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Mining Tires
— Fit-for-purpose designs improve performance

Fleet Management Systems

Material Handling

Engineering Safer Conveyors: Art Meets Science

A properly configured conveyor minimizes emissions for improved safety and easier maintenance.

All new conveyor systems will inevitably succumb to the punishing bulk handling environment and begin the slow process of degradation. The system will eventually require more time and labor for maintenance, shorter spans between outages, longer periods of downtime, and an ever-increasing cost of operation. This period is also accompanied by an increased chance of injury or fatality as workers are progressively exposed to the equipment to perform cleaning, maintenance and to fabricate short-term fixes to long-term problems. A total system replacement is cost prohibitive, but to remain compliant and/or meet ever-increasing production demands, upgrades and repairs are unavoidable.

When examining the safety of a system, improving efficiency and reducing risk can be achieved by using a hierarchy of control methods for alleviating hazards. The consensus among safety professionals is that the most effective way to mitigate risks is to design the hazard out of the component or system. This usually requires a greater initial capital investment than short-term fixes, but yields more cost-effective and durable results.

Control Methods

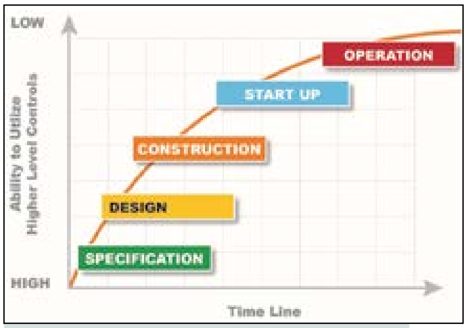
Examining the U.S. Occupational Safety and Health Administration (OSHA) accident database reveals the dangers of working around conveyors.[1] Studies have revealed that the highest prevalence of accidents are near locations where cleaning and maintenance activities most frequently take place: take-up pulley, tail pulley and head pulley.

Designs should be forward-thinking, exceeding compliance standards and enhancing operators' ability to incorporate future upgrades cost-effectively and easily by taking a modular approach. Designing hazards out of the system means alleviating causes with the intent to bolster safety on a conveyor system, but the methods of protecting workers can vary greatly. In many cases, it will be necessary to use more than one control method, by incorporating lower ranked controls. However, these lower-ranking approaches are best considered as support measures, rather than solutions in and of themselves.

Personal protective equipment (PPE) includes respirators, safety goggles, blast shields, hard hats, hearing protection, gloves, face shields and footwear, providing a barrier between the wearer and the hazard. Downsides are that they can be worn improperly, may be uncomfortable to use through an entire shift, can be difficult to monitor and offer a false sense of security. But the bottom line is that they do not address the source of the problem.

Administrative controls (changes to the way people work) create policy that articulates a commitment to safety, but written guidelines can be easily shelved and forgotten. These controls can be taken a step further by establishing "active" procedures to minimize the risks. For example, supervisors can schedule shifts that limit exposure and require more training for personnel, but these positive steps still do not remove the exposure and causes of hazards.

Safety improves as the type of hazard control moves higher up the hierarchy of methods.



Incorporating effective hazard control techniques is easier and less costly in the early stages of a project. [2]

Warning signage is generally required by law, so this is less of a method than a compliance issue. It should be posted in plain sight, clearly understood and washed when dirty or replaced when faded. Like most lower-tier methods, signs do not remove the hazard and are easily ignored.

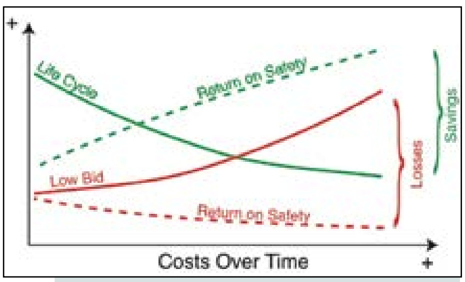
Installing systems such as engineering controls that allow remote monitoring and control of equipment — or guards such as gates and inspection doors that obstruct access — greatly reduce exposure, but again, do not remove the hazard.

