Belt conveyors for bulk materials Part 1: Equipment

A belt conveyor is an arrangement of mechanical components that supports and propels a conveyor belt, which in turn carries bulk material. The five principal components of a typical belt conveyor are: (a) the belt, which forms the moving and supporting surface on which the conveyed material rides; (b) the idlers, which form the supports for carrying the belt; (c) the pulleys, which support and move the belt and control its tension; (d) the drive, which imparts power to one or more pulleys to move the belt and its load; (e) the structure, which supports and maintains the alignment of the idlers and pulleys and supports the driving machinery (see Figure 1); (f) the enclosures through which the bulk material is deposited onto the belt or discharged from the belt.

2. Belt conveyors have been in use for more than 150 years. Because of the economy and efficiency with which belts move materials, their use has increased to the point where they have become one of the most common means of conveyance in the plant. Like all moving machinery, belt conveyors present hazards to workers and must be safeguarded.

3. This data sheet discusses equipment for conveyor safety and environmental control – such as guards, safe construction features, fire prevention measures, conveyor control and dust control devices. Data Sheet 570, *Belt Conveyors for Bulk Materials—Part 2: Operations*, discusses safe work procedures.

4. Safety aspects of conveying systems should be discussed with suppliers of new equipment before specifications are written and quotations obtained. The conveyor purchaser should decide the safety features, training features and maintenance features to be furnished in order to comply with state and federal rules and regulations pertaining to the safety, health, and welfare of the worker before a contract with the supplier is signed. It is difficult and expensive for the purchaser to provide overlooked safety features after the conveying equipment is delivered. In the end, howev-

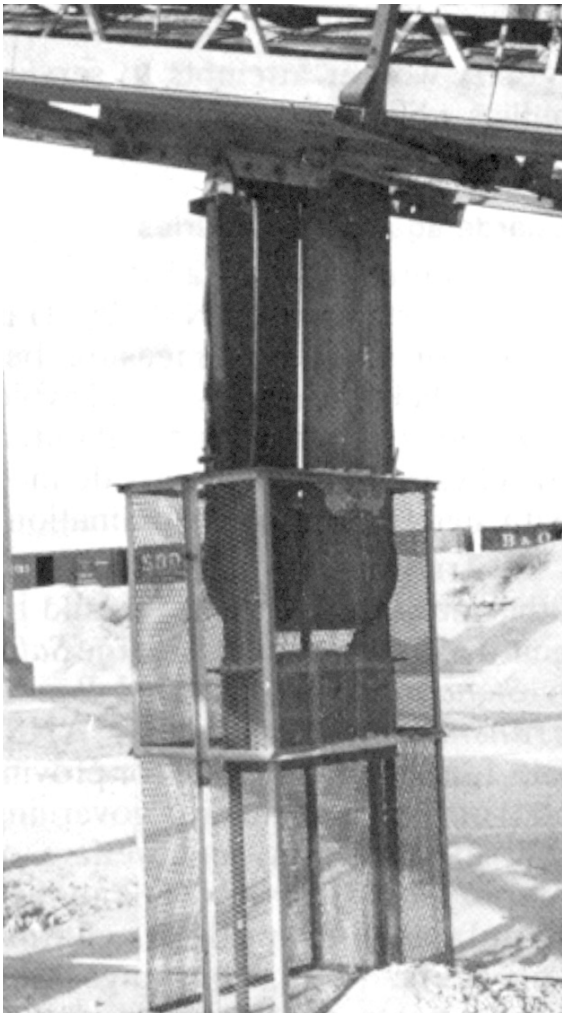

Figure 1. The belt conveyor delivers bulk material to storage piles. The belt, idlers, drive and walkway are supported by the conveyor frame.

er, conveyor users must supply safeguards that manufacturers cannot supply, and they also must supply safety devices for existing installations to comply with state and federal regulations.

