Hot Spots®

WHITE PAPER

COOL MINE

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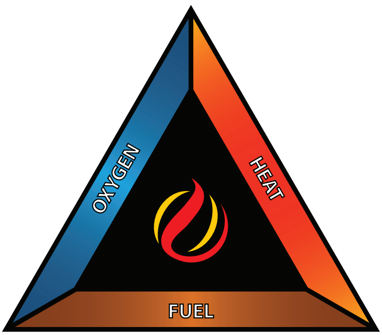
The Safety Aspect

One of the more common causes of heating and potential ignition sources leading to fires in Underground Coal and Mineral Mines, is the frictional overheating of conveyor idlers / rollers internal bearings that are in the process of, or have failed in service.

A multitude of risks to the safety of people arise from fires in an underground mining environment, such as, but not limited to –

- Initiation of a gas or flammable dust explosion.
- A fire that hinders emergency escape, by impairing visibility due to smoke or loss of a respirable atmosphere.
- Asphyxiation or poisoning of persons.
- Heat stress or stroke.
- Risk to the mine ventilation system.

With these idlers / rollers constantly being in the presence of fuel sources such as accumulations of coal spillage and dust, other flammable dusts, flammable gas, accumulated lubricants or accumulations of combustible material (belt fabric, rags, paper, wood), the strict management of the potential heat source is not only paramount, but a legislated obligation to negate the unintended initiation of fires and or explosions.



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Control measures that are risk ranked manage this identified hazard, yet recurrently fail. The primary control used to manage this potential ignition source is regular monitoring. This takes place in the form of suitably qualified and competent mine workers, maintenance personal and Statutory Officials carrying out specific periodic visual inspections along the conveyance system, ensuring varying levels of site and legislative compliance is maintained. Such inspections cover but are not limited to –

- Areas of material spillage at transfer chutes and along the conveyor
- Areas of conveyor belt rubbing on a fixed object
- Seized or failed conveyor idlers or pulleys
- Presence of heating
- Unusual noise or smell

With reference to a host of both State and Australian legislative requirements, in managing and mitigating risks for both the health and safety, associated with the operation of conveyor belts in a mine, one of the foremost considerations is given to the competent inspection of the system, to detect and act on any overheating, smouldering or any other condition likely to cause fire. To add further guidance to these requirements, it is also legislated that the maximum allowable surface temperatures in an Underground Coal Mine is <150°Celsius. Further reference can be made in the below industry legislated documents –

- **QLD Coal Mining Health and Safety Act 1999**
- **QLD Coal Mining Health and Safety Regulation 2017**
- **NSW Work Health and Safely (Mines) Regulation 2017**
- **NSW Code of Practice Mechanical Engineering Control Plan (Mines)**
- **MDG-1032 Guideline for the prevention and early detection and suppression of fires in coal mines.**
- **AS/NZS Standards 4024.3611 Conveyors-Belt Conveyors for Bulk Material Handling** - Section 5.2 Idler Management and Appendix A - A1 Fire or Explosions. (Relevant to all mining sectors).

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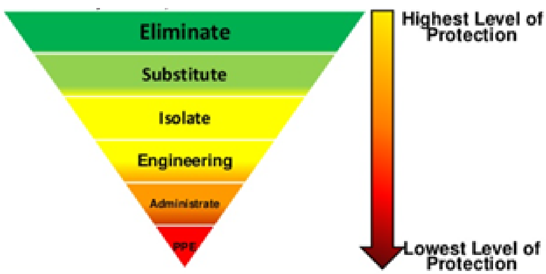
KEY TERMS

POTENTIAL FIRE HAZARD - is the interaction of a fuel source and an ignition (heat) source in an oxygen rich environment.

HAZARD **–** A danger of risk.

RISK – Arising from a hazard – Consequence and Likelihood.

Australian Mining Legislations state in words to the effect, that Fire Risk Management in mines shall have control measures which ***effectively*** manage identified risks. The Hierarchy of Controls is a method in which we can limit or eliminate exposure to hazards to help control the risks being realised.



(Thepinsta.com, 2018)

Question - *What happens when the primary Hazard Control Measure in the Hierarchy of Controls is Administrative, being regular inspections, and the expectation of that control is that it only becomes real when the* ***hazard has realised into a risk being a "hot roller"?***

Answer – *The hazard control* ***(inspection)*** *has failed to stop the hazard becoming a risk.*

Such is the paradox of "hot idler / roller" identification on bulk material handling conveyor inspections, that use regular inspections as the primary tool to manage the hazard becoming an incident, without any means to determine if the hazard has begun to escalate into the risk.

You can't *PREDICT* what you can't *DETECT.*

Hazard Management *before* **Incident Response.**

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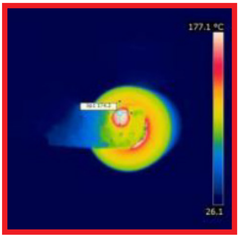
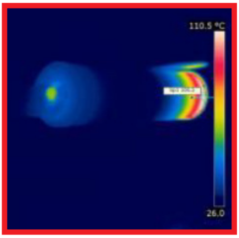
CURRENT APPROACH TO MANAGING FIRE RISK FROM CONVEYOR IDLERS / ROLLERS

1. **Established Identity of the Hazard** – Conveyor idler / roller / pulley bearings. Mechanical components known and expected to fail in service, with an output of excessive frictional heating.
2. **Managing the Hazard** – Regular physical inspections for signs of heating. Sight, smell and sound.
3. **Control Effectiveness** – ***Ineffective.*** If there are signs of heating, then the hazard has already turned into a risk. You are now managing a risk that has variable ***Likelihoods of Consequence*** and will invariably introduce people to additional operational hazards during the control of the risk or incident, being an overheating (≥150°C), smouldering and or fire.



