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Risk Control Services: Special Hazard

Belt Conveyors & Related Equipment

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Standard recommendations based on recognized international standards and good practices are proposed. Moreover, very good NFPA (National Fire Protection Association) and FM Global Property Loss Prevention Data Sheets on these subjects exist. Since there is no need to reinvent the wheel, readers are referred to those references when relevant.

- NFPA free viewing at http://www.nfpa.org/
- FM Global Data Sheets free viewing and download available when registered at http://www.fmglobal.com/

Note that these materials are periodically revised and updated. Please monitor the above websites for updates and/or revisions.

Acknowledgments:

- Franck Orset (FPO) Fire Prevention Engineer

Technical Documents:

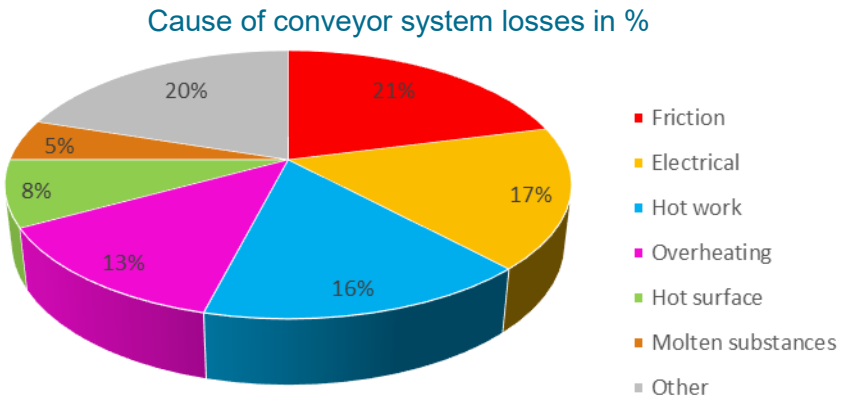
- NFPA 13 Standard for the Installation of Sprinkler Systems
- NFPA 15 — Standard for water spray fixed systems for fire protection
- NFPA 850— Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations
- NFPA handbook
- FM Global Data Sheet 7-11 Belt conveyors
- FM Global Data Sheet 7-76 Prevention & Mitigation of Combustible Dust Explosion & Fire

SCOPE

Belt conveyors are used to carry a wide range of combustible and non-combustible materials in a wide range of occupancies such as those in the mining, manufacturing and power industries.



Belt conveyors, transfer towers and attached loader/unloaders, stacker/reclaimers and storage facilities (i.e., warehouses, silos), are responsible for numerous losses every year leading to Property Damage (PD) and Business Interruption (BI). This is obviously not an emerging risk, but simply well-known latent risk that occurs regularly but is not well managed. An efficient Risk Management approach, prevention and adequate fixed fire protection allowing the risk to be controlled should therefore be considered.



Notes:

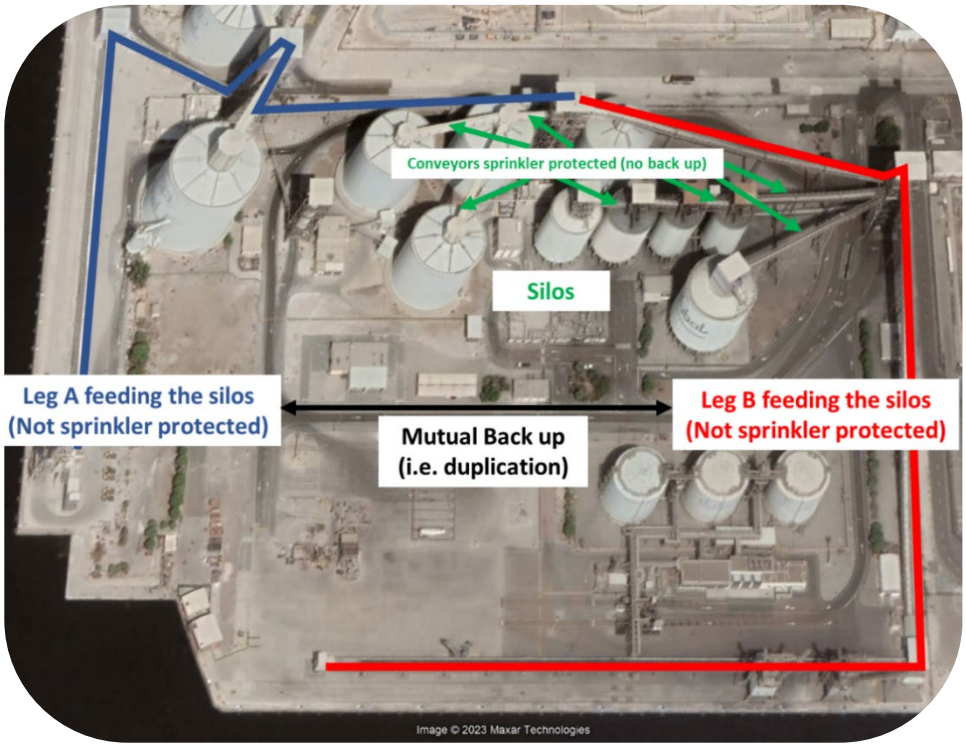
- Most of the causes except “Other” may lead to fire and possibly collapse of the gantry.
- “Other” also includes collapse of the structure due to the loss of integrity or natural perils.

Guidance for understanding this special hazard, ensuring property conservation and business continuity is given in the following section.

Table of content

1. Risk Management

- People have usually a problem figuring out how a loss on a conveyor system can happen considering all safety interlocks (when provided—see below), the usual lack of visible ignition sources, the hot work permit system in place, the use of so-called “fire retardant” or even “non-combustible” rubber belts and the level of maintenance within the plant.
- Because of the above, the loss of a conveyor due to fire or collapse is deemed as an event of low to very low probability. This is an idealistic view.
- In the real world, belt conveyor safety interlocks may fail, a hot work system may not be strictly enforced and the conveyor may not be recorded within the computerized maintenance system, so that structural members may never be inspected before they collapse due to corrosion. Moreover, equipment may be added from time to time, or the conveyor may be used to carry heavier material than it has been designed for, resulting in imbalance or an excessive weight situation.
- The low to very low probability means that the loss of a conveyor may happen infrequently but at any time.
- As a result of the above, people in charge of Risk Management need to think in terms of consequences rather than in terms of probability.
- With the loss of a conveyor, Property Damage (PD) may be significant (i.e., conveyor and related equipment plus any exposure—see below). For example, a fire on a belt conveyor may not be limited to the loss of the belts. Spare belts are usually available, but large-scale fire damage can cause the collapse of the conveyor structural elements, resulting in high replacement cost.
- The conveyors and their supports may cause a long period of downtime in the event of a loss such as a fire event, resulting in a relatively long period of Business Interruption (BI) for the associated process units.
- Duplication of critical conveyors and related equipment (i.e., transfer towers, loader/unloaders, stacker/reclaimers) located in different fire areas and feeding different storage units is always the best solution for ensuring business continuity. Example below:



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- When duplication is not feasible, mitigation measures such as adequate and approved automatic fixed fire protection systems for conveyors and transfer towers are a good alternative (see “Fire Consideration” and “Fire Mitigation Recommendation”).

2. Conveyor system

- A conveyor system is a mechanical handling system for moving materials from one location to another.
- Mechanical conveyors are commonly used for materials-handling operations. They can transport bulk and packaged materials in a quick and very efficient manner.

2.1 Different types of conveyors

- There are many types of conveyors. The choice for a given process is primarily based on the distance and inclination (orientation) over which the material is being conveyed.
- The choice also depends on the type of atmosphere and the location through which the material is being conveyed. Regarding the material itself, the lump size, density, fluidity, abrasiveness, toxicity, corrosiveness and other physical properties need to be considered.
- Dust materials and dust atmospheres require adequately enclosed equipment.
- Long distances usually require belt conveyors.
- This document addresses both indoor and outdoor rubber belt conveyors.

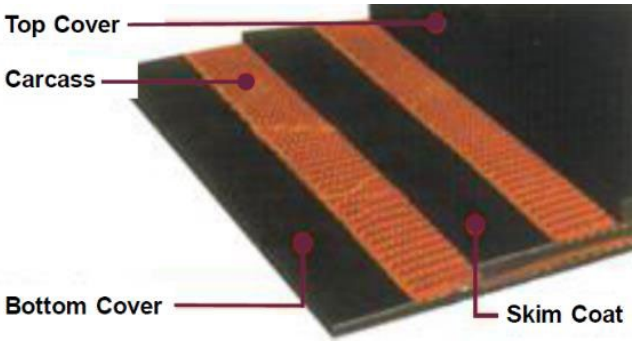
2.2 Temperature

- Screw, vibrating and certain pan conveyors are normally used for the handling and transfer of hot materials or for use in very hot atmospheres.

- The theoretical upper limit for most belt conveyors is around 93 °C (200 °F) but they are normally not used in atmospheres exceeding 65 °C (150 °F).
- Most belt conveyors are not suitable for moving hot or molten materials.

2.3 Conveyor belt components

- Conveyor belts are made of different layers, and they can be single- or multi-ply.



The 3 main components are:

- The carcass, for reinforcement and load strength.
- The skim, which is used to glue the different layers.
- The cover, which is the external protection of the belt. This part is normally combustible and presents one of the main fire hazards associated with conveyor belts.

