Swiss Re
Corporate Solutions

Belt Conveyor Fire Safety & Risk Engineering Guide

Lessons Learned and Best Practices for Mining Operations

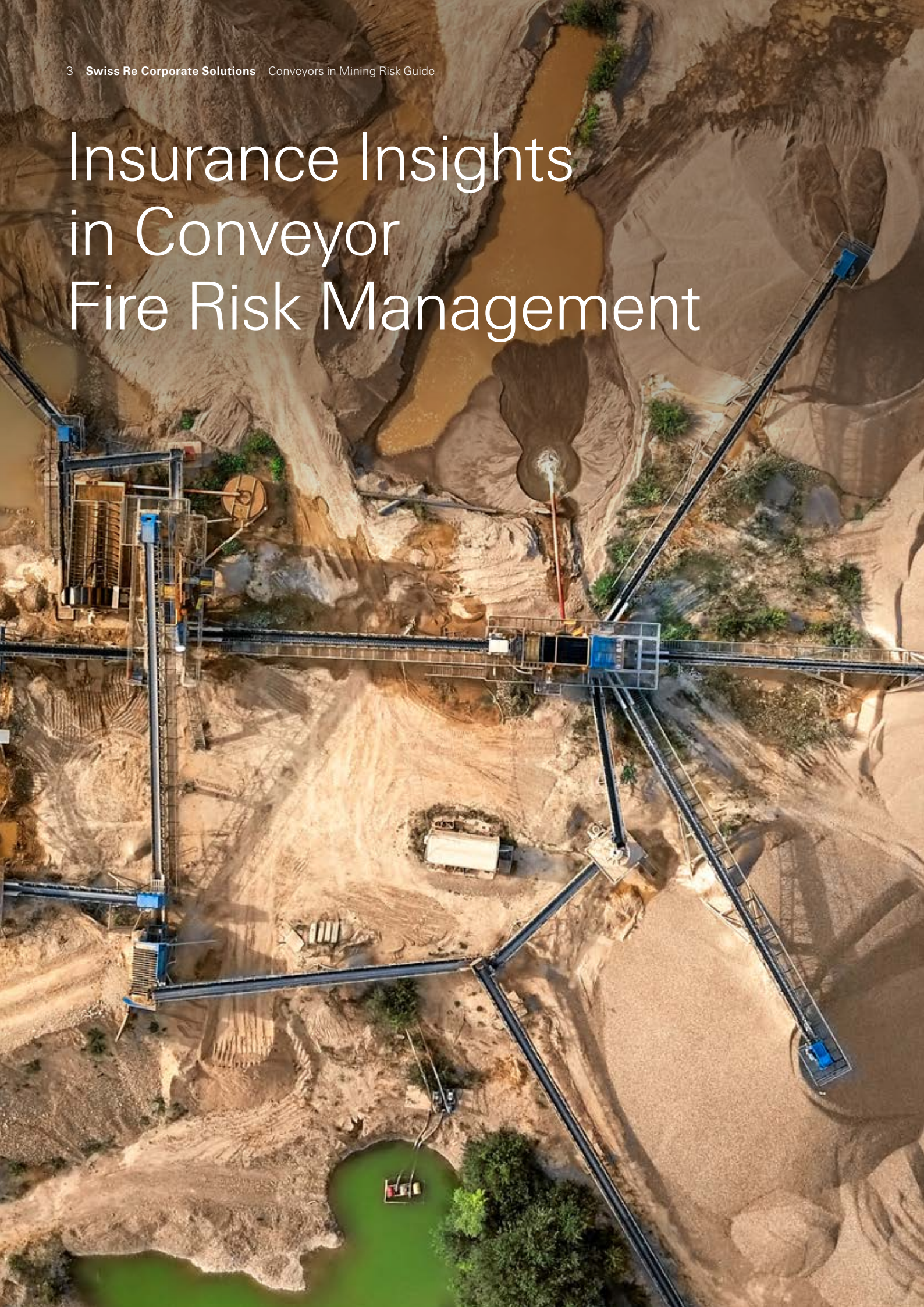
Introduction

Belt conveyors are critical to many mining operations, moving ore across large distances between the mine and plant, and interconnecting multiple internal processing circuits. For both non-combustible and combustible ore, they represent one of the most significant fire hazards on mine sites due to the combustible nature of all conveyor belt types. Conveyor-related fires represent a significant area of loss frequency in the mining sector.

