Mining Industry Safety Leadership Group

CONVEYOR FIRE PROTECTION

Guidance document
STATUS OF THIS DOCUMENT

This information and guidance was prepared, in consultation with the Health and Safety Executive (HSE), by a working group representative of all sectors of the mining industry. It represents what is considered good practice.

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1 \hspace{1em} INTRODUCTION
This guidance has been prepared to capture current best practice and is intended to implement a strategy for the safe, effective management of conveyor operations including identification of improvements in equipment design, in the mining industry.

Fire underground is a major hazard. Fires on conveyors have the potential to propagate rapidly due to component parts, conveyor belting, mineral and debris.

2 \hspace{1em} WHAT THIS GUIDE IS ABOUT
This guidance sets out the key elements for the prevention of fires and safe operation of belt conveyor systems and installations (conveyors) at mines and advocates current best practice for fundamental conveyor fire prevention. It is aimed at:
- owners and mine operators;
- managers;
- operatives;
- members of the management structure, whose duties include the assessment, design, commissioning, operation, inspection, maintenance, supervision and monitoring of conveyors and those whose duties include the installation, operation and maintenance of conveyors;
- safety representatives.

3 \hspace{1em} SAFETY MANAGEMENT SYSTEM (SMS) FOR CONVEYOR OPERATIONS
Controlling and reducing the risks and hazards associated with conveyor operations must be an integral part of the required organisational health and safety management system (SMS).

The structure of any SMS should consider HSG65 “Successful Health and Safety Management”, and the principles therein, to reduce the likelihood of low frequency, high impact catastrophic incidents associated with conveyors.

Mine operators need to introduce and implement an effective health and safety policy that meets legal requirements, controls health and safety risks and is reactively revised to address additional hazards.

Operators must also maintain an effective health and safety management system that is proportionate to the risks and ensures communication of health and safety duties throughout the organisation.
3.1 Plan, Do, Check, Act
The principles follow the “Plan, Do, Check, Act” sequence:

Plan
Determine your policy and plan for implementation

Do
Profile risks, organise for health and safety, implement your plan

Check
Measure performance, (using appropriate Safety Performance Indicators (SPI’s))

Act
Review performance and act on lessons learned.

3.2 Safety performance indicators
Safety Performance Indicators (SPIs) provide information, which can be used to identify, understand, and control major hazard risks at conveyors, including fires.

There are two types of SPI:

- **Leading indicators** are proactive monitors focussed on critical risk control systems to ensure their continued effectiveness. They are factual precursors to weaknesses in the risk control system and can be
identified during routine auditing (pre event) and prevent significant events and include:

- failure modes and effects analysis (FMEA)
- threats to barriers and control measures
- inspections, testing and maintenance completed on time
- prioritised resolution of defects according to severity
- training and competence of operatives
- staff turnover
- compliance with operational procedures
- correct calibration, use and operation of instrumentation, alarms and environmental monitoring
- provision of adequate communication systems
- conveyor system design
- quality assurance
- routine condition monitoring techniques
- complaints are routinely investigated
- over inspections and audits

**Lagging indicators** identify weaknesses discovered following an incident or near miss (post event) and could be a precursor event to an undesirable outcome (fire), including:

- conveyor idler failure rates
- inadequately trained operatives
- inadequate communication
- failure of components
- contamination and debris
- repeated alarms
- belt wear
- belt joint life
- inadequate maintenance of installation standards
- supervisors inspections
- non compliance with recognised standards
- dangerous occurrences
- near miss/incidents

Analysis of SPIs for root cause failure of incidents and trend analysis of leading and lagging indicators may provide precursors to major hazard events and fires.

### 3.3 Risk assessment and risk ranking

A suitable and sufficient assessment of the risks to health and safety to which employees at work are exposed must be undertaken.
The risk assessment structure may include a generic assessment reflecting the core hazards and risks associated with fire prevention on conveyors; this may be adapted to address the specific hazards of each installation.

Hierarchical categorisation of control measures and tasks should reflect inherent risks and ensure a safe system of work and inspection.

Dynamic, on-site risk assessments should be undertaken and identify hazards, and subsequent control measures, resulting from changing circumstances, for example breakdown and maintenance.

Ranking of operational risk using “traffic light” indicators gives guidance to operatives on the level of control measures needed to carry out certain tasks.

Traffic light colour coding to risk rank each individual conveyor installation, including hazards, changes of grade, clearances and ventilation velocities may be applied providing guidance on appropriate resource allocation.
3.4 **Training, Leadership and competence**

3.4.1 Legal requirements

One or more competent persons are required to comply with the requirements of health and safety legislation. A mine operator should ensure that persons are competent to discharge statutory health and safety responsibilities to safely and effectively undertake the range of workplace activities.

Demonstration of adequate competence will typically include a combination of sufficient training, experience, knowledge, practical skill and the personal and interpersonal attributes and qualities necessary to comply with this requirement.

3.4.2 Training

Formalised and structured training should be developed and delivered to operatives, supervisors and safety representatives for all tasks e.g., spillage cleaning, belt inspection, testing and maintenance, conveyor extension, coupling and tensioning activities.