The carcass is mainly made of the following materials:

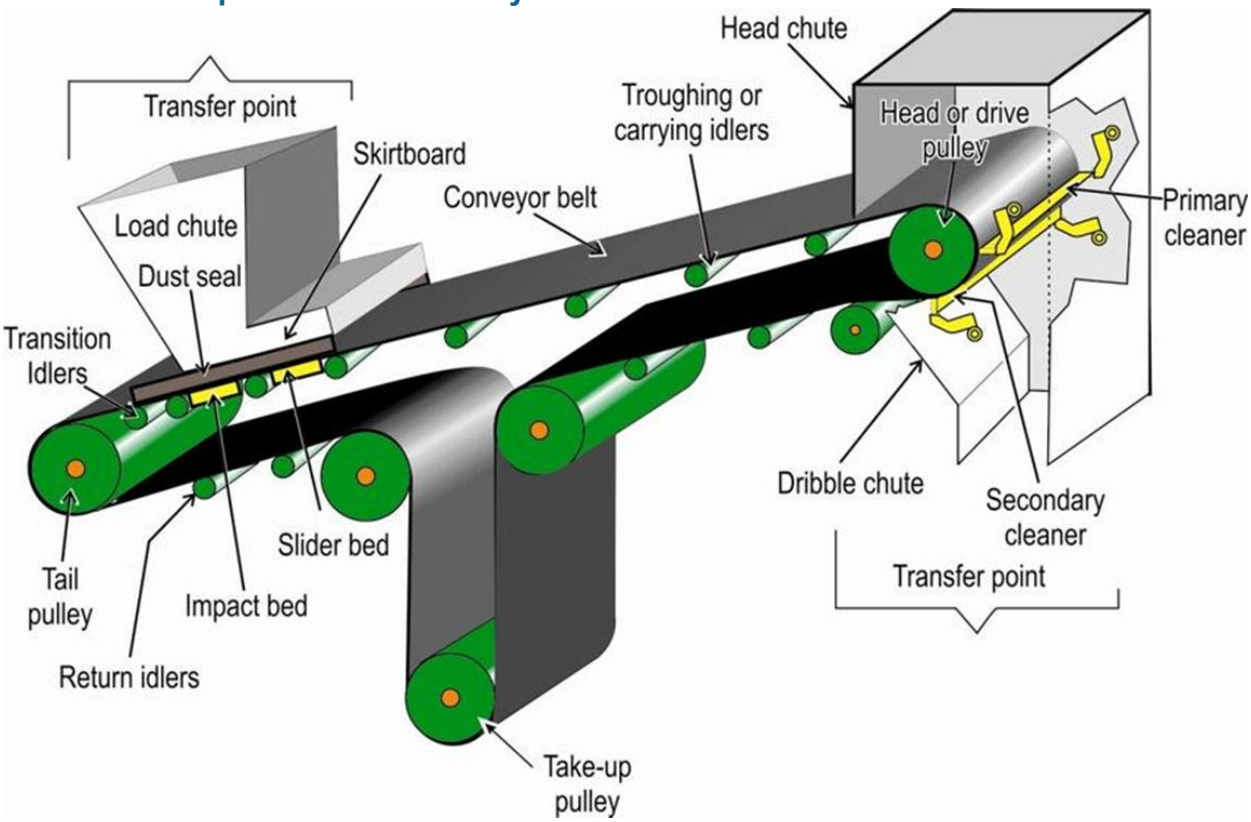
- Cotton
- Rayon
- Glass
- Polyester
- Nylon
- Steel
- Kevlar

Glass is used in approximately 70-75% of all conveyor belts, and polyester in just under 20%.

The skim is mainly made of rubber.

The cover is usually made of PVC, rubber or urethane, with some additives (fillers, stabilizers, fire retardants, pigments, resins). Rubber belts have a higher rate of flame propagation, but the ignition characteristics of neoprene, rubber and polyvinyl chloride are similar.

2.4 Basic components of a conveyor belt



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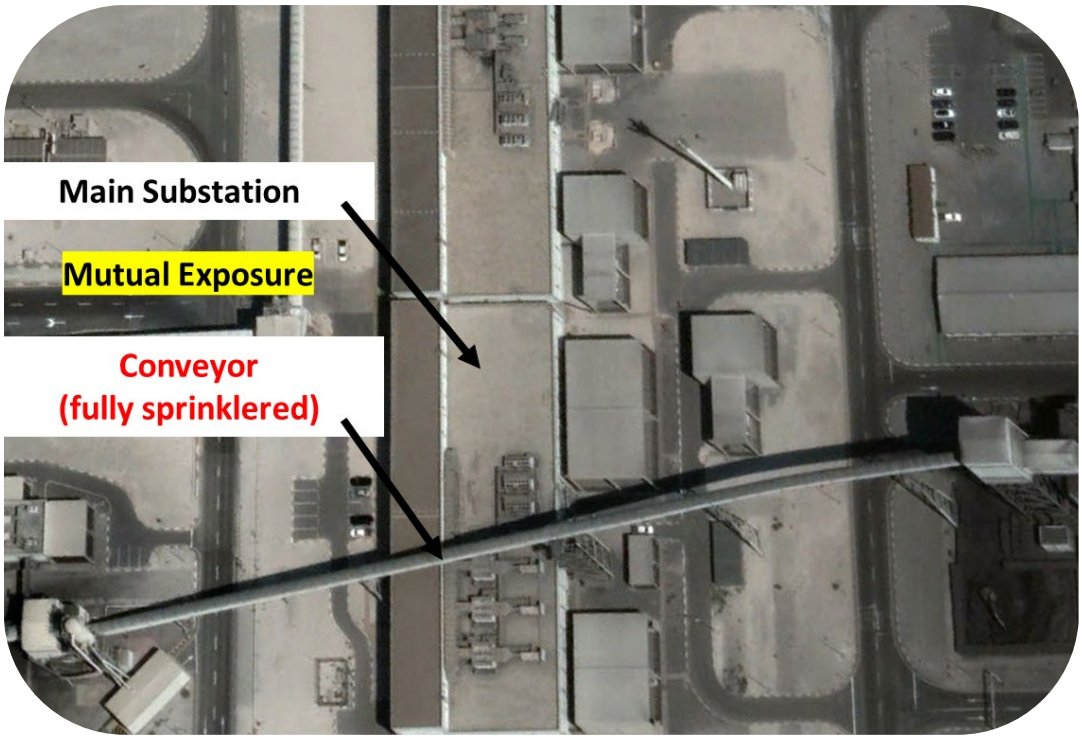
3. Location and exposures

- Rubber belt conveyors and related equipment should not be installed in areas subject to known local natural perils (e.g., floods, mud slides) for which no special protection is possible.
- Conveyor galleries should be protected against any known natural hazards such as landslides, floods, surface water runoff and ground subsidence.

- Ignitable liquids, flammable gases and liquefied flammable gas operations such as storage tanks, pumping stations, and tanker truck unloading or loading facilities, should be removed and relocated away from underneath or near conveyors.
- Combustible yard storage should be removed and unprotected combustible buildings should be kept at a distance of at least 7.6 m (25 ft).
- Fueled vehicles should be prevented from being staged or parked under conveyors.
- The conveyor should not expose highly critical facilities (e.g., overhead conveyor passing over a main substation, silos, warehouse, process unit, etc.) that could be severely damaged if the conveyor collapses (thus leading to a relatively long BI for the associated process units). Example below:



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- Conveyors should not run through fire walls.
- An indoor conveyor should not be located above another (either in parallel or crossing over) since this would create unnecessary obstructions to the sprinklers installed at the ceiling level.
- Accumulations of trash, grass or brush growths outside storage or combustible buildings that expose conveyor housings and supports should be eliminated or moved least 7.5 m (25 ft) away.
- Where a serious exposure cannot be eliminated or controlled, sprinklers for external protection of major conveyor structures and related equipment should be provided.

4. Structural integrity

- Conveyor structures and related equipment structures (i.e., transfer towers, loader/unloaders, stacker/reclaimers) need to be adequately designed in order to sustain the load of material to be carried, local wind and any seismic exposure. Adequate foundations should be provided and piles should be driven into the ground prior to erection where soil conditions require.

Example of conveyor collapse structures

- Conveyors need to be protected against mechanical impact such as impact from vehicles (i.e., provide crash barriers around gantries, pillars and safety bollards on elevated conveyors passing over roads).
- Any structural changes such as the replacement or addition of equipment (e.g., cable run, additional driver, second belts on the same gantries, equipment upgrade on loader/unloaders, stacker/reclaimers, etc.) need to be subject to a Management of Change (MOC) procedure aimed at identifying and assessing the impact of a change. Any imbalance or excess weight situation may lead to the collapse of the conveyor structure.
- Any changes in material to be carried on by the conveyor should be subject to a Management of Change (MOC) procedure aimed at identifying and assessing the impact of the change (e.g., heavier material or wind-sensitive lighter material, etc.).

Rubber belt conveyor overload

Belt conveyor snap due to joint failure

Loss history & support for recommendation:

Mining industry: Partial collapse of a dome which is a semi-spherical structure and its related conveyor. This structure is made of arches, radially distributed three rings, two for compression in the top and one for traction from the top. The structure of the conveyor belt supports its last section near the top of the dome. During the work of disassembling the structure, a discovery of interventions that were made to this structure, during its operational lifetime, specifically to the arches that supported the conveyor belt. It is concluded that the collapse was due to deficient tightening of bolts that supported the bracing elements of the mentioned arches.