Loss experience reveals that fires spread quickly due to the combustible nature of belts and the enclosed, inaccessible design of many conveyor systems. Even with good maintenance, failures can still occur. This makes interlocks, detection systems, and suppression measures vital layers of defence.

This brochure draws on lessons learned from past incidents to highlight key risk drivers and common failure points. It outlines practical measures to prevent and mitigate conveyor-related fires, based on industry experience. In addition, this document outlines best practices aligned with leading international standards to support effective risk management. By engaging with Swiss Re Corporate Solutions' Mining team, organisations can implement practical loss-control solutions for conveyor systems and promote best practices for both new and existing conveyors. These measures help reduce the risk of property damage and business interruption while enhancing operational reliability.

Insurance Insights in Conveyor Fire Risk Management



Types of Belts

Conveyor belts are used in multiple applications within the mining industry, to transport material in surface and underground mining, and within processing facilities. Even when carrying non-combustible minerals, the belt is capable of sustaining and spreading fire. Conveyors in most cases form critical bottlenecks for an operation and can take extensive times to rebuild with limited work around to regain full production.

Traditional Rubber Belts

Traditional rubber conveyor belts are widely used due to their durability and cost-effectiveness. They are strong, offer excellent abrasion resistance, and provide long service life even in harsh operating environments. The initial investment for these belts is lower compared to alternatives, and options with high tensile strength are available to meet demanding applications. Maintenance costs are generally modest, with replacement expenses varying based on belt width and length. They have a higher vulnerability to damage and loss from a heating event than Fire Resistant Anti-Static conveyors.

From a fire safety perspective, traditional rubber belts present several risks. They are easily ignitable, especially from friction caused by seized idlers or misalignment, and once a fire is established, the belts sustain flame and produce large volumes of dense, toxic black smoke. Flame spread can be rapid within enclosed galleries, and steel cord reinforced belts can intensify heat retention. These belts contribute significant fuel load, cannot be relied upon to self-extinguish, and may lead to severe smoke production and structural collapse in enclosed systems. Robust fire detection and suppression systems are essential to mitigate the higher fire propagation potential and minimise business interruption should ignition occur.

Fire Resistant Anti-Static (FRAS)

FRAS conveyor belts are engineered to improve workplace safety by resisting ignition, slowing fire spread, and preventing static discharge, but they are not fireproof and should not be relied upon as the sole means of fire protection. Designed to meet fire retardancy and anti-static standards like EN 12882 and EN 14973, these belts are ideal for hazardous environments, yet operators must carefully consider abrasion resistance and maintain the belts regularly to preserve their safety properties.

In terms of fire behaviour, FRAS belts offer significant advantages over traditional rubber belts. While they are not entirely fireproof, they slow the progression of fires, providing valuable time for fire suppression systems to activate and minimise the likelihood of rapid, longitudinal fire propagation. Their improved resistance to localised friction heating and reduced static ignition probability make FRAS belts a requirement in many jurisdictions for underground coal mining, and they are integral to explosion prevention strategies. However, it is essential to recognise that FRAS belts are not a substitute for robust fire detection and suppression systems; they serve to reduce fire exposure but should not be relied upon as the sole means of fire protection.