5. The following injuries and hazards may be reduced by proper guards and environmental controls on bulk handling conveyors:

a. Injuries from nip points. Usually employees are pulled in when their hands, clothing, or tools are caught in the nip point.
b. Injuries from pieces of material falling from moving conveyors
c. Injuries and deaths to workers crushed against stationary objects by moving conveyors
d. Injuries to workers who fall from moving conveyors while riding on them or from conveyors that are started while they are standing or working on them
e. Injuries to workers who reach in around guards at head and tail pulleys that are running
f. Injuries to workers who service moving conveyor belts
g. Injuries to workers who fall while trying to cross over conveyors where there is no crosswalk
h. Fires from friction, overheating, or static or other electrical sources
i. Explosions of dust raised by combustible materials at transfer points, where belts are loaded or discharged.
j. Hazards to health and vision from irritating or toxic dusts
k. Electrical shock from ungrounded or improperly installed controls or conductors
l. Muscle strain injuries resulting from cleaning spills

6. There are many nip points (sometimes called pinch points) on conveyors: between the belt and its drive, take-up, bend, and tail pulleys; between wheels and rails on shuttle conveyors; between skirt plates and troughing and return idler rolls; in or around power-transmission parts. The large, heavily loaded belts used in mining and construction, and in the cement, quarry and mineral aggregate industries pose a more severe hazard than small, light-duty belts used in some other industries. Still, even small belts cannot be disregarded with respect to safety.

7. Many workers have been caught and severely injured while working in areas of the drive, tail and take-up pulleys. These accidents have occurred when:

a. A worker's loose clothing is pulled into a moving pulley and belt
b. A worker attempts to apply a belt dressing to a pulley to prevent a belt from slipping. Some employees have been caught when trying to throw "fines" or sand between a slipping belt and pulley.
c. A worker attempts to clean sticking material from moving belts and pulleys
d. A worker, "cleaning up" around a tail pulley, shovels against the direction of the moving belt
e. A worker attempts to service pulleys while they are operating

Guards against nip injuries

8. Painting guards according to the color standard (ANSI Z53.1) is an important safety measure because it helps workers see and avoid hazardous moving parts. Painted travel ways should be clearly defined with signs and proper illumination.

9. Transmission equipment and other power-driven parts should be guarded in accordance with the *Safety Standard for Mechanical Power-Transmission Apparatus*, ANSI B15.1, and with any state (or provincial) or federal regulation governing the safety, health and welfare of employees. The ANSI standard stipulates how pulleys, chains, sprockets, belts, couplings and other parts of conveyor drives should be enclosed.

10. Suitable sweeps should be provided for shuttle conveyors, movable trippers, traveling plows, and hoppers and stackers to push objects ahead of the moving nip points between the wheels and the rails, in order to guard against nips. Again, it is imperative to comply with all state (or provincial) and federal regulations.

11. Nip points at the head, tail and take-up pulleys should be completely guarded. The sides of each belt should be enclosed far enough back along the run (at least 36 inches), so no one can reach in, over or around to contact the nip between belt and pulley (see Figure 2). Belt pulleys require skirt guards in addition to reach guards.

12. An idler pulley becomes a hazard when skirt plates and chute skirts are so positioned as to force the belt against the idler and create a nip point. If there is no room for the belt to lift, the idlers must be guarded. Another hazard occurs when a stone gets caught between the end idler roll and the mounting bracket, and an employee attempts to remove the stone with his hand while the conveyor is operating.

13. Mechanical belt cleaners, such as fixed or tension scrapers, revolving brushes, or rubber disks, sometimes eliminate manual cleaning (see Figure 4). They also eliminate a major reason for working around moving pulleys.

14. Guards should be sturdily constructed and designed to withstand conveyor vibration. They also should be easy to remove and replace for maintenance (see Figure 5). Take-ups and drive adjustments should be easily accessible. A means for easy access for cleaning of spillage also should be considered in any guard design, including entry for small mobile equipment, which would eliminate most manual labor clean-up.

15. In order to lubricate a conveyor in continuous operation, extension grease lines should be installed to prevent a worker from being caught by rollers and bearings when he is working around them (see Figure 6). All grease fittings inside a guard enclosure (except those that move with the part they serve) should be fitted with

Figure 2. Enclosing the sides of the belt will prevent contact with nip points. Grease fillings are placed so guard does not have to be removed while servicing.

