

## Fire-protection guidelines for: Conveyors transporting coal

Conveyor systems in general have a fire risk due to external events and equipment failure. However the flammable nature of coal including the ability of some types to self ignite introduces an exceptional hazard requiring special consideration.

Recognizing this, Patol Limited has recommended a set of practices for safely preventing, detecting, and extinguishing fires on coal conveyors.

**P**atol Limited has developed recommended fire prevention practices and guidelines for conveyor systems that transport coal.

The guidelines defined here are not equipment specific, and are limited to conveyor belt transport mechanisms. Physical layouts of coal-handling plants vary significantly and considerations of storage in bunkers and silos is addressed in a separate document.

The guidelines are not comprehensive as their purpose is to recommend the general practices necessary rather than comprise a detailed operating procedure or engineering specification.

The guidelines provide information about two principal areas:

- ◆ Fire prevention
- ◆ Automatic fire detection & suppression

### FIRE PREVENTION

Some types of coal have the ability to self combust under certain conditions. One of the worst of these is Powder River Basin (PRB) coal which can self ignite even in very small quantities and in very short time periods.

Even with less volatile coal types measures that reduce the possibility of fire occurrence are by far the most economic.

Expenditure on both 'preventative design' and 'additional operational procedures' provides the most effective use of financial resource.

These actions can be considered to be '**Good Housekeeping**'.



**Housekeeping** means limiting dust accumulation, preventing spills and conducting effective regular clean up.

For example, float dust should be contained within transfer points, and spillage from belts must be minimized.

Conveyors should never be stopped and allowed to stand with an undischarged load for an extended period.

The accumulation of coal below a conveyor provides fire fuel and can even result in spontaneous ignition.

Float dust either in the air or settled on static fixtures can in certain circumstances form part of the fuel mix for explosions.

Routine 'clean up' activity should form part of the Plant Operating Procedure.

As a minimum dust and spillage built up around rollers and bearings must be removed to prevent ignition from stalled hot rollers.

For volatile coals such as PRB, daily wash-down of conveyor housings and transfer towers is recommended.

Fixed wash-down systems, designed for 100% coverage, are commercially

available and when installed provide greatly reduced labour costs.

For optimum results these piped installations should be combined with Automatic Fire Suppression / Extinguishing Media.

Plants that have installed this form of integrated Fire & Cleansing hydraulic water-spray system, and operate it on a daily basis, report being satisfied with the performance.



**Coal accumulation at a conveyor tail**



**FIRE DETECTION**

Despite the most stringent measures to prevent fires, even the best managed sites can experience fire events from time to time.

The faster that these are detected and addressed (extinguished) the lesser will be the cost due to plant damage and down time.

A fire condition within a conveyor system may be considered to be :-

- ◆ A "static" fire - On a stationary conveyor belt, or within the conveyor mechanism / housing.
- ◆ A "moving" hazard - Hot or burning coal imported onto a traveling conveyor belt.

It has been established that each of the above requires a different form of fire detection to provide a reliable fast responding and trouble free system.

It is the object of this guideline note to indicate general solutions. However, it should be emphasized that any specific installation/site/plant must be addressed individually in order to obtain the correctly engineered system.

**Static Conveyor Fire**

In the conveyor structure any coal which falls from the moving belt, or an accumulation of settled coal dust, is a potential hazard.

A mechanical fault in the bearing of a roller, or the friction between a seized roller and the belt, will result in a build up of heat which can be sufficient to ignite the belt, when the belt stops, on its own.

The introduction of coal makes a fire highly probable.

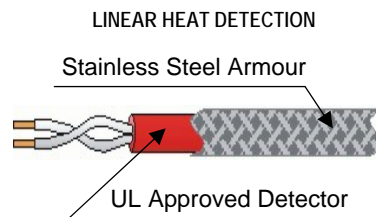


Many different types of fire detector have been tried for conveyors. These attempts, some going back many years, include:-

- ◆ Collective reflectors (thermo-couple hoods)
- ◆ Ionization & optical point smoke detectors
- ◆ Point Heat Detectors
- ◆ Point Flame Detectors
- ◆ Obscuration detectors employing infra-red beams
- ◆ Pneumatic detectors with fusible bulbs

In every case, experience has shown that these devices are either unsuited to the environment producing unwanted alarms due to dust or fog, or are so insensitive that a fire can propagate and cover many metres of the length of the static conveyor before they are operated.