Despite their safety benefits, FRAS belts come with certain drawbacks. They generally incur higher initial costs especially for the most stringent underground classifications and can have lower abrasion resistance compared to traditional belts. This can lead to faster wear and higher maintenance costs. Replacement costs are also higher, and ongoing maintenance is crucial to preserve their fire-retardant and anti-static properties. In practice, some operators revert to traditional belts for better mechanical performance, which can unintentionally increase fire exposure and risk. Careful consideration of abrasion resistance and adherence to maintenance plans are vital to ensure FRAS belts provide the intended level of protection.

More Information

Further details are available in our Risk Engineering Services (RES) brochure for FRAS, available at:

Preventing losses: Fire Resistant Anti Static (FRAS) Conveyor Belts | Swiss Re

Conveyor Locations

Reclaim Conveyors

Reclaim conveyors are typically located in enclosed tunnels taking feed from stockpiles, silos and bins. They are commonly more difficult to inspect, have higher spillage accumulation and their location makes them more susceptible to trapped heat and mechanical damage at feed points. High risk ignition points include drive stations, tail pulleys under load, skirted transfer points, and buried/covered return runs where debris accumulates. Frictional heating from seized idlers can be of a greater issue on reclaim belts.

If the reclaim is enclosed/subgrade, smoke and heat confinement increases in severity and reduces the manual firefighting effectiveness.

Best practices of risk reduction for this type of conveyor arrangement include strong housekeeping (spillage control), bearing temperature monitoring, and misalignment/zero-speed interlocks. Early detection, such as linear heat detection (LHD), is usually justified. When access is limited, or the zone enclosed, automatic fire suppression should be provided.

Overland Conveyors

Overland conveyors often run through remote areas where identification of a condition requiring maintenance or even in the event of a fire, this can be delayed. Examples of the source of a fire may start at local drive/take-up stations, lightning/wildfires exposure, and mechanical friction.

Open or partially open overland conveyors typically allow for better heat dissipation, as well as making fires more accessible for intervention. The risk is heightened by the remoteness of these systems, which often leads to delayed detection and response. As a result, fires in these areas can cause significant business interruption, especially since overland conveyors usually serve as the main connection between the pit and the plant or port. If truly open and accessible with robust mobile firefighting and access roads, manual strategies can work, otherwise consider automatic protection.

Elevated Conveyors (Up to 40 feet in elevation)

Elevated conveyors often combine hazards; elevation or surrounding infrastructure can complicate access in certain areas. Spillage tends to accumulate under raised sections, and the risk of impact with mobile equipment is higher (struck structures, damaged idlers, belt mistracking).

Fire propagation may occur along the belt, which serves as a fuel source, and response effectiveness is dependent on segment-specific conditions.

To manage risks associated with semi-elevated conveyors, it's important to focus on protection measures on drives, transfer points, and any enclosed segments, as these are the areas with elevated fire hazards. Additionally, ensuring that access roads or hose streams can reach along the semi-elevated runs enhances emergency response capability

Elevated Conveyors (Above 40 feet)

Elevation drives consequence. The ignition sources are similar (idlers, misalignment, drives), but a key risk escalation factor is poor hose-stream reach and limited physical access during a fire. Where enclosure is combustible or belt is conventional rubber, risk escalates further.

It is widely accepted by the insurance industry, that for galleries/towers greater than ~12 m (40 ft) height are generally inaccessible for manual firefighting. This is supported by internationally recognised standards. In addition, enclosed elevated structures can experience rapid fire spread and potential collapse due to the steel structure buckling and deforming. Even if open-sided, access constraints and wind effects can make control difficult. Elevated conveyors are a strong case for automatic protection, detection, and shutdown interlocks at drives/transfer points along the entire conveyor length.

Underground Conveyors

Underground conveyor systems pose a heightened fire risk within mining operations, primarily due to their placement in confined spaces with limited ventilation and restricted access for firefighting. Unlike surface conveyors, these underground installations often feature long, continuous belt runs that can quickly propagate fire, while tunnels and drifts trap heat and smoke, making fire containment more challenging. Fires involving rubber conveyor belts generate dense, toxic smoke that can rapidly spread throughout the mine via ventilation systems, increasing risks to personnel safety, causing widespread smoke migration, and potentially resulting in extended operational shutdowns.