Specific training in conveyor system and protection transducer alarms should be provided to control room operators to recognise and respond correctly to alarms and emergencies.

3.4.3 Competence

Competence may be achieved and developed, with evidence verified and recorded, over a period of time by:

- induction
- instruction
- training
- experience
- assessment
- appropriate qualifications
- personal and interpersonal qualities
- refresher training and re-assessment

Developing and Maintaining Staff Competence (ISBN 07176 1732 7) refers.

The competence of staff deployed on conveyors should be determined by their proven ability to recognise and safely and effectively undertake a range of activities, typically:

- transportation
- installation
- commissioning
• operation
• diagnostics
• maintenance
• remedial actions

Formal risk assessment of conveyor installations should consider the full range of activities to be undertaken and include:
• the selection of competent persons for specific activities
• identification of specific competences, training and qualifications for job functions
• the interaction of persons with conveyor installations
• emergency situations

3.4.4 Information
Training of staff should include:
• hazard awareness
• Original Equipment Manufacturer (OEM) technical and operational information
• relevant legislative requirements
• codes and rules

3.4.5 Simulation
Conveyor operational and hazardous situations may be simulated in a safe environment for training purposes; OEMs can provide training programmes including software, videos, computer programmes, on line testing and practical sessions on equipment.

3.4.6 Assessment
Competence can be measured against recognised industry standards such as National Occupations Standards (NOS) that have been written by industry experts.

Conveyor NOS have been developed for job functions:
• operators
• craftsman
• technicians
• supervisors
• control room

4 SAFETY CRITICAL COMPONENTS & CONDITIONS
4.1 Definition
Safety critical components include single-line components or assemblies, which, if they were to become defective or fail in service, have the potential for functional inadequacy of the component and/or result in ignition.
Safety critical conditions include scenarios whereby the consequences of operational, environmental failure and/or degradation and/or human error may combine to engender unsafe events and/or result in fire.

4.2 Safety critical components or assemblies
The highest incidence and risk of fires on conveyors are attributable to the following range of components or assemblies:

4.3 Safety critical conditions
The highest incidence and risk of fires on conveyors are typically attributable to the following range of conditions:

- Bearing failure
- Frictional heat due to slip/rubbing
- Mechanical sparking
- Electrical energy
- Accumulation of combustible material (mineral, debris)
- Exceeding design tolerances
- Overloading and alignment
- Maintenance regimes

Fire risk areas associated with conveyors are typically:

- Gantries
- Belting
- Catenary
- Loop winches
- Fines/debris handling (AFC)
- Chutes
- Maintenance stations
- Tripper units
PARKGATE No 1 & 2 CONVEYORS

RISK AREAS ASSOCIATED WITH INSPECTION

- **HIGH RISK**
- **MEDIUM RISK**
- **LOW RISK**
1.9.3.795. – 8 May 2015

**Generic Hazards**
- Dust (Inhalable / Fire)
- Noise
- Rope Haulage

- Falling from a height
- Nip point
- Blocked chute
- Belt running out of line (fire)
- Collapsed bearing (fire)
- Oil / Grease (Fire / Contact)
- Build up of fines

**Parkgate No1Chute**
These areas can be risk ranked as shown in the table.

<table>
<thead>
<tr>
<th>High Risk Areas</th>
<th>Medium Risk Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Jib Area</strong></td>
<td><strong>Intermediate Belt Line</strong></td>
</tr>
<tr>
<td>• High tension rollers – heat, noise and vibration.</td>
<td>• Idler rollers – at bridges and underpasses and where nip guarded.</td>
</tr>
<tr>
<td>• Jib top and bottom idler rollers – rotation, noise, spillage.</td>
<td>• Tracking.</td>
</tr>
<tr>
<td>• Spillage, fines and belt strim.</td>
<td>• Floor – where wet and slippery, debris, coal and combustible material collect.</td>
</tr>
<tr>
<td>• High wind velocity.</td>
<td>• Under belt – fines, combustibles.</td>
</tr>
<tr>
<td>• Security of structures/A frames.</td>
<td>• Areas where materials are stored under the belt.</td>
</tr>
<tr>
<td><strong>Drive and Loop</strong></td>
<td></td>
</tr>
<tr>
<td>• Drive, snub and loop drums – heat, noise and vibration.</td>
<td></td>
</tr>
<tr>
<td>• Belt tracking.</td>
<td></td>
</tr>
<tr>
<td>• Build up of debris and spillage.</td>
<td></td>
</tr>
<tr>
<td>• Idler rollers rotating freely.</td>
<td></td>
</tr>
<tr>
<td>• Cleanliness of Drive i.e. oils, greases.</td>
<td></td>
</tr>
<tr>
<td>• Security of structures/floor bolts.</td>
<td></td>
</tr>
<tr>
<td>• Maintenance/clamp assemblies.</td>
<td></td>
</tr>
<tr>
<td><strong>Intermediate Structure</strong></td>
<td><strong>Low Risk Areas</strong></td>
</tr>
<tr>
<td>• High velocity areas.</td>
<td><strong>Intermediate Belt Line</strong></td>
</tr>
<tr>
<td>• Changes in grade/catenary.</td>
<td>• Good, well aligned structure at a good height from the floor.</td>
</tr>
<tr>
<td>• Tight areas to roof and sides including obstructions.</td>
<td>• Well maintained rollers.</td>
</tr>
<tr>
<td>• Structure close to the floor.</td>
<td>• Clear under belt, free from spillage and combustible material.</td>
</tr>
<tr>
<td>• Areas where combustible materials/fines collect.</td>
<td>• Well stone dusted.</td>
</tr>
<tr>
<td>• Magnets.</td>
<td></td>
</tr>
<tr>
<td>• Platforms.</td>
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</tbody>
</table>
5  CONVEYOR SYSTEM DESIGN
Conveyors are a range of assemblies; these can be from different manufacturers and/or comprise a variety of compatible components combined to form an integral system or installation.