5. Maintenance and inspection practice

- Heat from friction can cause fires involving conveyors, such as those used for materials like raw cotton, grains, powders and coal.
- This situation results from accumulated grease and dirt and the overheating of defective or unlubricated parts, especially rollers and bearings.
- This hazard is reduced by regular monitoring of belts, frequent equipment inspections and the removal of dirt and grease buildups with a frequency determined by routine inspections or patrols.
- Maintenance, including early replacement of old and worn parts, is essential.
- The following issues are often associated with overhead conveyors.
    - Poor take-up adjustment: the chain take-up device ensures that the chain is pulled tight as it leaves the drive unit. Poor maintenance can result in the chain surging or jamming, and in extreme wear on the track and chain. Take-up adjustment is also important for any conveyor using belts to power rollers or in which belts themselves are the mover. With poor take-up on belt-driven rollers, the belt may twist into the drive unit and cause damage. In the case of belt conveyors, poor take-up may cause drive unit damage or may allow the belt to slip off the side of the chassis.
    - Lack of lubrication: chain bearings require lubrication in order to reduce friction.
    - Contamination: paint, powder, acid or alkaline fluids, abrasives, glass beads, steel shot, etc. can all lead to rapid deterioration of track and chain. Once a foreign substance lands on the raceway of a bearing or on the track, pitting of the surface will occur and wear will accelerate.
    - Contamination can also apply to belts (causing slippage, or in the case of some materials, premature wear), and the motors themselves.
    - Product handling: boxes that are too small, too large, too heavy, too light or too awkwardly shaped may not convey, or may cause various problems including jams, excess wear on conveying equipment, motor overloads, belt breakage or other damage.
    - Cardboard boxes handled on conveyors should be in good condition or else spills, jams, downtime and possible accidents and injuries may result.

- Other issues are associated with belt conveyors. Specific maintenance on electrical equipment (to avoid failures/sparks) and mechanical equipment (to avoid friction and overheating on rotating elements) are essential. Poor preventive maintenance can result in rollers sticking, causing friction between belts and rollers.

- Routine checks:
  - Examine all bearings for overheating at least weekly using an infrared thermometer or scanner.
  - Monitor inaccessible bearings with fixed thermocouples. Inspect and maintain gears and monitor for vibration.
  - At least weekly, check for abnormal vibration in belt drives, turning pulleys, tensioning pulleys and other heavily loaded pulleys operating at more than 60 rpm (1 Hz).
  - Provide spares for equipment with long lead times, such as complex or specialist gear sets and tensioners.
- Structural integrity inspection:
  - All conveyors and related equipment such as transfer towers and loader/unloaders should be recorded on the list of assets to be part of the integrity management program.

- Conveyors and related equipment are usually supported by exposed metal structures.
- All structural members of these structures need to be regularly inspected, maintained and protected against corrosion.

Loss history & support for recommendation:

Collapse of a coal conveyor in a coke plant of a steel mill: Total cost of USD 60 million of which USD 38 million PD and USD 22 million for Extra Costs. Based on information provided by Insured the coal moisture content was 14%, an increase of about 6% over normal situation. Rack structure lost 20% of its original thickness, as a result of corrosion resulting from steam emanating from nearby operations over a long period of time. It is considered that without the loss of original thickness, the structure would not have collapse. Additional weight of coal miniscule compared to weight of structure.

- Spare part management program:
  - Obsolete spares need to be identified and alternate suppliers need to be identified or plans should be made to modernize the equipment.
  - Critical spares, for example slew bearings for a reclaimer, should be kept on site. If a reclaimer fails, stacking will not be possible. Reclaiming may or may not be possible using trucks, but only for a certain period (this should be investigated as part of the contingency plan).

Non-combustible construction materials:

- Only non-combustible construction materials should be considered for the cover or structure around the conveyor (i.e., walls and roof made of single metal sheet, with Fiber-Reinforced Plastic prohibited, even if it is treated as “fire-retardant”).

6. Operation

- Normal operating procedures should be clearly established for operating the belts within its standard limits (i.e., speed, load).

7. Spillage

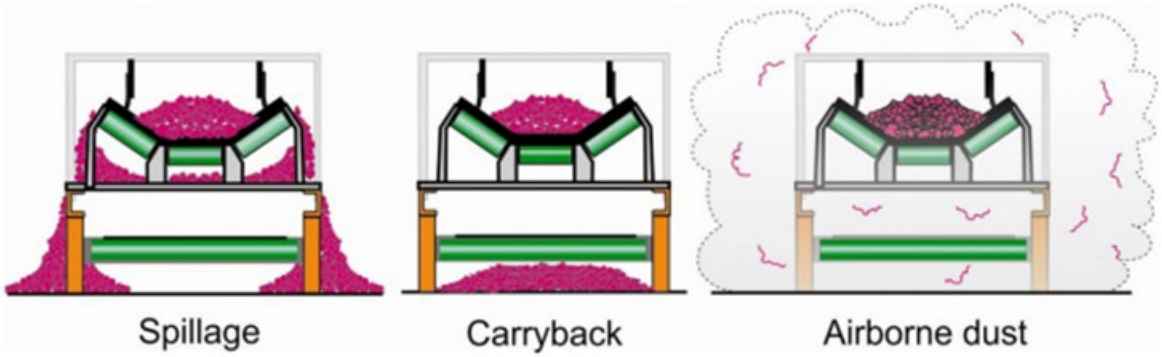
- Spillage of material from the conveyor may occur so that material may accumulate on the structure below, on the transfer tower or on the gantry of the conveyor or any other conveyor below, leading to excess weight and imbalance and ultimately collapse (e.g., mineral material accumulating on the roof of a warehouse).
- The cause of the spill should be investigated. Additional cover on conveyors and dust collector systems should be provided when needed. In some cases, overhead conveyors are installed in a duct protecting against wind (i.e., marine terminal).

Loss history& support for recommendation:

Ore processing unit: The collapse occurred at the center of a warehouse and involved the warehouse structure and the conveyor(s) in the area. Much of the conveyors were built in 1940’ and 1950’ and also has been in operation with little modification. Collapse was due to overweight on the roof of the warehouse due to gradual accumulation of mineral spilling from one overhead conveyor.

8. Dust control

- Housekeeping and maintenance are very important when dusty material is transported by conveyors.
- Dust may accumulate around static and moving parts of the conveyors, affecting their normal operating conditions.
- Dust can collect on rollers and bearings, creating friction, which can accelerate degradation or cause excessive temperatures and result in ignition of the material or belt. Rollers or bearing could seize, creating friction with the moving belt, which could generate sufficient heat for ignition or generate a static charge.
- The primary root causes of fugitive dust emissions associated with conveyor belts are spillage, carryback and airborne dust. Control of all three primary dust sources is necessary to eliminate fugitive dust emissions.



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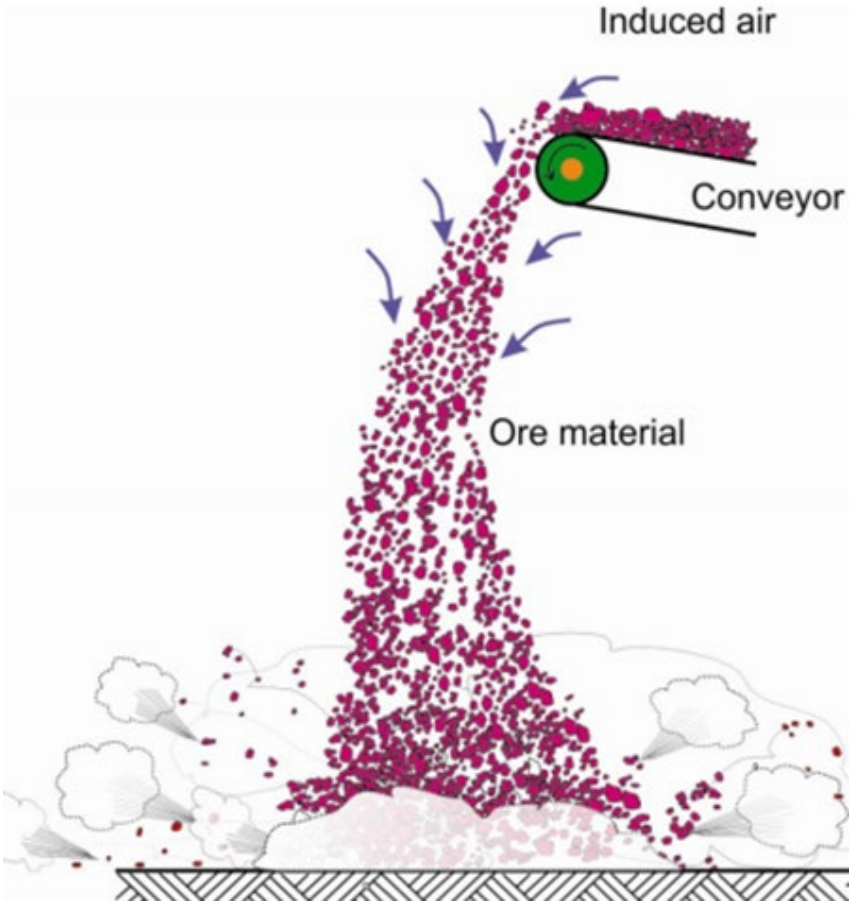
- Dust is mostly produced at inlet and discharge points and at long chutes for free-falling materials.