Figure 3. Skirt plates prevent material from falling off conveyors, but also may create nip points at idlers if they prevent belts from lifting freely.

Figure 4. A simple fixed scraper will prevent build-up of materials on the belt and will do away with unsafe cleaning while the belt is moving.

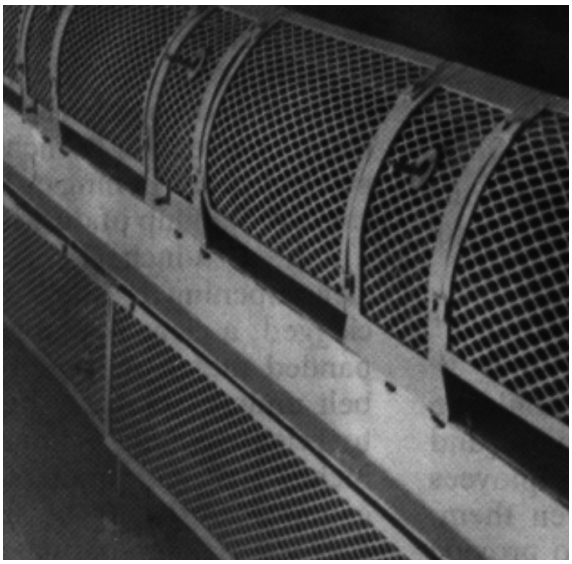

Figure 5. Complete skirt guards prevent spillage and keep clothing from catching in pulleys along much-traveled walkways. Extension pipes for lubricating idlers extend through easily removable guards.

extension pipes to make them accessible from outside the guard (see Figure 5). Sometimes pressure lubrication or automatic gravity oilers (where a central lubricant reservoir is used to feed one or more branch lines, which lubricate moving parts of the conveyor) may not only eliminate a source of injury to oilers, but may decrease the cost of lubrication.

Belt take-ups and backstops

16. All properly designed belt conveyors require the use of some form of take-up device for the following four reasons:

a. To keep the proper amount of slack side tension at the drive pulley to prevent belt slippage
b. To assure proper belt tension at loading and other points along the conveyor to prevent loss of troughing contour of the belt between idlers, thus avoiding spillage of material from the belt
c. To compensate for stretch or shrinkage of the belt
d. To allow belt storage for making replacement splices. Take-ups may be designed for periodic manual adjustment or for automatic adjustment by the use of counterweights or by hydraulic or pneumatic means.

17. The manually adjusted take-up, usually a screw type, has the advantages of compactness and low cost. The disadvantages are:

a. The take-up must be made manually, while the conveyor is operating, because each screw must be adjusted separately to make sure the belt tracks properly along the length of the conveyor.
b. Because the take-up is periodic, the resulting belt tensions are almost always too high or too low. It is imperative the tail pulley and shaft be properly guarded to ensure the worker's safety while manually adjusting the take-up.

18. Automatic take-ups are the most desirable type for use on any belt conveyor. They can be installed horizontally, vertically,

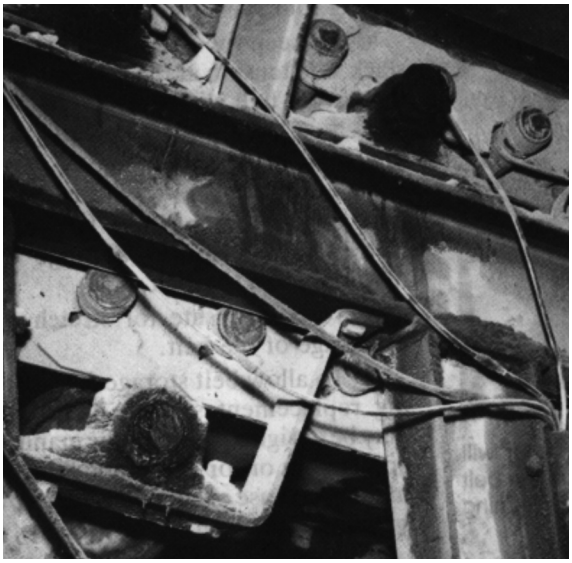

Figure 6. Extension lines on lubrication fittings will keep workers at a safe distance from pinch points while they grease the idlers.