The capacity, power and size of conveyors can vary significantly from small mineral fines handling systems to high-powered heavy-duty mineral clearance or man riding systems.

It is the responsibility of those assembling a conveyor to ensure that the essential health and safety requirements (EHSR) are met in accordance with the formal legislative documentation process.

5.1 Safety considerations
Consideration should be given to complete system design to ensure the compatibility and suitability of all elements to control the risk of fire. Provision of design drawings, compiled by suitably qualified and competent persons, should be incorporated into a technical file.

A technical file should be created for each conveyor specifying and detailing, inter alia, all aspects of its construction, components, operation, duty, design calculations and adequate factors of safety.

- belt capacity
- belt selection tensile strengths
- power capacity
- radius of curvature
- suspended loads
- support frames/structures
- intermediate structure/supports
- slinging anchors
- conveyor idlers/design principles
- gradients/catenaries/levels/alignment
- access
- intermediate loading points
- man riding

The system comprises a number of safety critical assemblies, components, high hazard areas and activities that are essential to the safe operation of the conveyor and associated fire risk control.

Examples are:

- transfer points
- fines conveyors
- scrapers/belt cleaners
- drives/drums/gearboxes/traction
- couplings/transmissions/brakes
- motors/VSD
- coolers
- drive houses/fire proofing
- switchgear/substations
- loops
- loop winches
- return ends
- cleanliness
- conveyor joints
- vulcanising
- nip points
- guards
- emergency stops/control
- monitoring
- lighting
Typical tail end & loading section
6 INSTALLATION
All conveyor installations should be designed, planned to a schedule and constructed using suitably selected equipment, appropriate to the most onerous operating conditions, environment and pre-determined duties minimise the risk of fire.

6.1 Installation site preparation
Preparation of the selected installation site should be undertaken robustly by sufficient numbers of suitably qualified and competent persons to meet the design parameters, and have:

- adequate ventilation and lighting
- access and egress
- safe, suitable workforce/plant interaction arrangements
- suitable foundations
- adequate room and clearances
- uniform gradients
- services, communications and utilities
- resources for the supply and transport of materials
- lifting and installation equipment
- materials for the construction of the installation site appropriate to the operating conditions and fireproofing
- positional marks for all equipment including centre and gradient lines
- installation plan and schedule documentation
- plan conformity assurance (audit and inspection)
6.2 Installation standards
The installation should meet the design parameters and standards, be undertaken robustly and safely, by sufficient numbers of suitably qualified and competent persons, in accordance with plans, method statements, risk assessments and the commissioning process.

Conveyor support structure is designed to carry the conveyor belt with all rollers taking a share of the load. Missing or badly aligned rollers will cause greater than normal loading on adjacent rollers leading to reduced life and premature failure.

The structure comprises longitudinal carrying framework (stringers) designed with $K_{1.0^\circ}$ maximum articulations ($K_{50 \text{mm vertical displacement over } 3 \text{mt length and equating to a circle radius of } 180 \text{ m}}$) to allow for changes in ground levels. Check this

Should convex radii smaller than 180 m be required, these should be adequately engineered with additional idlers.

Concave radii should be large enough to prevent the belt leaving the idlers under all conditions of operation.

Standard rollers should not be used for belt deflection and areas requiring nip guards should be identified.

Contour limitations
Preferred installation

Max acceptable level of deviation
1.9.3.795. – 8 May 2015

Structure straightness tolerance

Stringer squareness tolerance

Correct Installation

Incorrect Installation
Chain slinging methods
Floor Mounted structure shown as an example, slung structure to be cross levelled using the same method.
6.3 Use of centre, offset and gradient lines
Conveyors should be installed to ensure, where practicable, planned and optimal uniform gradients. Centre lines indicate correct alignment of conveyors in accordance with the design parameters during installation. Misalignment can create belt debris and spillage, induce frictional heat and engender an increased risk of fire.
Survey plan showing conveyor catenary lines and roadway section
6.4 Clearances
Adequate clearances throughout the conveyor are essential and should be maintained to permit effective inspection, cleaning and maintenance. Accumulations of material that may combust, if exposed to any ignition source, should be prevented.