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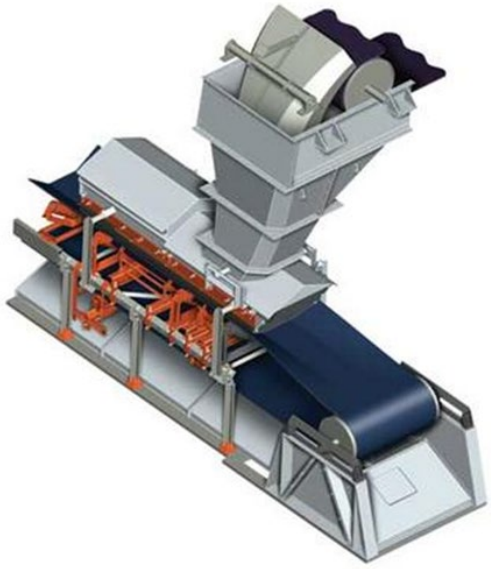
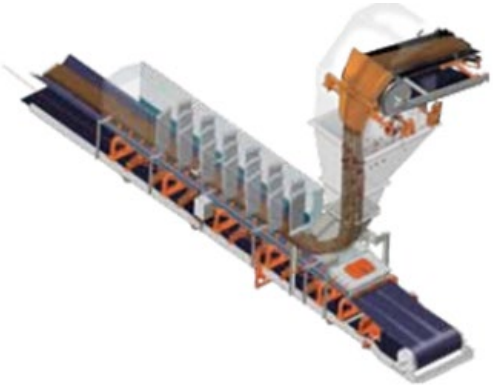
- Factors behind fires involving mechanical conveyors include dusty materials, a dusty atmosphere and dust that is usually created by the materials-handling process.
- If dust clouds cannot be avoided, it is better to use spiral or enclosed conveyors, where the escape of dust can be more readily prevented.
- Dusty material should be fed to belt conveyors through a choke feed to prevent dust clouds.



Example of a flow chute including a “hood” discharge chute and a “spoon” receiving chute along with a flow enclosure that contains the stream of material as it leaves the head pulley until it is deposited onto the receiving belt.

This reduces the impact that degrades the material and wears the belt at the same time it minimizes air expulsion that drives dust into the air



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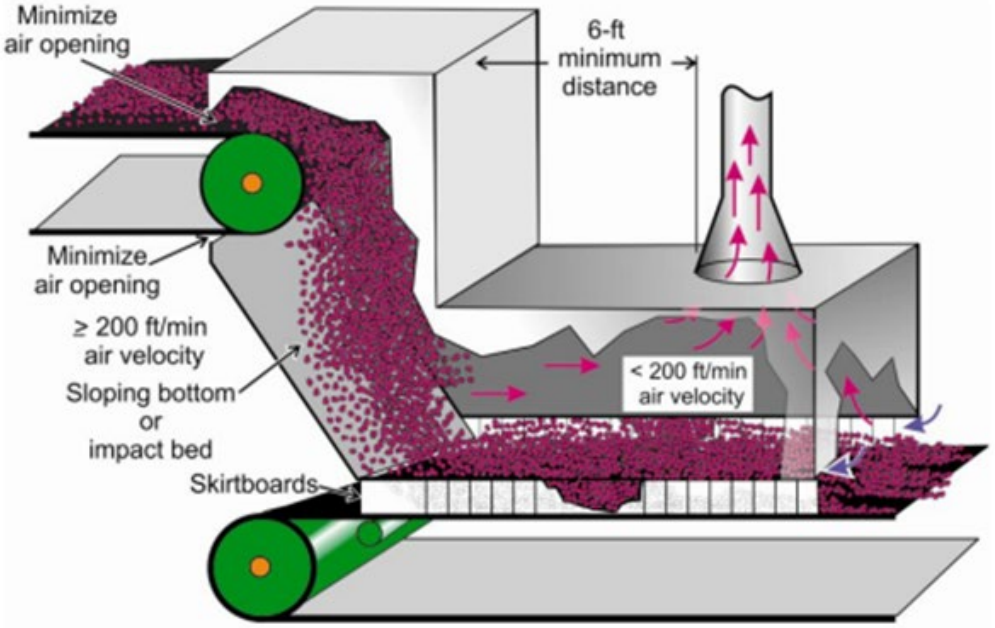
- Where dusty conditions exist, adequate ventilation should be provided to remove dust and collect it in safe locations. Dust collectors should be located outdoors or in separate rooms with adequate explosion vents for the collector and the room.

Conveyor transfer enclosure used with an exhaust ventilation system



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- When combustible or explosive dust is handled, conveyor piping should be strong enough to withstand the maximum pressure produced by explosions of the dust involved. Adequate static grounding is essential.
- Sharp changes in direction should be avoided wherever possible and vent pipes to the outdoors should be provided wherever a change in direction is necessary and at the end of lines.
- Screw conveyors should be fully enclosed in tight non-combustible housings with free-lifting covers at the discharge end and over each shaft coupling.

9. Safety interlocks

- To avoid ignition due to a mechanical failure on the system, the following elements should be considered:
  - Belt rotation detector, with an interlock to stop the belt moving in the event of a defect being detected (to avoid heat accumulation by friction with a non-rotating element). The rotation detector stops the conveyor when the speed falls under a set minimum speed (20% below the nominal speed). Speed reduction is always caused by some disturbance.

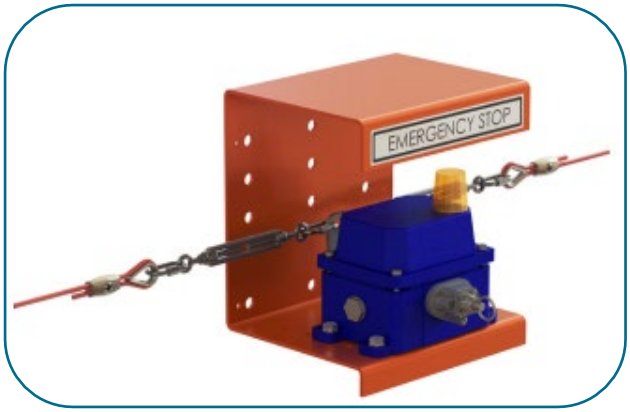
Example of belt rotation detectors

  - Belt overflow control (or belt misalignment control), with an interlock to stop the belt moving if the belt is not on its normal path. This alignment and rip detection switch detects any dangerous misalignment of the conveyor and may also detect belt tear damage.

Examples of belt conveyor misalignment switches

- Pull cord emergency switches should also be provided to allow the belt to be stopped manually if a defect is detected during a maintenance round or by an operator. This system is designed to operate (i.e., the conveyor belt stops immediately) when the cord is pulled in any direction or if the cord breaks.

Example of pull cord emergency switches



10. Control of ignition sources

There are several different ignition sources associated with conveyor belts:

- Friction (between the belt and rollers), mechanical failure (bearings), belt alignment (a misaligned or incorrectly adjusted belt can cause heat buildup capable of igniting the belt or material transported). See above for prevention.
- Hot work should be prohibited on and around conveyors. When needed, hot work permits and special precautions should be provided.
- Molten material in contact with the belt.
- Avoid any electric shock from damaged cables and damaged junction boxes.
- Avoid metal-halide high density lamps without borosilicate covers, and fluorescent lights without adequate cover in the direct vicinity of the conveyor.
- A no-smoking policy should be strictly enforced around conveyors.
- Accumulation of static electricity—see below.

11. Static protection

- Generation of static electricity increases when a conveyor belt is operated in a heated or dry atmosphere. All machinery and conveyor parts should be bonded and grounded to minimize static discharge.
- Static electricity can be controlled by using belts made of conductive material, by applying conductive dressing to the belt surface or by installing a grounded static collector that is nearly in contact with the belt just beyond the point where the belt leaves the pulley.
- Pulleys, guards and other metal bodies should also be grounded.
- Caution is necessary when handling or disposing of sludge from wet collectors, as certain combinations of metal dust and water are hazardous.

12. Fire considerations

Fire on rubber belt conveyor – inclined above ground and in tunnel.

The following points mean that automatic fixed fire protection needs to be considered in detail.

- Combustibility:
  - Although the conveyed product and the structure may be non-combustible, loss history demonstrates that the belt itself presents a sufficient combustible loading to spread the fire without the involvement of any other fuel.

Fire on rubber belt conveyor – sand storage

- Loss of integrity:
  - The flame speed would be so great that it would result in the loss of not only the conveyor belt, but also of structural members such as gantries and legs supporting the overhead conveyor.