The true solution has been determined to be Linear Heat Detection. (LHD)



Typical arrangement for *Electrical - Digital* LHD

**LHD** takes a number of forms, the three principal ones being :-

- ◆ Electrical - Analogue
- ◆ Electrical - Digital
- ◆ Optical - Analogue

In all of these cases the LHD comprises a robust 'Cable' that will 'Annunciate' an alarm if any portion of the LHD experiences an abnormal temperature.

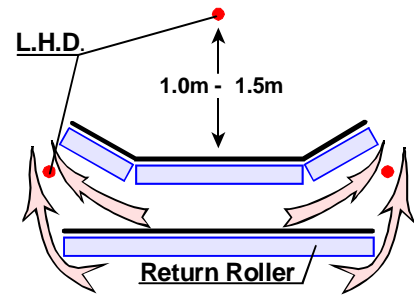
Being a sealed 'Cable/Wire' the LHD is not prone to the water & dust problems that cause conventional smoke / heat / beam detectors to be ineffective in the rigorous environment of a coal conveyor housing/enclosure.

Whilst each supplier of LHD will have their own recommendations regarding location and mounting of the detector, all types respond to heat. Tests have been carried out to determine the optimum location for the LHD.

To protect the upper side of the conveyor itself a detector "run" should be installed above the centre of the belt

at a height of 1.0m to 1.5m (3ft-5ft). Normally this is achieved by the use of a steel catenary support wire to which the LHD is affixed .

Ideally LHD "runs" should also be sited at the conveyor sides such as to detect fire heated air 'spilling' upwards around the belt edges from events occurring on the underside. The detector is mounted above the return roller (belt) on each side.



**Cross section of conveyor.**

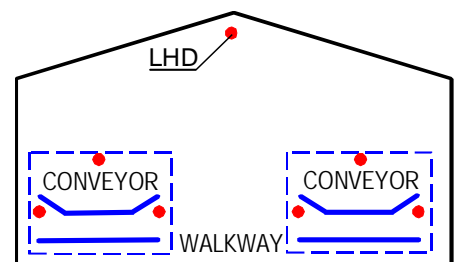
However, experience has shown LHD when installed in this location can be prone to damage from rigorous cleaning regimes and maintenance activity such as roller changes.

Each specific conveyor arrangement must be considered in order to determine the optimum mounting method. The mechanical arrangement of some conveyor truss work can provide a suitable mounting without further protection such as slotted steel trunking or LHDC Armour.

The LHD must always be mounted (by clips or spacers) such as to be in the air flow. It must not be directly mounted to steelwork which would act as a heat sink and retard response.

In some cases, especially with knowledge of site operating procedures, it may be deemed that LHD side runs are not practical.

Enclosed conveyors should have extra detection at ceiling height to detect PRB dust ignition on cable trays, pipes etc located above the conveyors. With a pitched roof enclosure LHD should be located near the apex.



**Cross section of dual conveyor housing**



LHD & Catenary Wire Support  
 Courtesy : Patol Limited.

**Fire Zoning & Extinguishing**

The design of the fire detection system must take into account the level of alarm definition required to provide personnel with adequate indication of event location.

Some LHD equipment types provide ‘Distance Monitoring & Display’ units which indicate the exact length into the LHD installation that the initiating ‘fire event’ has occurred.

Normally each conveyor is sub-divided into fire zones. Automatic initiation of Water Spray extinguishing by the LHD (if this has been implemented) is likely to be the defining factor regarding zone size due to :-

- ◆ Hydraulic limitations related to water delivery. (Pump & pipe sizing)
- ◆ The nature and efficiency of the water spray delivery.
- ◆ Consideration of the “clean up” activity needed after a conveyor loaded with coal has been deluged. Coal slurry handling problems must be minimized.

**Response Tests - Suppression**

As an indication of relative performance between water spray operation that is initiated solely by self activating sprinklers, and that electrically initiated from LHD, tests have shown :-

LHD located above a conveyor at 1.0m (3ft) height responded within 2 minutes to a small coal fire with a surface area of approx. 0.1 sq m. (1 sq ft)

A conventional sprinkler bulb took over 12 minutes to respond.