Dimensional convergence of roadways (geological movement) can typically impair the safe operation of the conveyor by restricting design clearances.

Suspended conveyors are a practicable solution to geological movement and improve access whilst meeting operational design requirements.

6.5 Foundations
Conveyor foundations should adequately restrain and support the installation, permit effective inspection, cleaning and maintenance and afford removal of combustible material.

6.6 Access and egress
To afford adequate escape and rescue provision at least two means of access/egress must be provided. It is not always possible for single line development roadways to be so equipped and the numbers of personnel deployed in that area should be restricted by mine operator’s rules and special provisions.

6.7 Services, communications and utilities
To reduce the propensity for fire, effective services, communications and utilities should be installed, maintained, available and positioned to permit access and use. They should be arranged to avoid any damage, obstruction or interference to the conveyor or services.

Fire hydrants and fire fighting equipment should be provided in sufficient quantities and positioned to allow ease of access, inspection, testing, maintenance and effective use when required. Typically, fire equipment is installed at high risk locations:

- transfer points
- drive and loop take up
- switch gear housings
- tripper or booster drives
- intermediate loading points
- additional high risk areas identified
A cross section drawing shows an example of services and utilities in position on a typical conveyor.

**6.8 Ventilation**

Ventilation must be maintained, in accordance with legislation and mine operator’s ventilation rules, at appropriate levels to afford optimum environmental and working conditions. Excess air velocities can cause airborne debris, leading to accumulations of material, which can engender component failure, malfunction and/or a greater risk of fire.

Fire propagation is aided by ventilation. Any products of combustion will be carried throughout the mine by ventilating currents, velocity and direction.

Installing conveyors in the return air roadways mitigates the consequences of any potential outbreak of fire and the amount of heat and humidity emanating from conveyor operation and mineral production. Return ventilation currents aid removal of these products.

**6.9 Illumination**

All conveyor high risk areas should be provided with suitable and sufficient illumination to facilitate safe operation, inspections, examinations and maintenance.
6.10 Construction materials
Fire hazards will be significantly reduced by the selection and use of construction materials having non-flammable or fire resistant properties. The use of combustible material should be avoided.

6.11 Commissioning
The conveyor should conform to relevant regulations, design standards and mine operator’s rules. Static inspections and dynamic testing should demonstrate conformity; defects must be identified and rectified before the commissioning process is completed.

7 OPERATIONS
All conveyors must operate safely, fulfil pre-determined duties in the most onerous conditions and obviate any risk of fire.

7.1 Selection, duty & installation
Conveyor installations, their assemblies and safety critical components should be designed, selected and installed with adequate service life capability and capacity to safely fulfil the range of duties they are intended to perform and negate the propensity for fire.

7.2 Design life
OEM specified design life should be adhered to when conveyors, their assemblies and safety critical components are installed. Maintenance regimes should be designed in accordance with these specifications to identify any impending failure and allow replacement of assemblies and/or components to reduce fire risks.

7.3 Loading
Safe and effective transfer of mineral by conveyors is dependent on specified installation loading parameters. These are determined by; inter alia, mineral composition, speed, distance, gradient, and the specific transfer arrangements of each installation.

7.4 Fire Resistant belting
Fire resistant (FR) belting is available in a range of sizes and duties and should be used; although it will burn in the presence of a flame, removal of that flame causes the belt to self extinguish. These properties mitigate the propagation of fire and noxious fumes.

There are standard tests for FR belts including:
• Drum Friction Test - EN 1554:2012 A sample of belt is held in contact with a moving drum until it is worn through by friction. On parting, the belt must not show any sign of flame or glowing.

![Drum friction test](image1)

Belt sample after drum friction test

• Ignition Test - EN ISO 340:2013, A sample of belt is suspended and heated with a torch: the belt must not ignite.

![Ignition test](image2)

The extent of the damage to the upper surface determines the pass or fail criteria, the belt must not propagate the flame.
To reduce risks to as low as reasonably practicable only fire resistant belting should be used underground.

7.5 **Transmissions (motors, couplings, gearboxes)**
Conveyor transmissions, including motors, couplings and gearboxes, should be designed, installed and maintained in accordance with OEM instructions, to ensure the safe conveying of mineral between all parts of the system. They should be rated commensurately with the intended duty of the conveyor, as overloading or excessive repeated starting, significantly increases inherent fire risks.

7.6 **Drums**
Drums types can be crowned, parallel, lagged or combinations of these. Particular types of drums are more suitable for specific operational requirements than others, e.g. a crowned drum may aid correct tracking of belting whereas lagged drums may reduce the propensity for belt slippage, frictional heating and a potential ignition source. Degradation of the chosen drum type, due to wear, will result in a reduction of their designed intrinsic advantages resulting in misalignment of belting and/or excessive slip and increased fire risk.

7.7 **Brakes**
Brakes on conveyors introduce significant fire risks. The use of braking systems should be avoided, wherever practicable, as they introduce a concentrated dissipation of energy, potential heat and ignition sources, into the system.