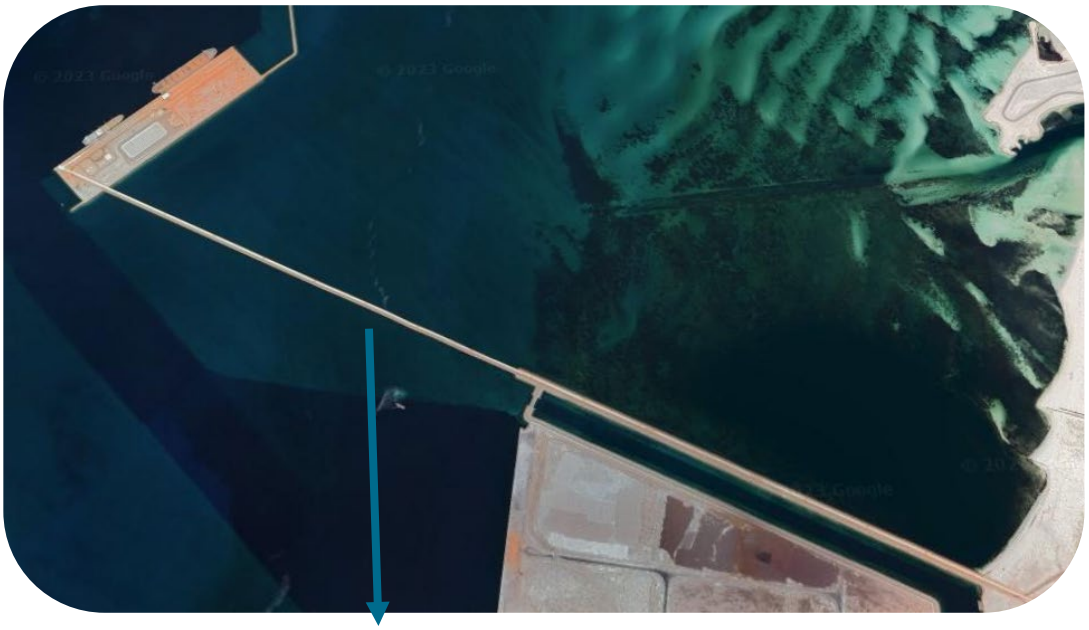
Fire on rubber belt conveyor – covered, elevated, inclined

- Burning characteristics:
  - Belts are often made of fabric-reinforced rubber or synthetic materials. The use of a fire-resistant belt may lower the hazard risk, but it will still burn, and a protection system is therefore still required.
  - Because conveyor belts have relatively slow burning characteristics, sprinklers are very effective in gaining early control.
- Manual firefighting:
  - Hose stream protection reaching all the parts of the conveyor should also be provided. The minimum additional hose demand for manual firefighting purposes should be 60 m3/h (250 GPM).
  - Portable fire extinguishers should be located within 15 m (50 ft) of the conveyor. For conveyors on mezzanines, extinguishers should be provided at readily accessible locations on the mezzanine level.
- Fixed automatic fire protection:
  - Totally open conveyors operating across considerable distances outdoors, such as in the mining industry, do not specifically require fixed fire protection systems if they are no more than 12 m (40 ft) high. They require the same controls and interlocks, as well as maintenance and fire prevention practices. Fire department access must be available and fire hoses that can reach all parts of the conveyor must be present.

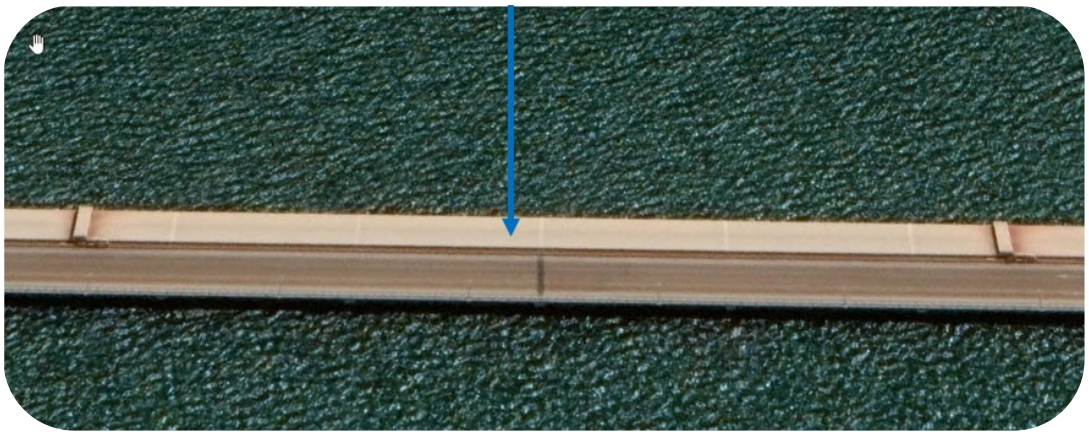
Mineral material

Coal

- However, for elevated conveyors, firefighters will not go on the gantry itself even if provided with hose reels. They will stay at ground level trying hard to prevent the fire spreading using hydrants. The section affected by the fire could collapse.
- In the case of inclined rubber belt conveyors, the slope (more than 10%) allows for a faster-spreading flame front. Underground conveyors are extremely difficult to access.
- Even above ground, in the case of conveyor(s) enclosed in a structure (i.e., a gantry supporting a frame to which walls and roof are attached), firefighters will not go inside and will fight the fire from outside, basically trying to prevent the fire spreading.
- Moreover, some structures that house conveyor(s) may also house energized voltage cables or even pipelines carrying chemicals (e.g., caustics). This is another good reason for firefighters to stay outside the structure.



Covered rubber conveyor on 1.5km long jetty carrying mineral and solid hydrocarbon product. Note: piping carrying chemical and cable trays also installed inside the structure



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- As a result of the above, in certain situations, such as a covered and/or elevated position, safe and efficient firefighting should be considered as virtually impossible.

- Since manual firefighting is both difficult and slow, and in some cases neither safe nor efficient, an automatic fixed fire protection system is recommended unless the conveyor belt is approved by a recognized laboratory (FM approved, for example) **AND** the material conveyed is non-combustible **AND** the enclosure housing is non-combustible.
- If the surrounding occupancy and construction do not require sprinkler protection, the sprinkler protection should be provided over the conveyor, treating the conveyor as if it were enclosed or partially enclosed.
- Feedback from numerous fire tests and losses show the following:

- ✓ The conveyor belt needs to be stopped as soon as possible to control the fire on a static belt and avoid having a “moving fire”.
- ✓ The distance between the belt height and the gantry (enclosure housing) is a dominant factor in flame propagation.
- ✓ The ignition intensity and exposure time (delay in activating the fixed fire protection system) are also critical parameters for flame propagation.
- ✓ Belt orientation is important: fires move much more slowly with horizontal conveyors.
- ✓ The temperature rating of the sprinkler heads is not a predominant factor.

13. Fire mitigation recommendation

The following points should be considered in detail:

a) Identification: all critical rubber belt conveyors should be identified.

b) Contingency Plan: a Contingency Plan should be developed in relation to the loss of a critical rubber belt conveyor including the belt and its structural support, identifying vendors, manufacturers or locations where spare conveyors are available.

or:

c) Protection: if the replacement time is not acceptable from a Business Interruption standpoint, an automatic sprinkler protection system complying with international standards (NFPA / FM Global Data Sheets 7-11 Conveyor Belts) should be installed for all critical rubber belt conveyors.

- An interlock should be provided to stop the conveyor belt, either with the activation of the fixed fire protection (automatic stop upon sprinkler/deluge activation) or with the activation of thermal detectors (if not yet stopped by other control switches).
- All fire alarms, perturbations and supervisory signals should be relayed to a constantly attended location.
- All material and equipment should be approved and/or UL-listed.
- A project plan review of fire protection systems should be conducted by qualified, recognized fire protection engineers familiar with NFPA / FM standards prior to installation, and a visit on site should be conducted during and after installation for final approval.
- The protection system should be installed by qualified contractors.

For indoor conveyors:

Except for belt conveyors, which represent a specific hazard, most of these systems can be adequately protected with existing sprinkler protection inside the building.

If not provided, or insufficiently designed, protection should be designed based on the material being conveyed, with a minimum density of:

- 6 mm/min/m² (0.15 GPM/ft²) over 186 m² (2000 ft²) corresponding to an Ordinary Hazard Group 1 occupancy for class I and II products (or equivalent),
- 8 mm/min/m² (0.2 GPM/ft²) over 186 m² (2000 ft²) corresponding to an Ordinary Hazard Group 2 occupancy for class III, IV and group A plastic (unexpanded or expanded) products (or equivalent),
- 10 mm/min/m² (0.2 GPM/ft²) over 186 m² (2000 ft²) for combustible bulk material transfers (coal, free flowing plastic materials, etc.).

Pendent sprinklers should be provided along the center line of the belt.

If sidewall sprinklers are provided, there are two possibilities, depending on the belt width:

Belt width <1.8 m (6 ft): position sidewall sprinklers along one side of the belt

Belt width> 1.8 m (6 ft): position sidewall sprinklers staggered along both sides of the belt (i.e., the sprinkler heads on one side of the belt are spaced 7.4 m (24 ft) maximum apart).

Note that there is a difference between combustible and non-combustible housing. Additional sprinkler heads might be required for the protection of the combustible housing where provided.

Protection of conveyor openings:

When conveyors run through openings, they can easily spread the fire from one area to another.

Openings should preferably be protected by passive fire protection such as fire doors.

Note that it is normally not permitted to run conveyors through fire walls. When feasible, conveyor penetration of a fire wall should be avoided by rerouting.

If a conveyor runs through a fire wall anyway, this wall can no longer be considered an “actual” fire wall for fire prevention and passive fire protection purposes.

When conveyors are running through openings equipped with fire doors, then provision of adequate systems should be considered to interrupt the flow of the conveyor and to leave the opening free of any material/equipment so that the fire door can operate properly.

Fire doors should be kept closed when the conveyor system is not in operation (during idle periods).