When combined with an "electrically actuated" sprinkler system, LHD provides the optimum rapid response protection system.

It must be appreciated that LHD is only recommended for detecting fires on a stationary conveyor belt or within the housing.

Fires on belts, which can be moving at up to 6m/s (20ft/s), can not transfer sufficient heat energy during the rapid transit to make LHD effective. (see following)

**Imported Fires On Moving Belts**

A number of years ago research was conducted such as to find the ideal "moving" belt fire detector. This being undertaken when it became obvious that systems existing at that time, employing thermocouples and heat detectors in “heat collecting hoods” were unable to detect anything other than a very large fire.

The reason why these methods can not detect small fires moving at speeds of up to 6m/s (20ft/s) is that they rely upon convected and radiated heat. Insufficient heat energy can be transferred, even to the very low thermal mass of the thermocouples, to produce reliable results.

The solution is to monitor for infra-red “black body” emissions, as opposed to imparted thermal changes.

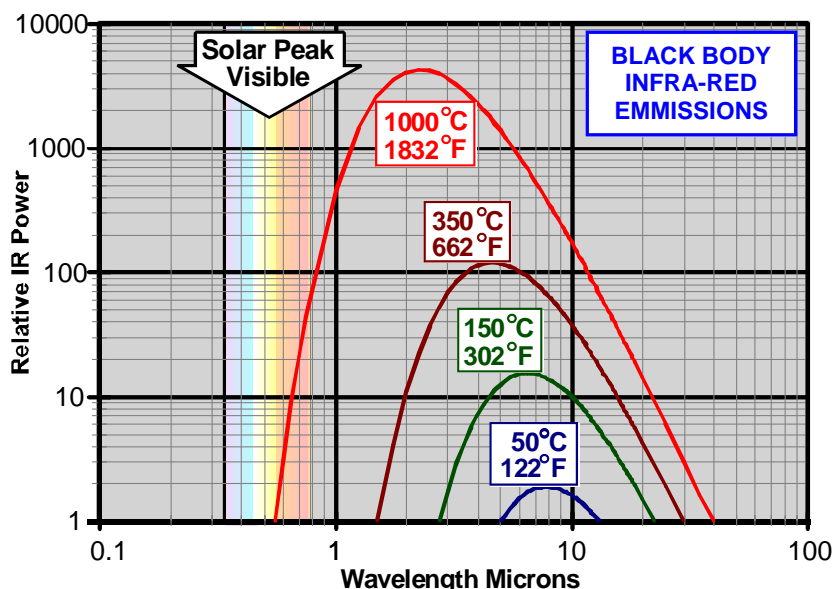
Infra-red emissions occur for all materials. The wave length spectrum and intensity of this IR depends on the material’s temperature, and for solid bodies such as coal is determined by the Laws of Physics formulated by Planck, Stefan, Boltzmann & Wien.

Planck’s Law defines the spectrum and level of IR emissions for a ‘black body’ at any given temperature.

A great variety of infra-red detectors are available for fire protection. However, whilst all do monitor for ‘infra-red’ emissions they have very different uses and operational performances. It is essential that the correct type is employed.

Infra-red monitors fall into four principal categories :-

- ◆ Thermal Imaging Systems  
 This equipment employs an infra-red camera and produces a thermal image (photograph) which may be either directly observed or computer analysed for anomalies. Thermal imaging is a very useful tool for monitoring static bunkers and silos; however, it is not usually practical for conveyors, as imaging scan times are too slow for fast moving belts.
- ◆ Spark Detectors  
 These are designed to detect sparks and very small visibly glowing embers. These types monitor for short IR wave lengths that are at or near the solar band and are mainly intended for installation in ducts where there is a zero level of ambient lighting. These types are not solar blind and the IR filters (e.g. 0.4 to 1.6 microns) do not permit detection of IR emissions from relatively low temperature abnormalities such as pre-ignited coal.
- ◆ Flame Detectors  
 Many of these types monitor for the peak IR emissions, associated with specific gases, that occur during combustion. These emission spectra are not the same as for “black body”





radiators as defined by Planck. E.g. for CO<sub>2</sub> formation a peak occurs at 4.3 microns which may be compared with specific narrow bands where little emission occurs. Other types filter shorter wavelengths, similar to spark detectors (e.g. 0.7 to 2.7 microns), and apply analysis to detect “flame flicker”. These techniques monitor for volatile fluids and gases after “flash point” and are not suited for close range monitoring of moving bulk materials such as coal when on conveyor belts.