Figure 7. Guards, such as the one shown here, will prevent workers from walking under take-ups.

or on an incline. They can be either gravity operated or power operated by hydraulic, electric or pneumatic means. The most common type of automatic take-up is the gravity take-up.

19. The gravity take-up pulley is counterweighted, and hangs down in a loop of the belt under the conveyor to maintain belt tension (see Figure 7). Where accessible by personnel, these counterweighted pulleys and associated turn pulleys must be totally enclosed to protect workers from being caught in their nip and pinch points. Other precautions include a limit switch at the bottom of the weight travel to indicate need for a major adjustment, as well as automatic safety stops to hold the pulleys if their suspension supports fail.

20. A loaded inclined belt conveyor of sufficient slope tends to move backwards when forward motion is stopped by a cessation or interruption of power or a mechanical failure in the driving machinery. Should the loaded belt move backwards, the material will pile up at the tail end of the conveyor. This could seriously damage the belt, and result in the need to clean up and dispose of the spilled material. To prevent this reversal of motion, a backstop is used.

21. A backstop is a mechanical device allowing the conveyor to operate only in the desired direction. It allows free rotation of the drive pulley in the forward direction, but automatically prevents rotation of the drive pulley in the opposite direction. There are three general backstop designs: ratchet

and pawl, differential band brake and overrunning clutch. Backstop devices must be checked periodically with a normal load on the belt to see if they operate properly.

Guards against falling material

22. Pieces of material rolling back down steeply inclined, lightly-loaded belts can be a hazard. The maximum safe angle for the conveyor should be carefully determined by experienced people. Careful consideration also should be given to loading and transfer points in order to prevent rollback by properly and evenly distributing material on the belt. Skirt plates should be provided where there is a tendency of material to roll back down the belt (see Figure 3).

23. Any conveyor that passes over an aisle, passageway or workplace must be enclosed on the bottom and sides to protect people below from falling material.

24. Side skirts along the length of the conveyor belt hold material on the belt, preventing spillage on the walkways and falling material from striking employees.

25. Cleaning spillage around conveyors contributes to a great number of injuries. Ample clearance under conveyors for safe manual cleanup of occasional spillage helps prevent accidents. Ideally, clearance should be such that a small machine could be used in cleaning up spillage. Great care should be taken to ensure nip points are properly guarded. Hazards particular to other clean-up methods also should be addressed, such as drainage and a protected sump for flushing material with water and access for vacuum equipment. Transfer points and feed chutes must be designed so no "plugging" occurs, thus minimizing spillage. Overhead belts must be guarded if the whipping action from a broken belt would be hazardous to persons below.

26. At transfer points, wear liners inside the skirtboards and seals below the skirtboards will help to prevent material from being ejected from the conveyor. Application of water on the conveyor should be minimized to help prevent the slide of material on a sloped conveyor.

Guards against crushing injuries

27. Enough clearance should be provided between conveyors and stationary objects so employees cannot be crushed between them. Where it is not possible to provide this clearance between or under stationary objects, a gate guard ahead of this low clearance will shut off the power when the gate is contacted.

Conveyors running in pits or tunnels should have ample side clearance to permit safe repair work and oiling. Illumination should be adequate where workers operate close to conveyors, as in pits and tunnels or on walkways.

28. Belt conveyors passing over designated walkways or work areas where there is less than 7 feet clearance should have the belt underpass protected with expanded metal or screen of ¾-inch clear opening or less. Where there is more than 7 feet clearance at designated walkways, passageways, or work areas, only the idlers need be guarded, using the expanded metal or screen of ¾-inch clear opening or less. If, because of build-up of dust falling from a belt, a ¾-inch clear opening is likely to become clogged, a clear opening in the expanded metal or screen guard for belt underpasses may be increased to a clear opening not to exceed 2 inches. A solid canopy guard may be used where there is danger of material being thrown by return idlers. Other belt underpasses, which are not recognized walkways and under 7 feet clearance, should be guarded with a standard hand railing at ground or floor level. Conveyors should be crossed only at desig-

nated points where elevated, well-lit crossovers equipped with standard railings are installed to allow workers to cross without contacting the conveyor.