When not practical (or feasible) to provide fire doors, openings should be protected with water spray systems.

The water spray system will overcome the draft due to the temperature differences between one side of the wall and the other, and the height of the opening above the floor level.

Adding an enclosure to the opening would increase the effectiveness of the heat absorption (the spray's cooling effect is directly proportional to the time of exposure of hot gases in the draft to the spray).

Water spray systems could also be used for openings through floors.

For outdoor conveyors with cover or in an enclosed structure:

Table 1: Automatic sprinkler spacing and location:

Belt Width	Sprinkler Type	Sprinkler Spacing	Sprinkler Location
0.6 m (2 ft) to 1.8 m (6 ft) (***)	Pendent or Upright (*)	3.7 m (12 ft)	Along the center line of the belt
	Sidewall (**)		Along one side of the belt
1.8 m> (6 ft) (***)	Pendent or Upright (*)		Along the center line of the belt
	Sidewall (**)		Staggered along both sides of the belt (i.e., sprinkler heads on one side are spaced 7.4 m (24 ft) apart)

(*) The use of upright sprinklers is acceptable if they can be installed in accordance with Data Sheet 2-0, Installation Guidelines for Automatic Sprinklers. Pendent sprinklers should only be used in wet systems.

(**) Sidewall sprinklers are only acceptable for enclosed or partially enclosed conveyors. Unenclosed conveyors can be protected by sidewalls if the installation guidelines of the FM Approved sprinkler are satisfied (e.g., distance between sprinkler deflector and ceiling, spacing, etc.).

Sidewall sprinklers may be considered for a conveyor in an enclosed structure with a mobile roofing system related to a loader/unloader feeding the belt from the top of the enclosed structure and sliding on top of the conveyor structure.

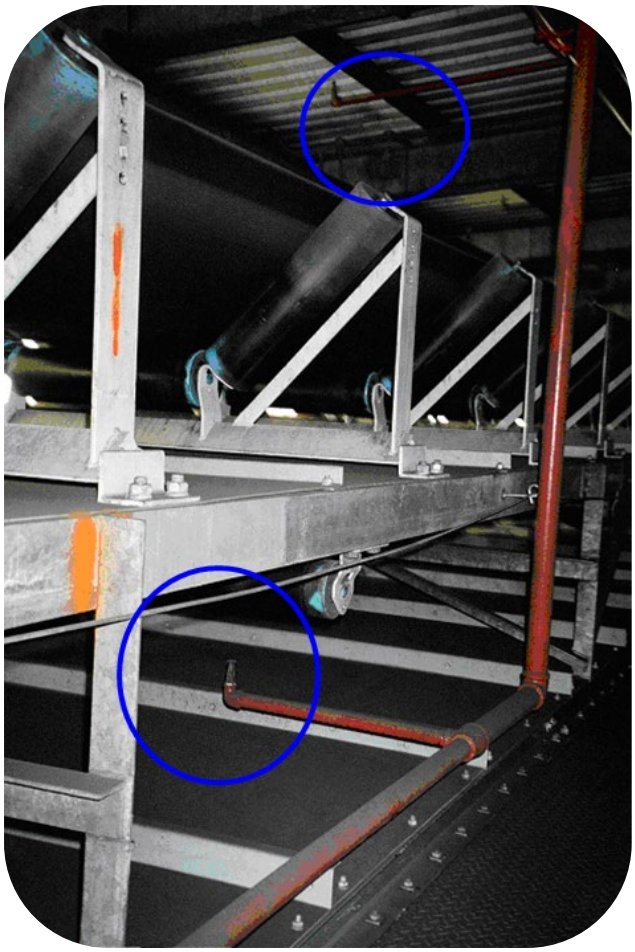
(***) For conveyors more than 3 m (10 ft) wide, ensure the maximum sprinkler coverage does not exceed 9 m² (100 ft²) with sprinklers no more than 3.7 m (12 ft) apart.

Where multiple parallel enclosed or partially enclosed conveyors are less than 0.6 m (2 ft) apart horizontally and are less than 0.6 m (2 ft) in width, provide sprinkler protection in accordance with Table 1 above assuming each conveyor is 0.6 m (2 ft) wide.

When installing sprinklers underneath a conveyor belt:

- If conveyors are more than 0.6 m (2 ft) wide, provide automatic sprinkler protection underneath them in accordance with the recommendations for obstructed ceiling construction.
- Install sprinklers under solid barriers of more than 1.0 m (3 ft) wide if combustibles are located (permanently or temporarily) beneath the conveyor.
- When a solid barrier of more than 1.2 m (4 ft) width is provided between the feed belt and the return belt, additional sprinklers are needed under the solid barrier for protecting the return belt. Sidewall sprinklers as per Table 1 above may also be installed along the wall facing the conveyor for protecting both feed and return belt.

Rubber Belt conveyors carrying Coal - Solid barrier between the feeding belt and the return belt – Automatic Sprinkler protection provided



For closed sprinkler head protection systems, sprinkler heads should preferably be rated at 74 °C (165 °F) and have a K115 (8.0) orifice size.

If the ambient temperature in the area is above 45 °C (113 °F), then intermediate or high temperature sprinkler heads can be used: 93 °C (200 °F) and 141 °C (286 °F). A minimum of 30 °C (86 °F) should be maintained between the highest ambient temperature expected and the temperature rating of the sprinklers.

In areas subjected to freezing conditions, dry or pre-action systems are preferable.

Fire protection should be designed in accordance with the following table:

Table 2: Sprinkler protection option

Belt orientation	Sprinkler system type	Sprinkler spacing	Sprinkler demand	
			Number of operating sprinklers	Flow per sprinkler
<10°	Wet, dry or pre-action	3.7 m (12 ft)	10	95 LPM (25 GPM)
10-30°	Wet, dry or pre-action		15	95 LPM (25 GPM)
>30°	Deluge		All sprinklers on a single system	12 mm/min (0.3 gpm/ft²) over the entire area

Note that NFPA 850 only recommends a design density of 10 mm/min (0.25 gpm/sq ft) over 186 m² (2000 sq ft) of the enclosed area or the most remote linear 30 m (100 ft) of the conveyor structure up to 186 m² (2000 sq ft). This protection is not associated with the belt orientation and is considered insufficient for an orientation above 30°.

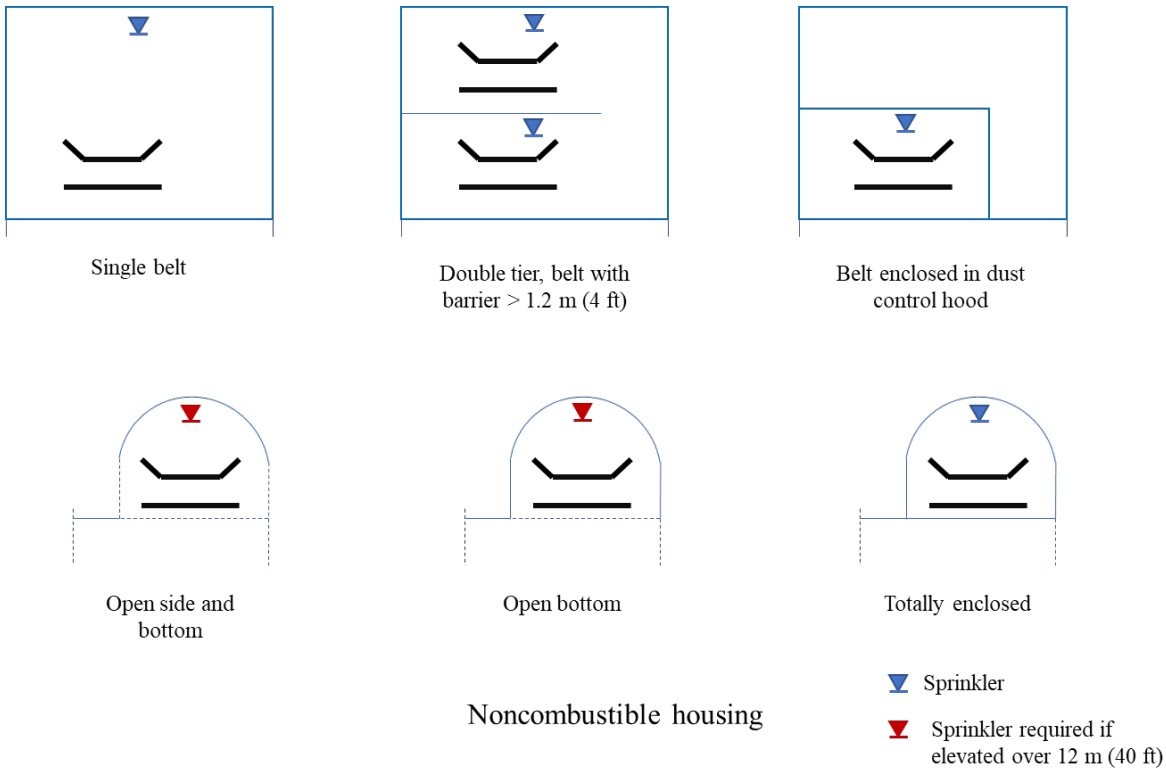
Linear heat detection systems (e.g., FM-approved thermal wire) should be provided to activate the pre-action or deluge systems. The maximum water delivery time should not exceed 60 seconds for dry or pre-action systems.