Where design parameter constraints and conditions require the use of braking systems, they should have sufficient thermal capacity to effectively stop the conveyor in the most onerous operating conditions without overheating and/or creating an ignition source.

7.8 **Sprag clutches**
The gravitational load of mineral raised by an inclined conveyor may induce a risk of run-back.

Sprag clutches are anti-run back devices designed and fitted to inclined conveyors to minimise this effect. They should be rated sufficiently for the installation capacity and have sufficient capacity to effectively address the most onerous operating conditions, without overheating and/or creating an ignition source and be temperature monitored. Sprag clutches have a fixed life span and should be replaced in
accordance with manufacturers’ specification; single units should be avoided to negate single line component failure.

### 7.9 Speed

All moving parts of the conveyor should be configured to travel at the same speed to avoid belt damage and excessive spillage, especially during transfer.

Start up operations on high capacity conveyors increase power, energy, tension and load system demands, these can be alleviated by the introduction of variable speed transmission systems affording smooth, slow, controlled initiation and stopping.

The correlation between speed and load and the effect on idler bearing life should be considered in selection of idlers, speed of conveyors, loading and duty.

Maintaining optimum belt speed is essential to ensure effective and efficient mineral clearance and safe manriding operations.

Typically a 22% increase in belt speed from 3.29m/s to 4.0m/s equates to a 27% decrease in the bearing life of a 6 ⅝” (168.3mm) idler.

Reducing the idler size from 6 ⅝” to 5” (127mm) or 5” to 4” (101.6mm) equates to an increase in belt speeds of 32% and 25% respectively.
7.10 Idlers/rollers
A range of different sizes and types of idlers (rollers) are available for varying duties. Specific idlers are designed, and have suitability, for differing operational requirements of the conveying system e.g. heavy duty idlers should be installed where changes of gradient impart a greater loading on the conveyor.

Removing one idler increases the load on adjacent idlers by 50% and reduces the calculated bearing life by 70%.

**INFLUENCE OF LOAD ON CALCULATED BEARING LIFE**

Example: With one adjacent roller removed, load on roller is increased by 50% & calculated bearing life is reduced by 70%.

Designed
Idlers having design parameters that predominantly engender shell wear out failure before bearing failure should be selected.

Idler bearing failure results in a significantly increased risk and incidence of fire.

Bearing failures are typically caused by:
- increased loading
- ingress of contaminants
- loss of lubricant and grease
- misalignment
- in-service degradation
- incorrect idler selection

The bearing failure process can typically include:
- increasing frictional forces
- impeded bearing rotation
- heat generation
- loss of concentricity due to internal bearing misalignment
- bearing displacement
- high frictional rubbing and heating between hard bearing races as shell continues to rotate
Temperatures emanating from bearing failure can significantly exceed 600º C and are sufficient to ignite coal dust, CH4, coal dust/air mixture or any hydrocarbon vapours from the grease, paint, seal etc.

Fire Resistant (FR) grease has been adopted for idler end bearings in the UK coal mining industry since 1986 as it is less likely to ignite if exuded from a bearing during collapse.

The table below shows a comparison between the auto-ignition temperatures of FR and mineral grease.

<table>
<thead>
<tr>
<th>Auto-ignition temperature</th>
<th>FR grease</th>
<th>Typical mineral grease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>475 to 600ºC</td>
<td>340 to 375ºC</td>
</tr>
</tbody>
</table>

The ignition temperature is higher for FR grease. This has a minimal effect during the collapse of a bearing where temperatures may be in excess of 600ºC, and either type of grease can ignite.
FR grease is contained within clay and is resistant to running when heated. The temperature at which the grease becomes liquid is referred to as the drop point, and for mineral grease it is about 270 deg C after which dripping occurs.

Bearings must be fitted with efficient dust seals irrespective of the grease used. Bearings having FR grease are less tolerant to ingress of contaminants as debris becomes suspended in the clay abrading the moving parts.

Tests have been carried out that indicate:
- both FR and non FR grease lubricated bearings catch fire
- FR and non FR grease melt and exude from the bearings during failure
- exuded grease, and/or with flame present, dripped onto coal dust on the floor
- non FR grease ignited coal dust after several minutes
- FR grease did not ignite coal dust

### 7.11 Tracking

Tracking (alignment) of belting should be intrinsic within system design. It is essential to ensure design parameters are maintained and the risk of frictional ignition, due to belt rubbing, is negated.

Tracking the belt on a conveyor system is a process of adjusting idlers, pulleys and loading conditions in a manner which will correct any tendency of the belt to run other than centrally. The basic rule when tracking a conveyor belt is that the belt moves forward toward that end of the idler it contacts first.

When all portions of a belt run off line through a localised section of the conveyor length, the cause is most likely to be incorrect alignment or leveling of the conveyor structures, idlers or pulleys in that section.

If one or more lengths of belt run off line at all points along the conveyor, the cause is most likely to be within the section of the belt itself, for example the condition of the belt or its splices or loading.
When the belt is loaded off-centre, the centre of gravity of the load gravitates to the centre of the troughing idlers causing the belt to track away from the load as illustrated.