Guards around conveyor openings

29. Requirements for guarding floor and wall openings are described in ANSI A12.1, *Safety Requirements for Floor and Wall Openings, Railings, and Toeboards*. At points where conveyors pass from one floor to another and are not entirely enclosed, the openings must be protected by standard railings with toeboards so a person cannot accidentally walk or fall into the openings. Unprotected pit openings over conveyors also must be protected with standard railings and toeboards. If standard railings are not feasible, a hinged floor plate should be provided. This will cover the opening and protect against the spread of fire.

30. The top openings of hoppers, when not 42 inches or more above adjacent floors or walkways, must be protected by the same standard railings or cover plates as for pits. In such instances it may be feasible, when belt unloading devices discharge into bins directly under them through holes in walkways, to cover the openings with grating just large enough to pass the material coming from the conveyor.

Walkways and tunnels

31. For repairing or oiling overhead conveyors, suitable work platforms and ladders must be provided. Place platforms on walkways on both sides of the conveyor, unless the work can be performed safely from one side. Open-sided platforms and walkways 4 feet or more above the adjacent floor or ground level must be guarded by standard railing 42 inches high with an intermediate rail approximately halfway between the top rail and floor, and a toeboard provided on each platform or walkway. These walkways, platforms, stairs, ramps and ladders must be kept in good repair and free of spillage or material that could become a tripping or falling hazard. They must be lighted whenever natural lighting is insufficient.

32. Runways, elevated walkways and platforms should meet the requirements of ANSI standards. Inclined and slippery walkways must be provided with standard railings and be non-skid or provided with cleats.

33. Reclaiming tunnels under surge or stockpiles containing rubber belt conveying equipment should be of fire-resistant construction. Fire extinguishing equipment, sufficient to extinguish a fire the full length of the belt, should be available inside the tunnel. Where serious fire hazards exist, provisions should be made for the ventilation of long tunnels to exhaust heat and toxic or flammable gases. A door that can be closed should be provided to eliminate draft, in case of fire. Tunnels should have at least two ways of escape available for workers trapped inside. Proper tunnel design should include:

a. Provisions for drainage of water
b. Sufficient lighting
c. Sufficient space on each side of the conveyor for safe maintenance and removal of spilled material

Loading and unloading

34. Loading hoppers using vibratory pan feeders and similar methods minimize wear on belts, because they feed material to the belt evenly, over a distance of several feet. Because the feed can be controlled, these devices also prevent the hazard of excessive spillage at the loading point and permit maximum loading of the belt.

35. The top edges of loading hoppers and feeder skirt plates should be rounded or otherwise made blunt so they will not be a

source of injury to workers.

36. Movable receiving hoppers, after being moved into position, should be rigidly fastened in place to prevent any part or parts from catching a moving belt. Where these hoppers are mounted on wheels and moved over rails to loading points, sweep guards should be provided to push objects out of the nip area between wheels and rails. (See Industrial Data Sheet 703, Open and Closed Storage and Reclamation of Stone, Sand, Gravel or Slag.)

37. Consult with a reputable engineer, conveyor manufacturer or conveyor distributor during the design stage to ensure that the chutes at loading points are designed to minimize safety and health hazards.

38. Where a tripper or other moving deflector device for unloading requires an operator to travel on it, provide suitable platform protection with standard railings and toeboard to keep the operator from falling off or coming in contact with the moving parts of the tripper or deflector device. A standard railing should be provided along the walkway side of the tripper with preferably a minimum of 15 inches clearance between the railing and the tripper.

39. If the operator of a self-propelled tripper is careless while the mechanism is in gear, the tripper may run to the end of the runway or belt and cause an accident. To minimize this hazard, use a device to throw the propelling mechanism into neutral, or a limit switch to shut it off at each end of the runway. Another precaution, especially useful where the operator rides the tripper, is a "deadman control" that will not function without the operator's attention. A safer substitute for the self-propelled tripper is an isolated drive, by continuous cable, installed beneath the belt that automatically cuts the power and stalls the tripper, thus preventing its run to the end of the belt.

40. It is important when using portable conveyors to have substantial supports and to place the conveyors on level ground to avoid tipping during loading procedures.