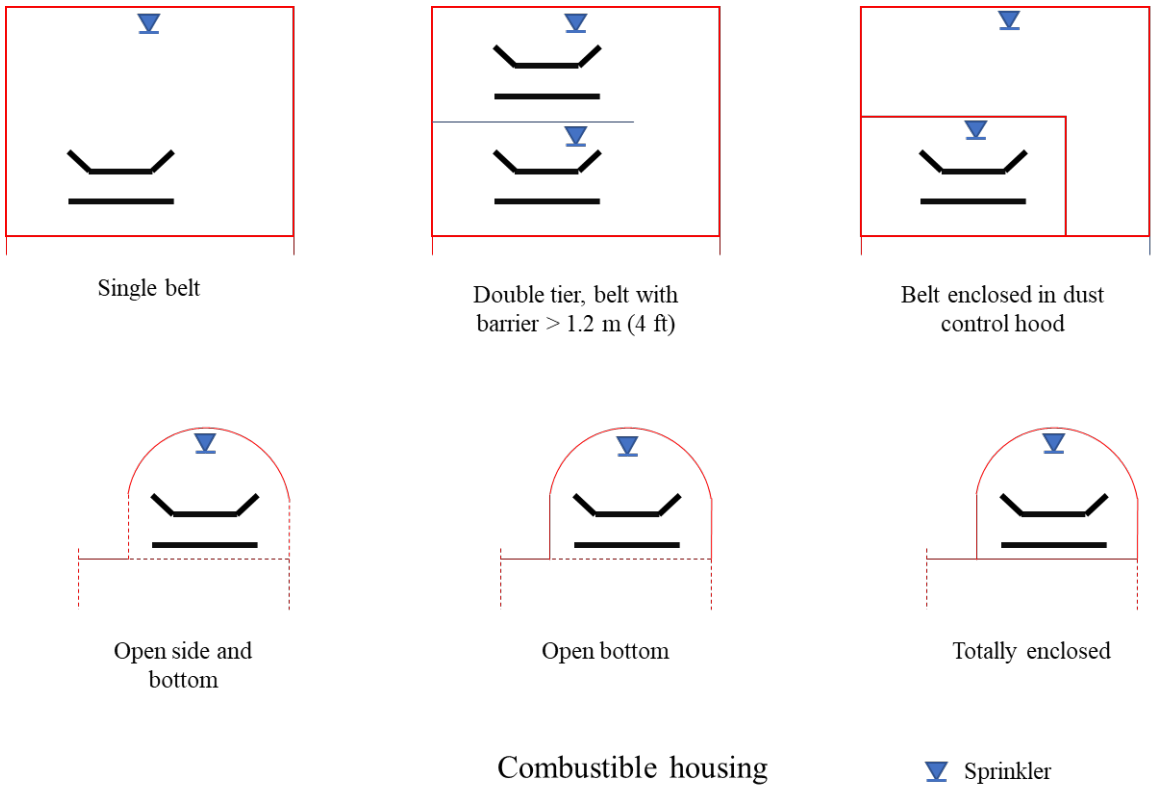
There should be a 60-min water duration for the system.

For conveyors more than 3 m (10 ft) wide, the maximum sprinkler coverage area should be 100 ft² (with a maximum spacing of 3.7 m (12 ft) between sprinklers).

The location of sprinklers over conveyors should comply with the following rules:

The sprinklers should be located in accordance with the following diagrams for outdoor conveyors (the occupancy is assumed to be non-combustible, apart from the conveyor or conveyed products).



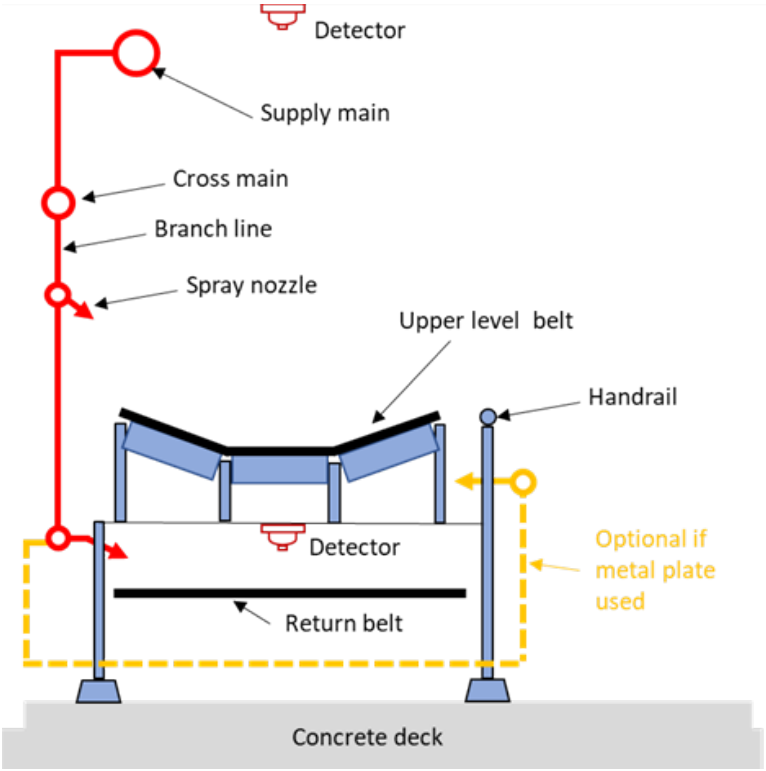


Deluge water spray systems should be provided for conveyors where fast response or immediate large area cooling is desired due to high values, unusual potential for severe loss, high frequency of fires or very difficult access such as a tunnel or belt with a slope of over 30°.

Rubber belt conveyor protected with deluge system

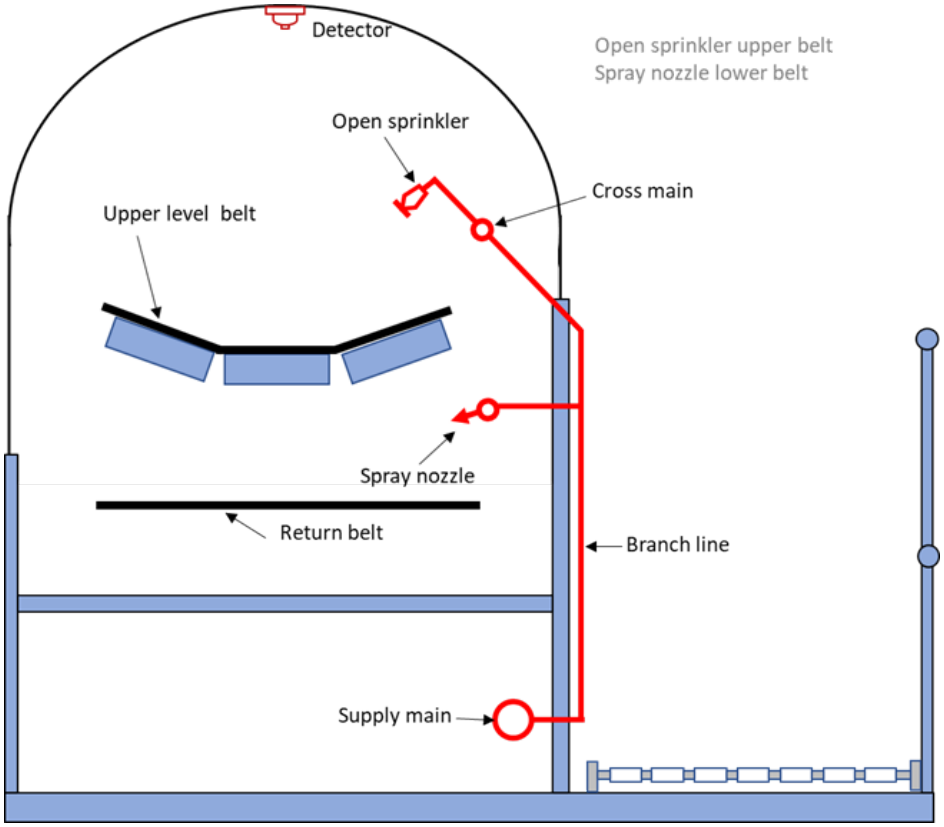
For deluge protection, the discharge pattern of the deluge nozzles should envelop the top and bottom belt surface area, conveyor surfaces where combustible materials are likely to accumulate, structural parts and the idler rolls supporting the belt.