On several occasions the structures supporting the belts are carrying: the electricity, optic fibre, and plumbing for dewatering; or are located close by these key lines.

Given these elevated hazards, many regulatory authorities mandate the use of Fire-Resistant Anti-Static (FRAS) or equivalent fire-resistant conveyor belts underground. These specialised belts are designed to minimise ignition risk, limit flame spread, and prevent static electricity buildup, but they are not a substitute for dedicated fire protection systems. Automatic fire detection and suppression systems are strongly recommended in high-risk scenarios, such as enclosed conveyor drifts, long conveyor runs with limited access, conveyors transporting combustible materials, critical production routes, and areas with combustible dust hazards. Depending on the case, fire protection should be also provided for the return section of a conveyor belt.

Effective protection strategies typically involve linear heat detection cables, temperature monitoring at key components, smoke detection in enclosed areas, and the installation of automatic suppression systems like deluge and sprinkler systems along conveyor belts and at transfer points.

Plant Conveyors

Plant conveyors are particularly susceptible to fires due to several key factors. They experience a higher frequency of ignition sources, such as maintenance activities, hot work, often more spillage, electrical equipment in close proximity, along with more frequent operational cycling (start/stop). Additionally, there can be a considerable presence of combustible materials nearby—including cables, structural components, and operating equipment—which increases the fire risk. The proximity of plant conveyors to other equipment and buildings further elevates their exposure, making robust fire protection measures essential in these environments

Fire spread pathways are more complex in this case: conveyor-to-conveyor crossover, transfer towers, cable trays, floor openings, and dust migration. Smoke impacts can be severe indoors. Shielding/obstruction can render ceiling sprinklers less effective if conveyors are stacked/covered.

Fire protection for plant conveyors should include automatic sprinklers where loss of the conveyor would cause significant operational disruption or spread of fire to surrounding equipment. Sprinklers can be considered at the ceiling level, along the belt, in areas where obstructions may limit manual response or strictly at tail and head end locations depending on risk assessment. Enforcing strict hot work protocols and routine housekeeping is of importance. Additionally, integrating detection and shutdown interlocks is crucial to halt belt-driven fire spread quickly, minimizing potential damage and operational disruption.

Conveyor Enclosures

No Enclosure or Open Conveyor

In this type of conveyors, heat and smoke vent freely; flame propagation along the belt is slower than in enclosed systems because heat is not confined. This improves manual-firefighting effectiveness and reduces structural collapse risk. However, open belts still ignite readily from friction, tramp metal or hot material and create long-running incidents if undetected.

Linear heat detection is useful at high-value transfer points, but for truly open runs a combination of quick-response flame/infra-red detectors at high-risk nodes (transfers, drives) plus visual/manned patrols is often cost-effective.

Automatic sprinklers are typically not required for exposed open conveyors unless other factors (e.g., elevation, nearby combustibles, poor access) push the risk profile up. Drive locations, transfer stations, and head/tail end coverage should still be considered.

Good practice includes housekeeping under open runs (remove windblown fines and vegetation), weekly visual checks at idlers/skirts, and thermographic surveys at drives.

Partial Enclosure

Partial enclosures trap some heat and allow pockets of concentrated heat that can accelerate ignition and local propagation. They also can create sprinkler-shadow zones.

Linear heat detection (LHD) routed through the hood / along the return belt is considered a good practice since detection delays are common with partial enclosures.

Maintenance practice should include the inspection of hood seals, access hatches, and sprinkler nozzles (if installed) for blockages. Clean inside hood areas more frequently because dust/ fines accumulate faster. Verify LHD routing and LHD end-to-end continuity.