Fire prevention

41. Where large amounts of combustible material, such as coal or grain are handled, fires are the outstanding hazard. Belt fires can cause loss of belts, as well as drive motors, speed reducers, and other equipment, resulting in costly production shutdowns. Many conveyors are rated by the manufacturer for the safe operating temperature. Rubber belts in particular, unless accepted and designated as fire-resistant by the Mine Safety and Health Administration, can develop a fire at the drive pulley almost within seconds, if the belt stalls. A belt may slip because of overloading or wetting. Other sources of friction that may cause fires are:

a. Bearing failures, "frozen" rollers and rollers running hot because of defects or inadequate lubrication
b. Incorrect belt tension
c. Spillage around idlers and tail pulleys that cause overloading of a belt
d. Incorrect threading of the belt, which may allow the edge to rub against a stationary object

40. To eliminate the fire hazard of a belt stalled while the drive pulley continues to turn, install a safety switch to stop the belt automatically in the event of excessive slippage. One type is a centrifugal switch (a roller switch) operated by an idler roll on the return side of the belt. When the belt is operating at full speed, centrifugal force will keep this switch closed. If the belt loses as little as 5 percent of its rated speed, the switch will open and shut down the belt. Automatic interlocks, if used, will shut down the rest of the belts within the system.

41. To reduce the tension of the belt and to assure sufficient friction between the belt and the drive pulley, a snub pulley may be installed to increase the pressure of the belt against the drive pulley.

42. Fires on belt conveyors also may be caused by:

a. Electrical failures from substandard electrical installation, worn installation, improper cable splices, lack of grounding, undersized electrical components or "plugging" of short circuiting overload protectors
b. Static electricity
c. Sparks from tramp iron in the material conveyed
d. Careless heating of frozen materials with an open flame when starting a belt

43. Conveyor electrical equipment, including motors, controls and wiring and its installation must conform to the *National Electrical Code*, NFPA 70. The equipment should meet requirements for the Class, Division and Group of hazards caused by the material the conveyor will handle. For instance, electrical equipment for grain-handling conveyors must meet Class II, Group G requirements of the *National Electrical Code*.

44. If heating devices for personnel are used around conveying equipment, they should be suitable for the hazardous conditions in which they will operate. Specifically, unenclosed salamanders, oil burners or heaters with unprotected electric elements should not be used near conveying equipment. Electrical heaters used near grain handling conveyors must have a Class II, Group G label. Adequate heating to prevent freezing of material on a stopped belt also is desirable.

45. Fuses and overload devices should protect electrical equipment from overloads. "Plugging" or short circuiting these overload protectors can create a serious fire hazard, and may occur if a worker doesn't have a fuse available. Workers should be cautioned against this practice, and the devices should be checked periodically to make certain they are not plugged.

46. Static electricity collectors, grounded to the conveyor frame, may help reduce fire and explosion hazards on belts that handle dusty materials or that run through areas where an explosion hazard exists. Static build-up also is reduced by maintaining relative humidity at 60 to 70 percent, and by grounding metal bins to the conveyor frame. Electrical ground connections, at loading and discharge points, can be checked with static voltmeters or a simple electroscope. Continuity of grounding should be checked once per year or each time a change is made.

47. Magnetic separators at process entry points will remove tramp metal, which may otherwise spark explosions during the receipt of bulk grain, meal or other combustible materials. *Safety Requirements for the Textile Industry*, ANSI L1.1, recommends magnetic separators to prevent fires in starch handling systems. Other industries also use them to prevent belt damage from tramp iron.

48. Dust control devices should be installed where ambient dust creates a fire hazard or a toxic or nuisance pollutant, which directly affects vision or health. Suction hoods (see Figure 8) at the belt loading and discharge points, and at all other points where dust clouds may form, are often advisable. Also, bins and hoppers may be ventilated (see Figure 8).