◆ **IR Black Body Emission Detectors**  
 These employ IR filters that select longer wavelengths and are “blind” to the visible spectrum. They can detect both the high energy emissions from very hot / glowing embers, and those from abnormal but relatively low temperature bulk coal transiting the monitored belt area.  
**It is this type of detector that is best suited to Coal Conveyor monitoring.**



**5011 Black Body IR Sensor  
 Conveyor Fire & Heat Detector  
 Patol Limited - Reading UK**

**Response Summary**

Coal is a good thermal insulator and therefore buried hot/burning coals will raise the belt load surface temperature by a relatively small amount. Similarly, coal in its pre-ignition cycle has an abnormal but relatively low temperature.

Whilst some detectors may be able to respond to *burning* coal (550°C to 1000°C / 1000°F to 1800°F), the correct type of black body monitor will also respond to an abnormal but non-ignited conveyor load (100°C to 200°C / 200°F to 400°F). Spark, Ember & Flame detectors will not respond to the latter condition.

Detectors must be blind to “visible radiation” from both local illumination units and reflected sun light.

It is not a requirement that detectors should be immune from being directly pointed at the Sun; it being a massive IR energy source.

Obviously the detector should anyway be directed at the conveyor for best performance. (See following)

**Installation Performance**

The Detector when mounted above the conveyor at a height of between 1.0 and 1.5 metres (3ft - 5ft), should be able to cover the full width of the belt with its optical system.

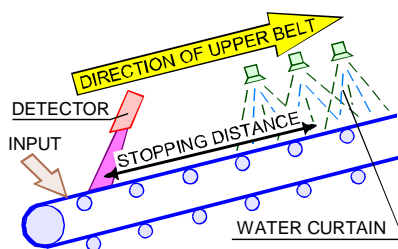
The response of the detector depends upon the size and surface temperature of the object. Typically an alarm must be given if an object of area 0.025 sq m (40 sq inches) at a temperature of 140°C to 190°C (280°F to 380°F) passes beneath the detector at a speed of up to 6m/s (20 ft/s).

The system must also detect glowing coals of 30mm diameter (1 sq inch in area) and less.

**Detector Location**

The infrared detector should be mounted at the loading end of each conveyor such that on detecting a fire the belt could be stopped:-

- ◆ Where the fire would be within a water spray deluge curtain.
- ◆ Before the conveyor can discharge the fire to another belt or silo, etc.



The Infra-red Detector is configured to automatically stop the conveyor and raise an alarm.

At this stage the water spray can be initiated :-

- ◆ Automatically by the IR Detector.
- ◆ Manually, after an operator has observed the belt.
- ◆ Automatically after a time delay, if not overridden by the operator.
- ◆ Automatically by LHD detection.



**Typical Control Equipment  
 Series 5000 Monitors and PSU  
 Patol Limited - Reading UK**

As these “stop zones” will be remote from the coal plant control room, they could be monitored by CCTV cameras.\*

\* If it is opted to always automatically initiate water spray from the IR Detection equipment then CCTV is unnecessary.

In addition to the arrangements described above for belt “loading” points, an IR Detector should be installed just prior to the conveyor system discharge to silos or hoppers.

The detector must be located sufficient distance back from conveyor end in order to be able stop the detected “hazard” within a water spray zone and before discharge of the belt.

In the case of very long conveyors due consideration should be taken of the fact that abnormal heat can be aided to develop into ignition by the movement of the coal in air and therefore it may be prudent to install additional intermediate IR detection units.

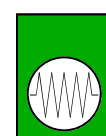
**Special Considerations**

Coal conveyor tunnels and housings are an extremely dusty environment. IR Detectors employed must accommodate “air cleansing” for optical lenses.

The same consideration applies to CCTV cameras and there will be an economy in sharing a clean air supply.

All equipment must be able to withstand the rigors of “housekeeping hose-down” arrangements.

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