Typical conveyor belt protection



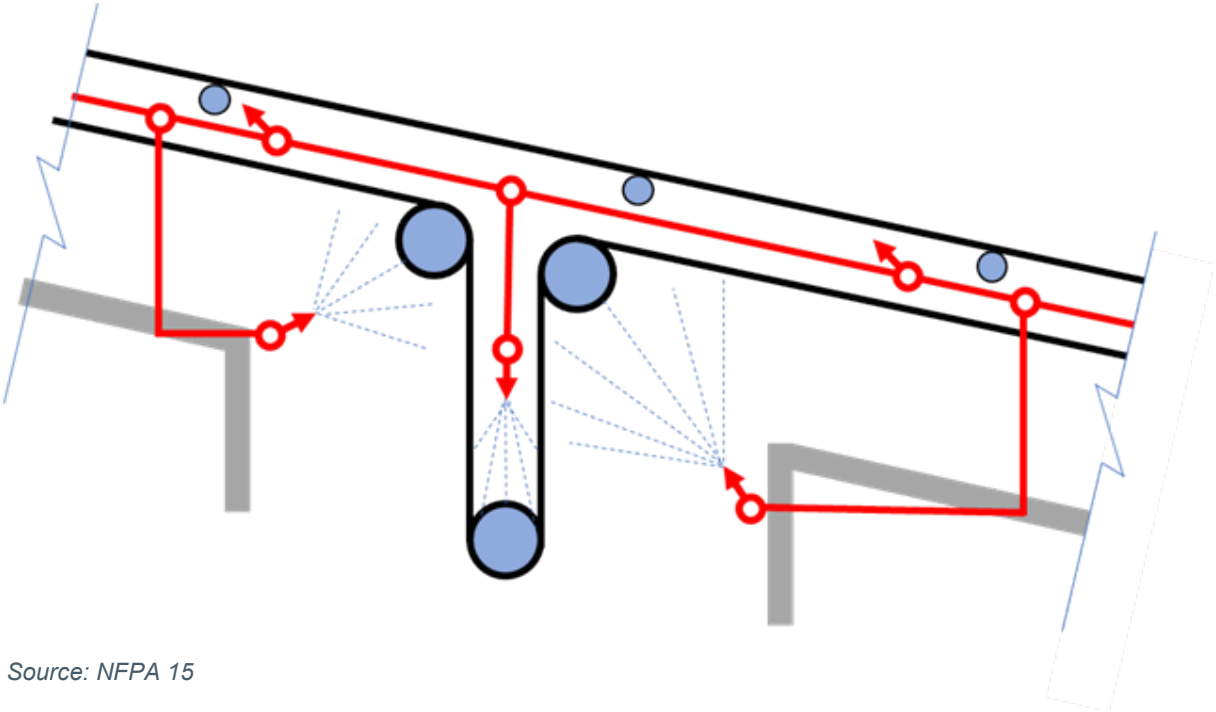
Courtesy of Franck Orset (FPO) Loss Prevention Engineer. (Source: NFPA15)

Typical hooded conveyor belt protection



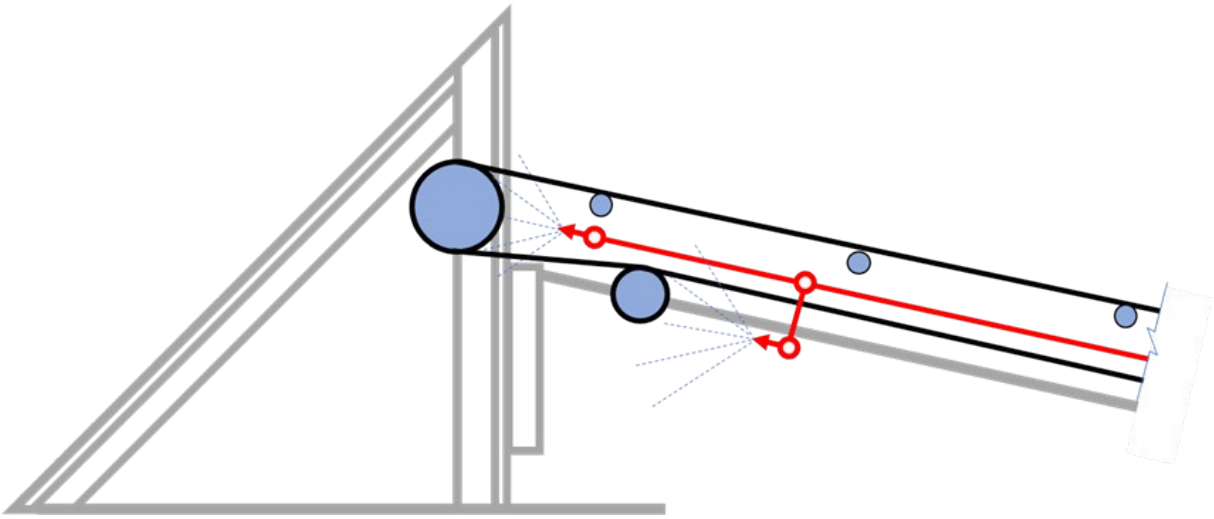
Source: NFPA 15

Elevation of typical take-up roller protection



Source: NFPA 15

Elevation of typical end roller protection



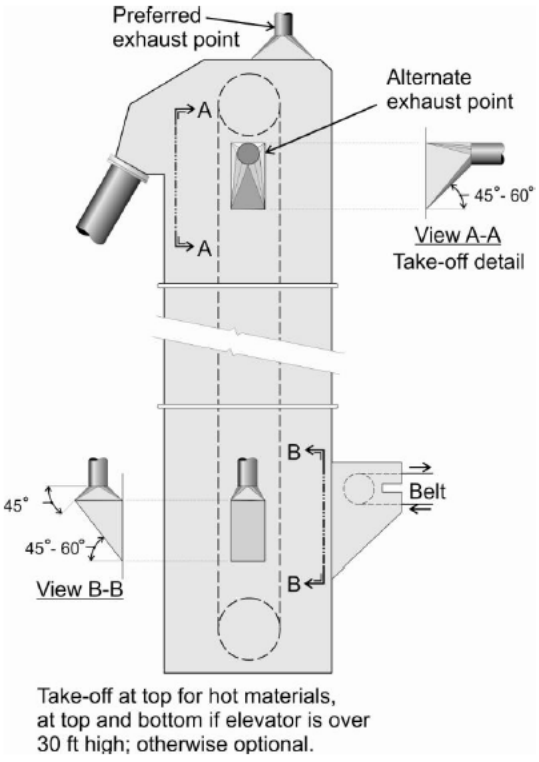
Source: NFPA 15

For Bucket Conveyors / Elevators:

Bucket elevators are used in bulk processing plants to convey loads vertically and are susceptible to the same fire hazards as conveyors.

The same precautions need to be taken for temperature, dust control, protection of openings, elimination of friction and ignition sources, overheating control, etc. Adequate maintenance and housekeeping should be enforced.

Depiction of a typical bucket elevator dust collection process



Source: RI 9689 Report of Investigation/2012 CDC NIOSH (public domain – may be freely copied or reprinted) Dust Control Handbook for Industrial Minerals Mining and Processing

Enclosed bucket elevators that handle combustible dusts present an explosion hazard and need to be installed in one of the following ways:

- Locate outdoors.
- For indoor bucket elevators, locate adjacent to an exterior wall so explosion venting can be directed to the outside via short ducts. The direct vents should be spaced at 6 m (20 ft) maximum intervals vertically for tall elevator legs.
- Provide the indoor bucket elevator with either explosion suppression or explosion venting through approved quench pipes.

Doors should be provided to provide access to head and boot pulleys and to facilitate housekeeping. All doors should be dust tight.

Fire protection for bucket elevators with rubber belts or combustible construction should involve a sprinkler system designed as follows:

- At the top (inside the enclosure) of the vertical bucket elevator shaft where the enclosure is non-combustible.
  If the enclosure is constructed from combustible materials, provide additional automatic sprinkler protection inside along the shaft (i.e., treat it as a vertical shaft with combustible sides), spaced every 3 to 3.7 m (10 to 12 ft).
- Design the automatic sprinkler to deliver a minimum flow of 95 LPM (25 GPM) from the most remote sprinkler.
- The belt should be interlocked to the automatic sprinkler protection in order to stop the conveyor in case of fire water discharge.

For serpentine (pipe) conveyor systems:
Provide protection in accordance with Section 2.2.3.3, Cross-Country Conveyors.

For Air-Supported Conveyors:

- Provide an interlock to stop the conveyor if one or more compressors are lost.
- Provide automatic sprinkler protection for air-supported conveyors in accordance with Section 2.2.3.3, Cross-Country Conveyors.
- Do not install grouped electrical cables, gas piping, or similar combustibles within the conveyor framework.

14. Loader / Unloader — (Port)

- Only non-combustible construction materials should be used.

- The same level of maintenance and inspection should be provided for such critical equipment, including structural maintenance and inspection.
- Adequate manual firefighting equipment with an adequate and reliable fire water supply should be provided.
- An onboard fixed fire protection system (e.g., gaseous extinguishing systems for MCC room, water-based fixed fire protection for lubricating group and rubber belt – if any - when water supply is provided i.e., for de-dusting system) should be considered.

Fires involving port loaders / unloaders

- Duplication of such equipment should be provided.
- When 2 loader/unloaders are using the same rails, anti-collision systems should be provided.

- An adequate breaking system should be provided.
- An operating procedure manual, taking into account the maximum wind, should be available.
- In the event of a major power outage, an electric loader/unloader may not be able to operate. As a result, one or two booms could be trapped in the bottom of a ship and rise during high tide, resulting in severe damage to the unloader (expensive piece of equipment) and potential BI due to the loss of unloading capabilities. As a result:

- A contingency plan should be developed in order to provide a reliable temporary back-up power supply for the electric suction-type unloader on the jetty when needed.

OR

- Where the contingency plan is not acceptable from a Business Interruption standpoint, the single electric ship unloader should be provided with an adequate and reliable fixed back-up power supply that is constantly available on site.

Loss history & support for recommendation:

A similar case was recorded during the 2010 earthquake in Chile: an electric unloader unit on the port lost power during the earthquake. Considering the tsunami risk, the ship's captain decided to steer the ship onto the open sea. However, the loading arm of the crane was trapped in the ship at that time (no back-up power for the electric drivers), resulting in severe damage to the unloader.

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