49. Fan or cone-shaped sprays at discharge points are effective in beating down and wetting dust from some minerals. However, avoid wetting the belt. High pressure, low volume (fog) suppressions systems optimize the application of water for dust control. Surfactants added to the

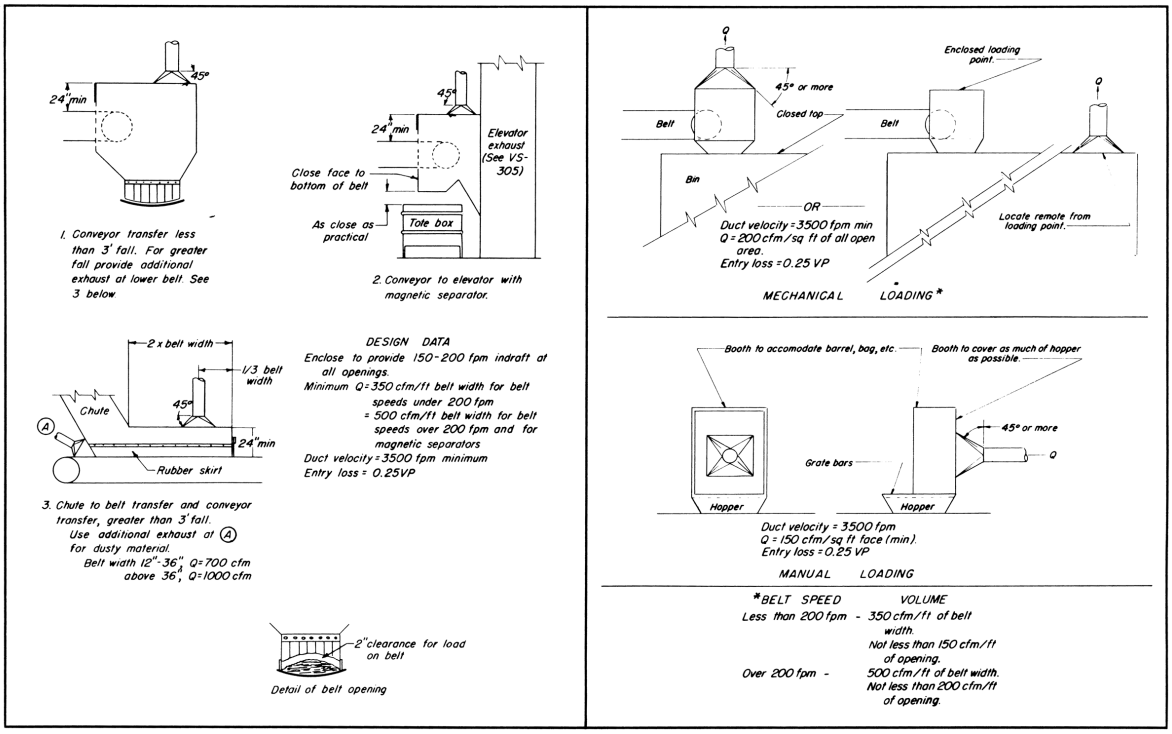

Figure 8. Left: Suction hoods at belt loading and discharge points control nuisance dust. Right: Bin and hopper ventilation will stop dust problems. Note: Air velocities indicated are minimum standards.
(Drawings courtesy Industrial Ventilation, published by ACGIH).

suppression system reduce the amount of water needed and improve the wetting characteristics of the system. In any case, minimize the free fall of material being transferred in order to reduce the dust created (see Figure 9). Radial stackers that can be raised or lowered according to the height of the stock pile also will reduce dust. Further information on dust control is given in the NFPA codes.

Conveyor control systems

50. Each belt conveyor control point, disconnect switch, motor starter and push-button should have a nameplate, or otherwise be plainly marked to identify the conveyor being controlled.

Note: All unused circuits should be de-energized or otherwise disconnected and conspicuously tagged or labeled.

51. Controls and power supplies for each belt, while the belt is being repaired, *must be locked out*. Also, a positive means of disconnecting the electrical drives for conveyors should be provided on the circuit breaker or switch controlling the individual drive. Lockout on push buttons and lockouts on pull-cable stops are not positive lockout devices. Therefore, the lock must be on the main control switch. Multiple lockout devices are required where two or more employees are working on the same equipment.