These basic indications help diagnose abnormal belt running conditions. Combinations of conditions sometimes produce events that do not appear obvious. Observations of the running pattern will help to determine the root causes.

All drums/pulleys should be level with their axis at 90° to the intended path of the belt. There are facilities to adjust these as wear takes place to maintain correct belt alignment.

Pulleys with their axes at other than 90° to the belt path will cause the belt to steer in the direction of the edge of the belt which first contacts the misaligned pulley. When pulleys are not horizontal the belt steers to the low side.
Belting can be tracked by adjusting the axis of the troughing idlers, altering the path of the belt. It is important to keep the troughing idlers in contact with the belt as illustrated. Additional proprietary tracking devices can be utilised to enhance and control belt alignment as a short term measure.

Conveyor correctly suspended and aligned
7.12 **Replacements**
Components should not remain in service beyond OEM wear and life parameters and continue to failure or destruction. Change out of time/life expired components and assemblies should be undertaken in a controlled and systematic manner.

Only OEM approved parts, or parts having the same specification, should be used to obviate unplanned failure of the system(s) that may generate increased fire risks and result in fire.

7.13 **Receiving sections**
Delivery chutes, belting and receiving sections should be designed, installed and maintained to ensure the safe transfer of mineral between parts of the system. All parts should have sufficient capacity to convey mineral without undue spillage, to reduce fire risks associated with excessive spillage of flammable products.

7.14 **Alarm handling and performance monitoring**
Alarm handling and performance monitoring should be undertaken by competent persons; they are two separate functions and priority has to be given to the safe operation of the system.

Alarms need to be clearly discernible above performance monitoring and include fire detection, fire prevention and other dangerous conditions.

All alarms generated by the system should be investigated, the source identified and remedial action taken by competent persons. Alarms must not be hidden or lost within other information generated by the system.

Monitoring should include:
- on-line data having suitable ranges to address the presence of low and high range readings
- visual
- audible
- examination/inspection
- statistical analysis
- fire detection systems
- environmental conditions
- abnormal conditions
- equipment performance data
8 INSPECTION, TESTING, EXAMINATION, MAINTENANCE

Planned, periodic and documented inspection, test, examination and maintenance schemes should be designed and implemented to prove risk controls are effective and the conveyor is maintained in a safe operational state.

A typical inspection, test, examination and maintenance scheme comprises:

- simple visual external inspections
- detailed comprehensive inspections and examination
- dismantling and testing of safety critical components
- continuous environmental monitoring
- fixed plant integral monitoring
- routine condition monitoring
- vibration analysis
- thermal imaging
- NDT
- pre-determined, planned component changes (life cycle)
- OEM recommendations
- conformity inspections and checks

Conveyor and infrastructure inspection, test, examination and maintenance schemes should be undertaken by trained and competent personnel.

Modifications, adjustments, planned component changes, defects and any remedial action should be recorded and documented in accordance with test, examination and documented maintenance schemes.

To ensure continued, safe and optimum performance of the conveyor the degree and frequency of maintenance should reflect the:

- operating environment
- specific operating conditions
- design life of conveyor
- mode of operation (manned/unmanned)
- operating life cycles
- duty
- loading effects
- physical conditions
- extraneous hazards (e.g. transport systems)
- high hazard areas of the system
Inspection, testing, examination and maintenance on conveyors should be carried out in accordance with the OEM technical publications.

8.1 Scheme for maintenance
A good scheme for maintenance may comprise:
- master schedule
- plant specification
- plant history
- examination sheets
- shift report sheets
- defect or action sheets
- temporary amendment to the scheme
- record of conformity/diagnostic tests
- record of statutory tests

8.2 Types of examinations
Types of examinations performed on conveyors typically mitigate high hazard risks, including fire, and are planned, undertaken, documented and recorded in accordance with the defined scheme.

8.3 Daily belt patrols
Visual and sensory daily belt patrol examinations are performed whilst the conveyor is operating; instructions and rules should detail suitable and sufficient control measures to obviate persons contacting dangerous moving parts.

To minimise the occurrence of fire particular attention should be given, inter alia, to:
- belt cleanliness
- conveyor belt slippage
- idler failures
- overloading idlers or rollers
- frictional heat from misalignment/belt rubbing
- mineral blockages causing belt rubbing/frictional heat
- worn gear box/drums/roller bearings
- brake drum shoes trailing
- transmission overheating
- electrical fault
- testing monitoring devices

To aid maintenance and defect reports and actions conveyor structure should be uniquely numbered for reference.
A conveyor daily patrol check sheet is illustrated: (this was developed under preceding legislation however the Check-Examination list is relevant).

