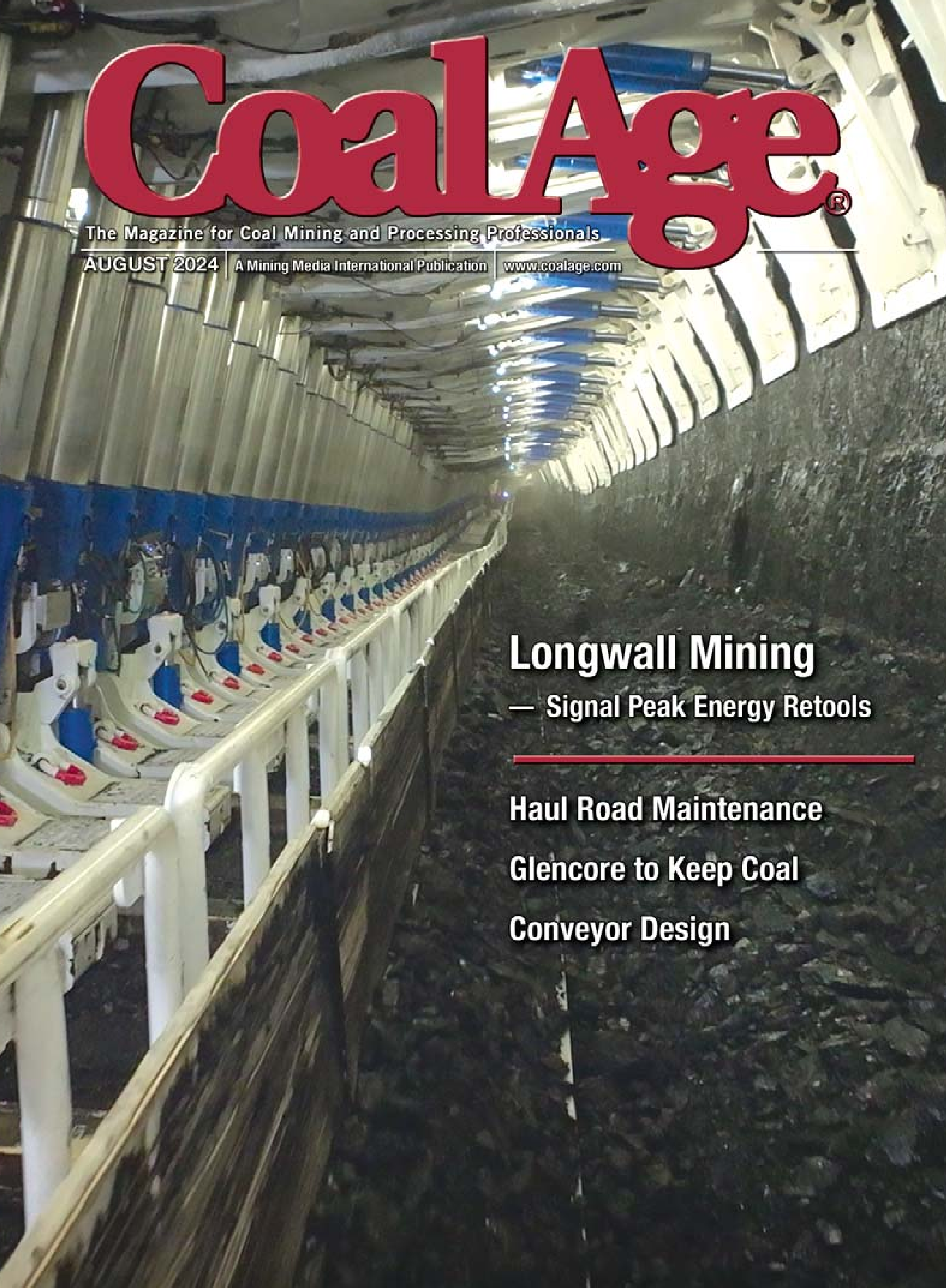

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Conveyor Design

Safe and Efficient Conveyor Design: Perception vs. Reality

If the design rules are proven, then why do mines still have all the issues of chute plugging, belt damage, dust, spillage, and injuries?

By Todd Swinderman

There are numerous conveyor design generalizations that are accepted as "axioms," established rules or processes assumed to be true regardless of evidence. They seemingly require no proof due to their long-standing use in conveyor fabrication and operation. This begs the question: If these rules are proven to address common problems, then why do we still have all the issues of chute plugging, belt damage, dust, spillage, and injuries when operating bulk material handling conveyors?