52. To prevent accidents to personnel who may be surprised by the sudden start of a conveyor, starting controls should be located where the operator is able to see the entire belt. If a conveyor passes through a floor or wall or into some area that is not visible from the control point, then added starting and stopping push buttons should be installed in each area away from the operator's line of sight. These push buttons

should be wired in series so operation of the entire circuit will be necessary to start the conveyor. In cases where the entire belt conveyor cannot be seen from the starting point, a positive, audible or visible warning device should be sounded by the operator before starting. All employees should stand clear of the conveyor. This alarm is an important precaution where a series of starting switches cannot be used, as in many underground mines.

53. Emergency stop cables must be installed on the entire length of the unguarded conveyors. They also should be provided at the drive and take-up ends, and at loading and unloading stations. Emergency stop cables should be positioned so a person caught in the conveyor or having fallen onto the conveyor can easily reach and activate the emergency stop device. A manual reset cable, extending alongside the entire length of the belt, also may be installed for emergency braking of the conveyor.

54. Overloading and spillage at transfer points should be prevented, because overloading may stall the belt and cause a fire, and spillage may result in injuries to workers. On all conveyor systems, where it is practical to do so, electrical or mechanical interlocking devices, radioactive instrument controls, or both, should be provided to stop a conveyor automatically when the conveyor, bin, hopper, chute or other part to which it feeds has been stopped or blocked. The conveyor system controls should be electrically interlocked so if one belt stops or fails, all the others will stop.

55. Provisions also should be made for cutting out the automatic interlocks when maintenance is to be performed on a belt. Moreover, there also should be some way to operate the belt separately at this time.

56. Some conveyor belts are now manufactured with imbedded condition sensors that can monitor speed, alignment, ripping and other belt conditions.

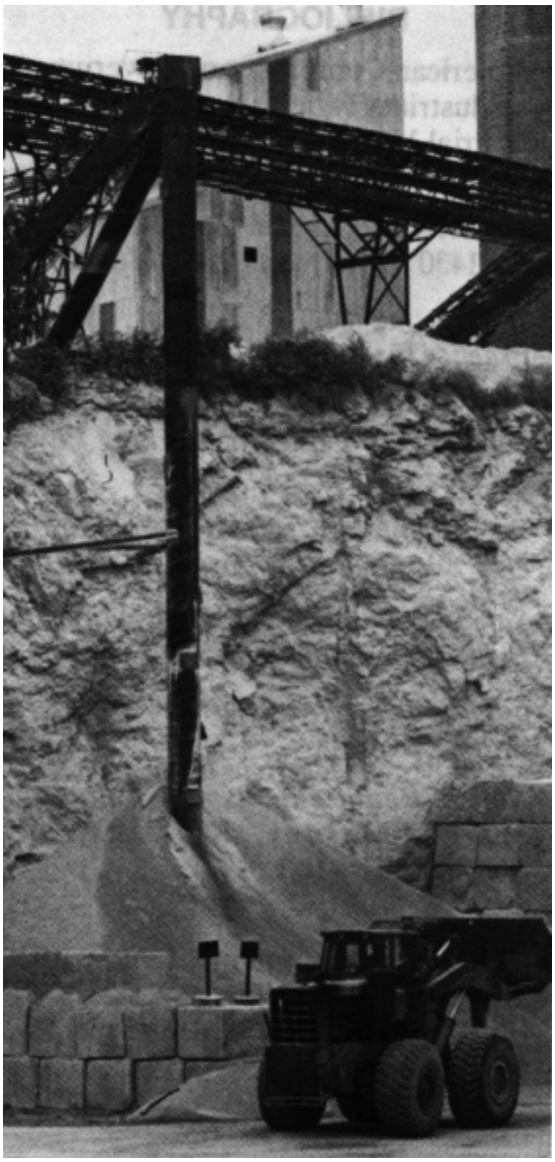

Figure 9. To minimize free fall and dusting, drop tubes contain falling material from belt and allow it to trickle out from ports opening just above the storage pile.

Acknowledgment

This data sheet was revised by the Cement, Quarry, and Mineral Aggregates Section, Industrial Division of the National Safety Council, 1121 Spring Lake Dr., Itasca, IL 60143.

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