<table>
<thead>
<tr>
<th>NAME OF CONVEYOR</th>
<th>DATE</th>
<th>SHIFT</th>
<th>DAY</th>
<th>Manriding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Check - Examination</th>
<th>IN ORDER</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Check condition and effectiveness of chute?</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(2) Is blocked chute device in position?</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(3) Are scrapers in position and working effectively?</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(4) Check tracking rollers if fitted.</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(5) Check delivery/job roller excessive noise and heat</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(6) Check job idler rollers: are rotating freely</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(7) Check job, drive &amp; loop for cleanliness</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(8) Check drive &amp; loop for excessive heat &amp; noise</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(9) Check job, drive &amp; loop guards: are in position</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(10) Are all nip guards: fitted and secure?</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(11) Is fire fighting equipment in order &amp; in position?</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(12) Are smoke detectors in position?</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(13) Is the belt alignment in order through the loop?</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(14) Check effectiveness of dust suppression equipment</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(15) Check belt alignment through box end</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(16) Check pleugh/wiper is in position &amp; effective</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(17) Check return end for spillage</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(18) Check return end roller for excessive heat, noise &amp; vibration</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(19) Check idler &amp; return rollers: for excessive heat &amp; noise</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(20) Check any mid position receiving section for spillage</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(21) Are there adequate cleaning tools available</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(22) Check and record number of spare rollers: on site</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(23) Check for spare oil at drive area</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(24) Check general condition of belting</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(25) Check general condition of joints</td>
<td>YES/NO</td>
<td></td>
</tr>
</tbody>
</table>

**MANRIDING CONVEYORS ONLY**

<table>
<thead>
<tr>
<th>Check</th>
<th>IN ORDER</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(26) Check safety gate is in position.</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(27) Check that the belt is free from holes, thin &amp; other damage that could present danger to persons riding</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(28) Check all joints: appear visibly in good condition</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>(29) Check that the structure of boarding &amp; aligning platform: are free from all defects and obstructions: (including steps and handrails)</td>
<td>YES/NO</td>
<td></td>
</tr>
</tbody>
</table>
8.4 **Craftsmen/technician examinations**

Detailed and rigorous prescribed examinations are carried out in accordance with the inspection, test, examination and maintenance scheme by appointed persons to minimise fire risks and typically include:

- lubrication levels and oil analysis
- bearings, drive shafts, gears and couplings
- vibration analysis
- alignment checks
- performance and diagnostics
• temperature devices
• environmental monitors
• belt protection devices
• belt condition
• brakes and sprag clutches (anti run-back devices)
• scraper adjustment

8.5 Supervisory official’s examinations
In addition to daily belt patrol examinations mine operators should appoint suitable people to undertake a thorough examination of conveyors to obviate the risk of fire. Additional examinations are required after conveyors have been stopped to ensure any latent event is detected.

The length of the conveyor, high hazard areas and number of persons being supervised will determine the resource allocated to ensure these examinations are practicable. Daily belt patrols may be undertaken by officials to avoid duplication.

One method to calculate the parameters and constraints of official’s examinations, taking into account other assigned responsibilities is shown in the formulae below:

The Empirical formula is

\[ L + \frac{HRA \times d}{S} = X \]

Where

- **L** is the length of conveyors to be examined in meters
- **S** is the average speed of examination based on a timed study in meters per minute
- **HRA** is the number of high-risk areas (i.e. jib, drive, loop, tripper, receiving section, return end, airlocks, dint areas etc) (NB drive and loop are to be classed as separate high-risk areas)
- **d** is the average time taken to examine high-risk areas
- **X** is the total time to carry out belt inspection duties by an official for the conveyors in his zone.
8.6 **Safety representatives’ examinations**
Appropriate safety representatives should be trained and competent to undertake periodic examinations of conveyors to determine they are operating safely and that risks from fire and other hazards are adequately controlled. Safety representatives should interact between the workforce and managers to identify deficiencies or departures from instructions or agreed standards and communicate these for appropriate action.

8.7 **Functional/engineering supervisor’s examinations**
Over inspections should be undertaken by supervisors to ensure that the routine inspection programmes are carried out and are adequate to control fire risks.

8.8 **Management audits**
Mine operators should periodically undertake detailed, planned audits to ensure compliance with their instructions and procedures, challenge any deviations or departures and anticipate and mitigate the cause and effect of unplanned events and practices.

8.9 **Incident investigations**
Investigation of incidents or unplanned events should be undertaken promptly and thoroughly to:
- control hazards emanating from the event
- determine root cause
- review and update processes, procedures and design parameters as necessary
- publicise the circumstances, findings, outcomes and resolutions
- minimise the likelihood of repetition.

9 **FIRE DETECTION & ALARMS**
Rapid, accurate detection of any potential incident of fire on underground conveyors is paramount in ensuring the safety of the personnel, plant and mine and may be achieved by several means.

9.1 **Temperature monitoring**
The temperature at critical points on machinery and equipment should be assessed and continuously monitored to ensure that OEM parameters for the safe use of the machinery are adhered to and the risk of fire is minimised.

Conveyors should be monitored for both temperature and the outbreak of fire, particularly at areas of high fire risk such as drives, loops, jibs and return ends.
Thermal monitoring using infrared devices (thermal imaging) of e.g. idlers may identify rising temperatures and potential fire. Examples are shown.

Bottom idler bearing collapse  Gearbox radiant heat

Temperature monitoring in normal operating conditions
Belt edge temperature raised due to rubbing structure

Various types of temperature monitors are available and careful selection of devices for the environment and operating conditions should be carried out to identify most appropriate instruments. Environmental monitoring and temperature monitoring systems should be regularly calibrated and tested.