Unless the designer has solid, real-world knowledge in bulk material handling and can make educated assumptions when applying the rules, it is easy to make mistakes. Those who established these rules are long gone or fast retiring, so there is a need to provide younger operators and maintenance personnel with the knowledge to avoid the expensive — and sometimes dangerous — trial and error associated with applying many of the handed-down design rules.

Training based on a combination of industry experience and engineering will greatly improve design decisions, resulting in higher productivity, fewer safety incidents and reduced unplanned outages. Certified training courses will offer staff a wider view of modern solutions and allow them to apply that knowledge to improve safety and productivity to operations.

Category	Guiding Axiom	Affects	Ref. #
Material Size	Lump weight 2 to 3 times nominal material mass	Idler Selection, Impact Force	[1]
	Maximum lump diagonal 2.5 times nominal for graded material and 3.0 times nominal for ungraded	Belt width, chute and skirtboard dimensions	[2]
Skirtboards	Skirtboard width 2/3 of the belt width, ½ of belt width for free-flowing materials	Side sealing, belt mistracking	[1]
	Skirtboard width 3 times the maximum lump size	Chute clogging, skirtboard dimensions, belt width	[5]
	Skirtboard extension 1.5 m + 0.6 m for every 1 m/s (5 ft + 1 ft per 100 fpm) of belt speed	Skirtboard dimensions, spillage and leakage	[3]
	Skirtboard length 4 times belt width	Skirtboard dimensions	[4]
Tracking	Training idlers spaced from 100 to 150 feet (31 to 46 m) apart, and at least one training idler on conveyors less than 100 feet (31 m) long	Pulley face width, mistracking allowance, belt cleaning, spillage and leakage	[1]

Table 1 — Examples of common rules for conveyor design.

Conveyor with proper loading and tracking.

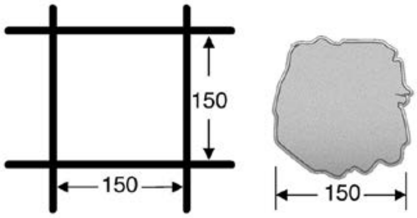
Historical Design Axioms

Undoubtably, many design principles are the result of the early years of conveyor use and were developed by trial and error. Others emerged in codes developed in the early 20th century due to catastrophic equipment failures, correlated with injury risks or connected to industrial disease outbreaks. Some are based on testing performed for early design manuals, but the original data has been lost. Yet the truisms live on. Then each industry and even each location developed their own rules. These were written into company specifications based on successfully treating symptoms rather than root causes, which can lead to costly and unsafe practices later.

There are often differences in rules by industry and many of them have no real engineering basis, instead being based on doing things the "same as before." Since the modern conveyor was developed in the early 1900s, much has changed in conveyor belt construction, capacities and regulations. Conveyors are still sources of pollution and accidents, so it seems clear that "same as before" will not be good enough. The rules selected for discussion in Table 1 are just a few of many common conveyor design guidelines that often contradict each other.

Material Size

When the quantity, quality or sources of the bulk material change, the design must anticipate new handling challenges. It may be that "nominal lump size" is the biggest lie in bulk material handling, as the actual lump size in production is typically much larger than the design specification. This discrepancy in lump size from specified to actual is often due to adjusting crushers or screens to increase production, from gradual wear or from longer maintenance intervals.



Limestone, Crushed

Bulk Density	~1440 kg/m³
Solid Density	~ 2700 kg/m³
Lump Volume	~ 4/3 × Π × r³
Slab/Rod Volume	~ Π × r² × L
Lump Mass	~ 4.8 kg
Slab/Rod Mass	~ 21.5 kg (L= 3 × D)

Figure 1 — Lump and slab mass example calculation

The lump size and percentage of fines provide guidance on selecting the belt width and then the skirtboard width and height. In Table 1, the references state that the lump size is to be considered 2 to 3 times the nominal or specified lump size. The lump size also influences idler selection due to impact forces. Picking the maximum lump size also depends on how the material tends to fracture — into lumps or slabs. It may well be that a slab is much longer than 2 to 3 times the nominal size, while at the other extreme, lumps may tend to be more spherical. Understanding the material, its properties and behavior is critical not just for idler selection, but for many other considerations such as chute size and slope. For example, just because experience shows that on one conveyor material flows well on a 50° chute slope doesn't mean material from another pit or seam will flow down the same chute.