Using the Substitute method replaces something that produces a hazard with a piece of equipment or change in material that eliminates the hazard. For example, manual clearing of a clogged hopper could be replaced by installing remotely triggered air cannons.

Examples of Eliminate by Design are longer, taller and tightly sealed loading chutes to control dust and spillage or heavy-duty primary and secondary cleaners to minimize carryback. By using hazard identification and risk-assessment methods early in the design process, engineers can create the safest, most efficient system for the space, budget and application.

Prevention Through Design

Another way of saying "Eliminate by Design" is Prevention through Design (PtD), the term used by The National Institute of Occupational Safety and Health (NIOSH). The organization spearheaded the PtD initiative. [3] In its report, the institute pointed



Risk assessment applied to design helps create a safer conveyor system.

Risk Assessment Matrix				
Probability / Severity	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequent (A)	High	High	Serious	Medium
Probable (B)	High	High	Serious	Medium
Occasional (C)	High	Serious	Medium	Low
Remote (D)	Serious	Medium	Medium	Low
Improbable (E)	Medium	Medium	Medium	Low
Eliminated (F)	Eliminated			

The return on better design and quality is realized over the extended life and safety of the system.

out that, while the underlying causes vary, studies of workplace accidents implicate "system design" in 37% of job-related fatalities.

Cost is most often the main inhibitor to PtD, which is why it's best to implement safer designs in the planning and initial construction stages, rather than retrofitting the system later. The added engineering cost of PtD is often less than an additional 10% of engineering, but has enormous benefits in improved safety and productivity.

The cost of PtD initiatives after initial construction can be three to five times as much as when the improvement is incorporated in the design stage. The biggest cause of expensive retroactive improvements is cutting corners initially by seeking lowest-bid contracts.

Low-Bid Process and Life Cycle Cost

Although the policy is generally not explicitly stated by companies, the Low-Bid Process is usually an implied rule that is baked into a company's culture. It encourages bidders to follow a belt conveyor design methodology that is based on getting the maximum load on the conveyor belt and the minimum compliance with regulations using the lowest price materials, components and manufacturing processes available.

But when companies buy on price, the benefits are often short-lived, and costs increase over time, eventually resulting in losses. In contrast, when purchases are made based on lowest long-term cost (life-cycle cost), benefits usually continue to accrue and costs are lower, resulting in a net savings over time." [4]

The Art: Design Hierarchy

Rather than meeting minimum compliance standards, the conveyor system should exceed all code, safety and regulatory requirements using global best practices. By designing the system to minimize risk and the escape and accumulation of fugitive material, the workplace is made safer and the equipment is easier to maintain.

Life cycle costing should play into all component decisions. Buying on Life Cycle Cost and anticipating the future use of problem-solving components in the basic configuration of the conveyor provides improved safety and access, without increasing the structural steel requirements or significantly increasing the overall price. It also raises the possibility for easier system upgrades in the future.

The Evolved Basic Conveyor

Using the Hierarchy of Controls along with the Design Hierarchy, engineers will be able to construct an "Evolved Basic Conveyor" that meets the needs of modern production and safety demands. Built competitively with a few modifications in critical areas, an Evolved Basic Conveyor is a standard bulk material handling conveyor designed to allow easy retrofitting of new components that improve operation and safety, solving or preventing common maintenance problems.

Installing or providing for maintenance-minded solutions in the loading zone can greatly improve safety and reduce man-hours and downtime. These components include slide-in/slide-out idlers, impact cradles and support cradles. On larger conveyors, maintenance aids such as overhead monorails or jib cranes assist in the movement and replacement of components. Also, designers should ensure adequate access to utilities — typically electricity and/or compressed air — to facilitate maintenance and performance. Next-generation conveyor designs may even feature a specially engineered idler capped with an independent power generator that uses the conveyor's movement to generate power for a wide array of autonomous equipment.