Full Enclosure on Top (Combustible)

This is one of the highest hazard combinations: the belt fuel plus a combustible enclosure creates conditions for intense longitudinal fires, dense toxic smoke and rapid heat buildup. Fire spread is aided by the enclosure; firefighters cannot easily apply hose streams. Totally enclosed combustible constructions are identified as prone to severe uncontrolled fires and structural collapse.

Automatic suppression must be considered: internal sprinkler lines or deluge systems actuated by linear heat detection are preferred.

Maintenance practice should consider high frequency inspection (daily/weekly) for enclosed sections. Test LHD frequently and inspect sprinklers/hoses and drainage provision (to avoid gallery collapse from water accumulation).

Full Enclosure (Non-Combustible)

Non-combustible enclosures greatly reduce enclosure-fuel contribution; however, the belt itself still provides significant combustible loading and enclosed geometry still traps heat and smoke

Linear heat detection combined with internal sprinkler protection is recommended for totally enclosed systems. Same as combustible enclosure: interlocked to stop upon detection, isolate feeds, actuate suppression. Because the enclosure is non-combustible, emphasis is on protecting steel structure from thermal weakening.

Design and Construction

Conveyors should be designed with fire safety in mind:

- Use non-combustible structures
- Avoid stacking conveyors in ways that shield sprinkler discharge
- Treat conveyors more than 12m (40ft) above ground as high-risk for firefighting access
- Ensure that transfer towers, junction houses, and tunnels are protected with non-combustible enclosures

Detection, Suppression, and Interlocks

Automatic Detection and Suppression

- Detection should be provided through a layered detection strategy, particularly for enclosed, underground and high value conveyors. Detection layers include early-stage overheating, open flaming along the belt and dust related ignition within enclosed spaces. Linear heat detection is usually recommended for detecting overheating before full flame development.
- Infra-red flame detectors can also be used to detect open flames. Spot type smoke detectors can also contribute to detecting a fire in an early stage.
- Sprinklers: Automatic fire protection should be provided following international standards (FM Global Data Sheet 7-11, and NFPA 13). Commonly, automatic sprinklers protection should be provided for indoor conveyors. For outdoor conveyors, sprinklers are generally needed when the conveyor is open/partially enclosed in higher-risk configurations, for fully enclosed systems, multi-tier conveyor or it is elevated enough (typically above 12 meters (40 ft)).
- Linear heat detection and smoke sensors should be installed within enclosures and interlocked with shutdown systems.

Essential Interlocks for Conveyor Fire Safety

To prevent ignition and limit fire spread, conveyor systems should integrate:

- Rip or Tear Detection Systems: Detect longitudinal rips or tears in belts, triggering immediate shutdown to prevent spillage igniting on rollers.
- Zero-Speed Switches: Monitor conveyor motion; if a belt stops while the drive runs, heat from friction can ignite the belt. A zero-speed switch halts the drive automatically.
- Misalignment Switches: Shut down or alarm when belts drift off-track, a common precursor to frictional heating and fire.
- Overload Protection: Detects excessive load or torque, preventing overheating of motors and drives. According to NFPA 13 and FMDS 7-11, fire detection systems must be directly connected to conveyor shutdown controls. However, there are exceptions such as underground coal mines, where the conveyor keeps operating until all combustible material has been removed.

Allowing belts to continue running during a fire accelerates flame spread across other section of the system such as transfer towers, screening, equipment or stock, and other belts.

Together, these interlocks not only prevent ignition but also ensure fires are contained before suppression systems engage.

Operations and Maintenance

Maintenance and inspections should consider the following aspects:

- Weekly inspections must check for roller seizure, misalignment, and debris buildup beneath belts.
- Thermographic scans of motors, pulleys, and bearings should be part of preventive maintenance.
- Outdoor conveyors should be kept clear of brush, weeds, or combustible storage within 25 ft.
- Hot work should only proceed under strict permit-to-work controls, following NFPA 51B.