Bulk materials are hard enough to handle when consistent in size, physical properties and percent of fines. In Figure 1, if the bulk density of 1,440 kg/m^3 (90 lb/ft^3) is used rather than the solid or specific density of 2,700 kg/m^3 (169 lb/ft^3), the mass used for idler and impact cradle selection would be almost 50% underestimated, almost guaranteeing premature failures. For a slab or rod shape, the error could be significantly more than if using the nominal lump size. Lump or slab mass is a direct variable inputted into the idler and impact cradle selection methodologies. Correct maximum size and mass calculations can also affect belt selection. [Fig. 2] As the percentage of fines increases, the size of the lumps that can be tolerated on narrower belts also increases. In this example, 150 mm (~ 6 in.) lumps and 10% fines, for a material with a 30° surcharge, can be handled on a 900 mm (~36 in.) belt, whereas if the cargo was 100% lumps it would require a 1,600 mm (~60 in.) belt.

Skirtboards

For the width of the skirtboards, most specifications follow the Conveyor Equipment Manufacturers Association (CEMA) recommendation of 2/3 of the belt width for most materials or 1/2 belt width for free-flowing materials, while the International Standards Organization (ISO) does not make a specific skirtboard width recommendation. CEMA and ISO have different free belt edge formulae for the distance between the loaded material profile and the edge of the belt. The free edge distance beyond the skirtboards is to prevent spillage outside the loading chute due to belt sag between carrying idlers. The free belt edge is often confused with the amount of belt edge necessary in the load zone for sealing systems and belt tracking. CEMA provides some guidance on skirtboard height based on lump size, but not for dust control.

Examining all the factors that go into an engineered loading of material on the belt would require a lengthy discussion of its own. The 2/3 of belt width rule is not generous enough on narrow belts and too generous on wider belts. ISO addresses the free belt edge with two formulae, one for belt widths under 2,000 mm and one for wider belts. In addition to lump size, a main consideration for the skirtboard width is

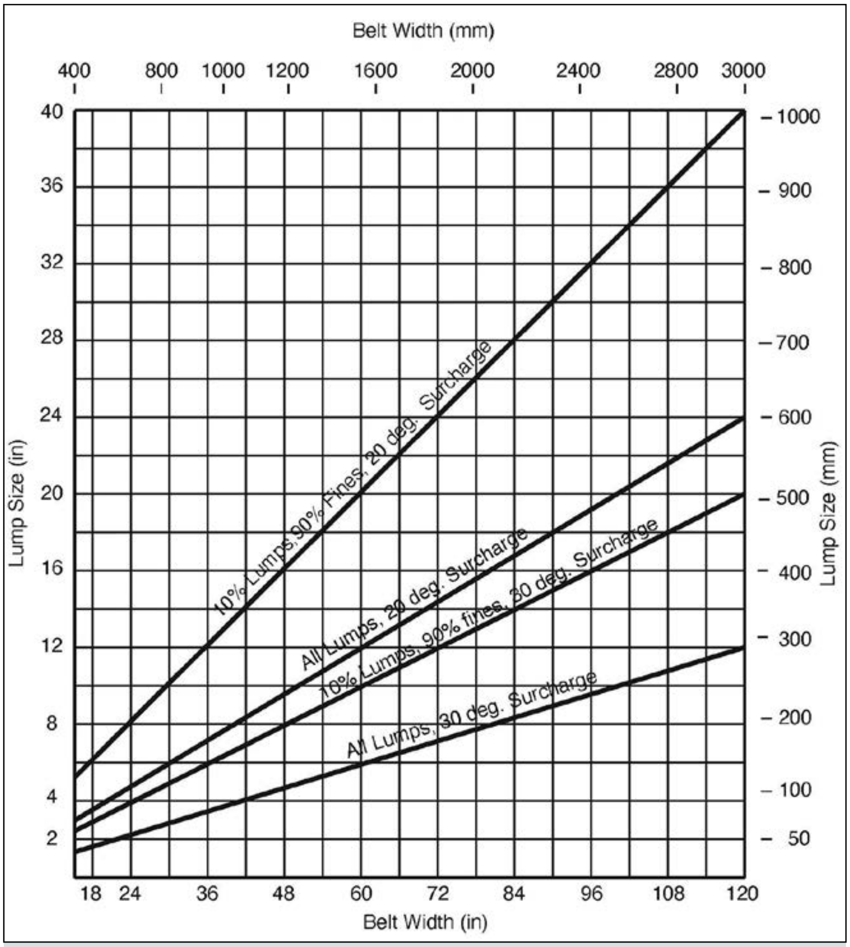


Figure 2 — Lumps vs Fines and Belt Width.

the space needed for the many different types of sealing systems, and to accommodate expected belt mistracking, because most belts mistrack far more than the commonly specified ± 25 mm (~ 1 in.) allowance on a standard pulley face.