Examples of temperature monitors typically include:
- digital probes and transducers
- surface contact (external temperature devices)
- insertion type probes
- analogue devices (incremental temp indication)
- thermometers
- infrared monitors

Temperature monitoring should typically be fitted to the following:
- jib drums
- fines conveyor
  - gearbox
  - motor
  - bearings
- drive/tripper units
  - gearbox
  - motor
  - sprag clutches
  - drums
  - deflectors
  - braking devices
  - power packs
  - cooling systems
  - lubrication systems
  - transmissions
• loop take up units
  o drums
  o gearboxes
  o motors
  o power packs
  o variable speed drives
• maintenance stations
• receiving sections

A defined safe operating envelope for each sensor is specified by OEMs. Temperature monitoring systems should have warning and alarm levels appropriately set and should automatically trip equipment when necessary.

9.2 Types of temperature monitoring
Direct contact monitoring of definitive areas of a machine, such as a bearing, can be achieved via specific drilled points, or the grease way, by utilising purpose designed temperature probe devices (temperature pockets). Direct contact devices accurately indicate operating temperatures at given points.
whereas surface contact monitoring devices indicate local surface temperatures only.

Analogue monitoring devices incrementally indicate temperature measurements, facilitate a trend analysis of the operating range of normal conditions and configuration of predetermined temperature alarm and trip levels.

Analogue monitoring should be used in preference to digital state indication of fixed temperature levels; a number of digital monitors are required to provide the same level of protection.

Temperature alarms should be set at a practicable level above the normal operating conditions to eliminate spurious indications. Trip levels should be set to mitigate the risk of fire from excessive temperature.

Hydrokinetic transmission systems typically incorporate fusible plugs as thermal protection devices to prevent any risk from transmission fluid fire resulting from overload, misalignment or component failure.

9.3 Fire detection & environmental monitoring

Various types of fire detection and environmental monitoring systems and monitors are available. Careful selection of devices for the environment and operating conditions should be carried out to identify the most appropriate methods. Fire detection and environmental monitoring systems should be regularly calibrated and tested.

Examples of fire detectors typically include:
- Carbon Monoxide (CO) detectors
- Products of combustion (POC) detectors
- smoke particle detectors
- fume sensors (e.g. Fire Detection Sensor & Carbon Monoxide – FIDESCO)
- volatile organic compounds (VOC)

Monitoring and detection systems should be able to effectively detect the presence of products of combustion during the early stages of any fire and trigger an alarm.

Fires on conveyors have the potential to produce copious amounts of smoke and/or toxic fumes. Monitoring and detection systems should be sited at suitable locations along a conveyor to ensure any product of combustion is detected promptly.
Products of combustion and/or CO transducers should be installed, and positioned with regard to airflow, to detect fires at the following positions:

• drive units
• return ends
• remote loop and tensioning devices
• transfer points
• ancillary equipment (fines conveyors)

Advice on fire detection and the positioning and installation of transducers is contained in the document “Guidance Notes: Underground fire detection equipment: Selection, installation, use and maintenance”.

Fire detection and environmental monitoring systems should be independent and separate to the conveyor operating system. Any alarm generated should be transmitted immediately to the designated command or control point to elicit the appropriate reactive response.

Cognisance should be given to the selection of instruments for detection and environmental monitoring systems with regard to their limitations in use, for example:

• POC detectors may be sensitive to a range of contaminants present in the general body of mine air and may not work reliably, for example in return airways, or in fluctuating temperatures and pressures.

• smoke detectors may be unsuitable for use in high velocity airstreams.

• advice should be sought from OEMs where the suitability of any particular detector or monitor, for a specific application, is in doubt.

• Examination, calibration, testing and maintenance of the instruments/equipment should not be compromised by the installation conditions and locations.

• Electrical transducers, suitably positioned, provide instantaneous information readings at the detector and remotely, enabling data trending at particular locations.

• Infrared heat sensors (thermal imaging) provide an instantaneous indication of the concentration of heat generation at particular points. Portable sensors are
typically deployed periodically, dependant on the applications, to ascertain temperature status. Fixed sensors continuously monitor specific high-risk conveyor areas.

9.4 **Alarm systems**
Alarm systems should be designed to provide immediate warning of any change in temperature, environmental condition and/or products of combustion that may indicate a risk of fire.

9.5 **Alarm levels**
Appropriate alarm trigger levels are essential for effective monitoring and warning against the onset of fire.

Trigger levels should be set by trained, competent persons and be assessed, prioritised and re-evaluated following any change in conditions or circumstances.

Individual transducers’ setting levels should be recorded in the planned preventative maintenance scheme and should not be changed without prior authorisation.

10 **FIRE FIGHTING PROVISIONS**
A Fire Risk Assessment (FRA) will determine the types and locations of fire fighting equipment appropriate to the installation, environment and hazards therein.

Fire fighting equipment should be clearly visible, inspected, tested and examined periodically, its position readily accessible and indicated with reflective signage.