Explosion Hazard Control

When conveyors handle combustible dust or operate where there is a combustible dust exposure a fire can trigger devastating secondary explosions. NFPA 650 specifies dust-tight enclosures, inerting measures, explosion venting, and suppression systems for bucket elevators and conveyors. Past disasters have shown that a small conveyor fire can become the ignition point for mine-wide explosions.

Contingency Planning

Fires in conveyors can halt operations for months if no redundancy exists. Focus should be on an emergency response team properly equipped and trained for indoor and outdoor conveyor fires (if applicable) and high elevation firefighting. Documented contingency plans should include:

- Stocking critical spares such as belting, rollers, pulleys, and motors.
- Identifying alternative material transport methods (e.g., trucking) in case conveyors are disabled.
- Downstream or intermediate stockpiles to sustain production upon a contingency.

Lessons Learned from Past Incidents

- Conveyor fires often begin with seized idlers or misaligned belts, generating enough frictional heat to ignite belts or spillage.
- Hot work has been a repeated cause of catastrophic fires, with sparks igniting belts and dust accumulations.
- Poor housekeeping and spillage accumulation beneath and along conveyors have been identified as key contributing factors, providing additional fuel for ignition and allowing small fires to develop and propagate unnoticed.
- In more than one case, the lack of interlocked suppression and shutdown systems have allowed conveyors to continue to run while burning, spreading fire along the full belt length and into surrounding infrastructure.
- Fires on operationally critical conveyors have caused production shutdowns lasting months and losses exceeding hundreds of millions of dollars.

Past incidents show a consistent pattern; interlocks and early shutdown systems can mean the difference between a small ignition and a catastrophic fire.

Key Takeaways

Conveyor fires are among the most significant property and business interruption risks in mining, yet they are largely preventable and manageable when a comprehensive risk management approach is adopted.

The most important actions are to:

- Design for resilience, not just prevention, by selecting appropriate materials, minimizing combustible construction, facilitating inspection and maintenance access, and considering fire and business interruption consequences throughout the asset lifecycle
- Control the primary ignition sources by implementing robust hot work management, preventing frictional heating through effective maintenance, and maintaining high housekeeping standards to minimise combustible spillage and debris accumulation.
- Implement effective conveyor interlocks such as rip detection, zero-speed monitoring, misalignment detection, overload protection, and temperature monitoring to identify abnormal operating conditions and initiate timely corrective action.
- Provide early fire detection through systems such as linear heat detection to enable rapid identification and response to developing fire events.
- Install automatic fire protection systems such as sprinklers or deluge systems to suppress fires, limit fire growth, and reduce the potential for major losses.
- Consider recovery and operational continuity when evaluating conveyor fire risk, as the most severe losses often arise from extended production outages rather than direct property damage alone.

By combining strong preventive practices, effective interlocks, early detection, automatic fire protection, and resilient design, mining operators can significantly reduce the likelihood and impact of conveyor fire losses.

To assess your conveyor fire exposures and identify practical risk reduction opportunities, contact the Swiss Re Corporate Solutions Risk Engineering Services team using the link below.

Risk Engineering Services | Insurance Solutions Swiss Re Corporate Solutions

Swiss Reinsurance Company Ltd
Mythenquai 50/60
P.O. Box
8022 Zurich
Switzerland

Telephone +41 43 285 2121
www.swissre.com

For more information, please contact the Mining team at Swiss Re Corporate Solutions.

David Prescott
Manager Mining Risk Engineering
David_Prescott@swissre.com

Erick Mondragon
Head Risk Engineering Services Energy
Erick_Mondragon@swissre.com

Title: Belt Conveyor Fire Safety & Risk Engineering Guide

Authors:
Francisco Arcos Elgueta
David Prescott
Erick Mondragon

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Swiss Re Corporate Real Estate & Services/Media Services, Zurich