The CEMA guidelines vary from the ISO standards for 36-, 42-, 48-, 54- and 60-in. belt widths because the ISO allowances exceed the CEMA standard pulley face widths and for 54-, 60-, and 72-in. belt widths because the ISO Standards exceed CEMA manufacturers' standard return idler brackets widths. These variances are easily overcome at the design stage by specifying wider pulley faces, offset return drop brackets and providing the required structural clearances.

Figure 3 illustrates that more than just the free belt edge must be accounted for in determining WS, the skirtboard width. It is generally accepted that WS is the inside dimension of the skirtboard uprights. If the wear liner is of significant thickness, such as cast iron or rubber blocks, the thickness of the wear liners should be considered in skirtboard spacing for their effect on conveyor capacity. Sealing system designs vary significantly, so the adequate edge distance in the load zone depends on the actual dimensions of the sealing system specified.

Belt Tracking

Theoretically, a properly installed and aligned conveyor system using a belt within manufacturing tolerances, with square splice(s) and center loaded should track without the need for training idlers. If most of the training idlers are tied off, it indicates that either they are ineffective or the belt must be constantly re-centered to compensate for structural and component misalignment or belt damage. Too many training idlers can interfere with each other and often make tracking worse. The guideline of installing training idlers a standard distance apart regardless of the quality of the installation and operation does not consider whether they are even needed or how much correction each training idler can generate. Sometimes more is less.

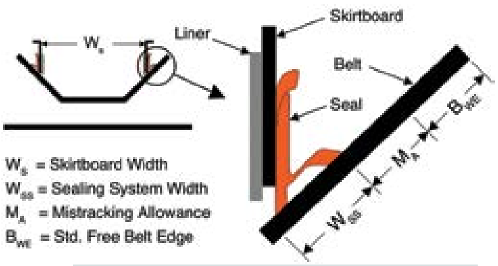


Figure 3 — Inputs for belt sealing, mistracking and spillage for determining skirtboard width.

Modern belt training devices detect slight variations in the belt path and correct it immediately to retain production efficiency.

If the belt doesn't have good contact with the training idlers (~50%), the poor contact can't create enough frictional correction forces to overcome the belt stiffness and move the belt toward the center. It's the same situation when knocking idlers to try to track the belt. Over-adjustment for tracking causes bottom cover wear and consumes more energy than one might think. Training idlers cost more than standard idlers and may be adding unnecessary expense with little benefit.

For a start in locating training idlers, the most critical positions are before the belt enters the tail pulley, after the loading zone, before the belt discharges and before the belt enters the takeup. Portable and underground conveyors may require more training idlers because of the installation tolerances or distortion of the structural alignment when portable conveyors are moved. Most belt tracking problems are related to misalignment of the structure, pulleys and idlers, not the absence of enough training idlers.

Today, there are many options for non-commercial conveyor training where companies offer in-person classes or virtual training. Some firms use real-time video conferencing with cell phones to show the actual problems and discuss solutions "live" one-on-one.

With the increased emphasis on dust control and safety, using these "same-as-before" rules probably is not going to mitigate the dust emissions or provide adequate spillage control, resulting in workers' unnecessary increased exposure to respiratory disease or safety hazards from cleaning. The most effective approach to training examines a plant's specific conveyor challenges and helps operators run safer, cleaner and more productively by treating the root causes of its problems. The one axiom that still rings true: "If you think education is expensive, try lack of knowledge."

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6. Conveyor Equipment Manufacturers Association, Belt Conveyors for Bulk Solids, 7th ed. Figure 4.2.

R. Todd Swinderman, P.E., is president emeritus for Martin Engineering. He has authored dozens of articles and papers, presented at conferences and customer facilities around the world and holds more than 140 active patents.