dust control performance. A slight improvement was found by increasing the number of curtains and evenly spacing them. Configurations of up to six curtains were tried. Staggered curtains and combinations of full width and staggered curtains did not improve performance, and above all, the dust curtain systems must be accessible and maintainable to gain the benefits of passive dust suppression.

Case Study: Coal plant in China

The Yanzhou Dongtan coal plant in Eastern China had spillage and dust issues at two conveyor transfer points. Coal was dropped down 5 m (16.5 ft) sloped transfer chutes onto 1000 mm (40 in.) wide belts traveling 2.56 m/s (500 fpm), with little control over impact or settling. The result was excessive fugitive dust from belt #111 throughout the facility. Inadequate chute control on belt #185 caused spillage to get caught between the belt and rubber tail pulley, damaging both. In both systems, dust and fines fouled rolling components and machinery causing consistent and disruptive downtime. Increased labour costs for maintenance and cleaning, along with workplace safety concerns, seriously impacted plant production.

Figure 5. Access to the #111 transfer point was seriously limited by the lack of visibility caused by dust.

Figure 6. Installers used the Mitered chute design for #185 with a tail box, shirtboard extensions, and curtains.

After an onsite inspection, technicians in the Martin Engineering China team installed transfer point solutions addressing both conveyors' dust and spillage issues. On #111, a new enclosure was installed which raised skirtboard and extended it to 12 m (40 ft) long with a sealed loading zone, stilling zone, and settling zone equipped with a full-length Martin ApronSeal™ Skirting and properly placed dust curtains. A Martin Impact Cradle was placed in the loading zone followed by a series of Martin Slider Cradles to create a smooth sealed environment. Belt #185 required a much longer enclosure, which extended 26 m (85 ft) and was also equipped with ApronSeal Skirting and a network of dust curtains. A heavy-duty impact cradle and several slider cradles supported the belt and created a sealed environment down the entire length of the chute. Both chutes also featured a Martin dust bag at the end to collect any unsettled dust.

Since the installation was completed, visible dust within the facility has drastically reduced. Respirable dust has been measured at less than 3.5 mg/m^3, and total dust is down to 10 mg/m^3. Operators report that onsite safety and the overall work environment have improved and that the significant drop in equipment failure rates has substantially increased plant productivity.

Conclusion

Controlling the amount of airflow through the transfer is also critical. The results of field tests and applied techniques clearly indicate that when dust curtains are properly spaced and kept adjusted close to the bulk material profile, the passive reduction of dust emissions is significant. Retaining a proper seal using skirting set in the modern skirtboard extension configuration will eliminate gaps where air can escape taking dust and fines with it.

Passive dust control has gone beyond merely adding some skirting and a dust curtain at the end of a chute. New retrofitted curtain and skirting designs require little monitoring and only occasional maintenance, while significantly improving the work environment around the transfer point. The amount of labour saved in the cleanup around the transfer point and the cost of replacing fouled equipment lowers the cost of operation and improves the return on investment. DB

References

1. 'Industrial Ventilation: A Manual of Recommended Practice for Design', 30th Edition, *American Conference of Governmental Industrial Hygienists*, Cincinnati, OH, USA, (March 2023), www.acgih.org/ventilation