Dust, spillage and belt tracking are top concerns for many safety professionals. Field tests have shown that enlarged skirtboards and engineered settling zones promote dust settling and reduce fugitive material. Curved loading and discharge chutes control the cargo transfer for centered placement and reduced turbulence. As the load is centered on the belt, guides ensure even travel through the takeup to promote consistent belt tracking.

Any transfer point is prone to buildup and clogging under the right conditions, be it ambient humidity, material wetness, volume or surface grade. Flow aids such as vibrators or air cannons on chutes can sustain material movement, improve equipment life, and reduce the safety hazards associated with manually clearing clogs.

Engineering safer conveyors is a long-term strategy. Although design absorbs less than 10% of the total budget of a project, additional up-front engineering and applying a life cycle-cost methodology to the selection and purchase of conveyor components proves beneficial.

By encouraging the use of the Hierarchy of Controls at the planning stage, along with the Design Hierarchy at the design stage, the system will likely meet the demands of modern production and safety regulations, with a longer operational life, fewer stoppages and a lower cost of operation.

Red, Amber, and Green List for Designing Better Belt Conveyors	
RED LIst	*Procedures, techniques, products, and processes to be prohibited in the Specification and Design stages of a conveyor project.*
	Prevent loading on the transition of the belt.
	Prevent transition of more than 1/3 trough.
	Prevent loading against the direction of the receiving belt.
	Prevent loading conveyor to 100% of CEMA standard cross section capacity.
	Prevent control and sequencing that allows conveyor(s) to run empty longer than necessary.
	Prevent belt identification stamps in top cover.
	Prevent installing equipment in elevated locations without provision of safe access or tie-offs.
	Prevent Component Selection Based on 'Or Equal' Specifications or 'Price Only' Bidding.
AMBER LIST	*Procedures, techniques, products, and processes to be eliminated or reduced as much as reasonably possible. Only allowed with a change in the specification and notice to project owner/manager explaining potential issues and ability to address them in the future.*
	Avoid reversing conveyors.
	Avoid multiple load points on a single conveyor.
	Avoid designs created with the intention to increase capacity in the future by increasing conveyor speed; design the system to accommodate future needs
	Avoid combined vehicle and personnel travelways or uncontrolled exits from buildings into traffic patterns.
	Avoid a site layout that does not allow for safe and efficient delivery, storage, lifting of major components such as pulleys, drives, and belting.
GREEN LIST	*Procedures, techniques, products, and processes to be encouraged in specification and design stages of a conveyor project.*
	Consider ergonomics in the design and access of frequently cleaned or maintained equipment.
	Consider use of pulleys with diameters larger than minimum required for the specified belting.
	Consider access and clearances according to CEMA recommendations.
	Consider the use of design to reduce exposure to hazards.

Rather than meeting minimum compliance standards, conveyor systems should exceed code, safety and regulatory requirements.

References

[1] Conveyor Accident Database, OSHA, U.S. Deptartment of Labor (2018). www.osha.gov/pls/imis/AccidentSearch.search?acc_keyword=%22Conveyor%20Belt%22&keyword_list=on.

[2] "Foundations for Conveyor Safety." Ch. 31, pgs. 404-440. Martin Engineering. Worzalla Publishing Co. (2016). www.martin-eng.com/content/product/690/safety-book.

[3] Howard, John, M.D. "Prevention through Design: Plan for the National Initiative." National Institute of Occupational Safety and Health (NIOSH), U.S. Centers for Disease Control, Department of Health and Human Services (2010). www.cdc.gov/niosh/docs/2011-121/pdfs/2011-121.pdf.

[4] Swinderman, R. Todd. "The Economics of Workplace Safety: Putting a price on material handling mishaps." *Coal Age.* Vol. 123, No. 3, pg. 28-31. April, 2018. www.coalage.com/features/the-economics-of-workplace-safety/.

Author Information

This article was submitted by Martin Engineering (www.martin-eng.com).