Heat at bearing and shaft end 177°C



Heat seen being transferred to the opposite end of the 110°C failing bearing through the idler shaft indicating approximately 60°C.

Without the aid of continual thermal imaging, fibre optic monitoring or telemetry from electronic smart idlers, early stage overheating's and or failing idler bearings, are being walked past during inspections, unknown to the persons completing the statutory inspections.

If a more accurate and detailed account of events were to be recorded and analysed with regards to reported "hot rollers" in Underground Coal Mines, it would be quickly noted that when the events are being flagged, that the said idlers have already surpassed the maximum allowable surface temperature of <150°C as legislated in both the QLD and NSW Coal Mine Health and Safety Regulations, MDG-1032 Guideline for the prevention and early detection and suppression of fires in coal mines and various other national Codes of Practice.

THE HOT SPOTS® APPROACH

Hot Spots® are intended as a single use disposable first warning indicator system, to assist in the early detection of conveyor mechanical components such as idlers, succumbing to frictional heating in an underground mining environment, leading to an unacceptable risk.

With visual inspections being one of the major recognised controls for the detection of overheating, smouldering's and fires in the mining workplace, **H ot Spots®** assist those undertaking the

inspections discharge their obligations and duties effectively, by recognising an *elevated hazard* **before** becoming an *unacceptable risk*. The **Hot Spots®** concept is easily adapted and added to a mines Safety Health Management System as part of Inspection Plans, Management / Hazard / Control Plans, Critical Control Monitoring Activities, Mechanical Engineering Control Plans and other critical Risk Management documents.

The concept of **Hot Spots®** is to give a ***S****imple* – ***A****ffordable* – ***F****unctional* – ***E****ffective* resource in which to empower persons completing inspections and maintenance on conveyor belts, enabling consistent and practical decisions, based on a visual repeatable engineered solution.

The majority of 'hot rollers" detected during inspections is either from noise or smell. At the advanced stages of failure, visual signs of a reddish oxidised powder on the roller shaft and or immediate structure (+200°C), smoke and or fire is likely and not uncommon. It is widely accepted that – ***'People carrying out inspections should be aware of the role one's senses play in discovering fires.' (MDG 1032 – 2.5.2.1 i)***.

(Resourcesandenergy.nsw.gov.au, 2018)

Hot Spots® give first visual indications of a failing bearing prior to the oxidisation, smoke or fire. The single spot **Hot Spots®** activate at **≥90°C** and the two spot **Hot Spots®** first visual indication at **≥60°C** and second final warning at **≥100°C. The Hot Spots®** ***predict to prevent approach,*** allows for a proactive resilient inspection scheme, over a reactive inspection structure tolerating non-compliances to legislative and principled obligations.

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Orange spot activated at ≥60°C
Bearing starting to fail.
Hot to touch, not detectable
by sight or smell.

2 White spots,
Condition
Normal

Red spot activated at ≥100°C
Bearing failure assured.
Not detectable by sight,
may have slight smell.

1 White spot,
Less than 90°C

Red spot activated at >90°C
Elevated temperature.

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Figure 1 Fire Risk Management Process

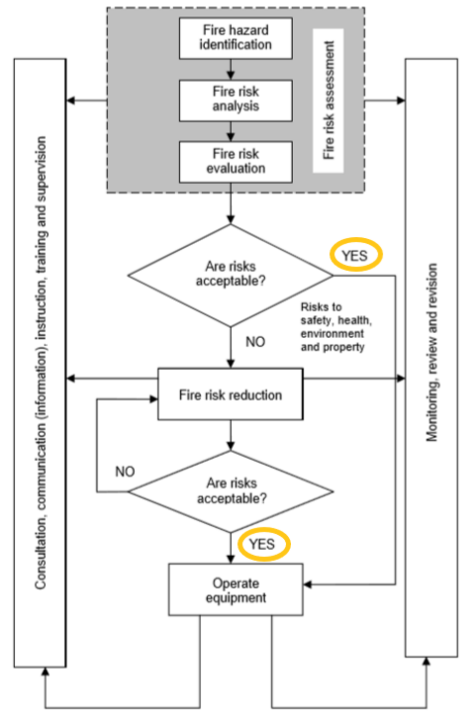

Figure 1 - Fire risk management process

(Resourcesandenergy.nsw.gov.au, 2018)

Extract from MDG 1032 Guideline for the prevention, early detection and suppression of fires in coal mines.

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With respect to the **Figure 1** extract from MDG 1032 - Guideline for the prevention, early detection and suppression of fires in coal mines, the daily industry occurrences and reports of "hot rollers" giving way to exceedances of surface temperatures of ≥150°C, beckons the question when we reach the flowchart diamond " Are Risks Acceptable?", how can we say "YES" without any further controls or strengthening of the current control, being regular inspections?

Unknowingly, complacency slips into the way we do business.

Hot Spots® purpose is to be the link in **Figure 1**, for the confident transition from ***"Are Risks Acceptable" → "Operate Equipment"*** stage of the flow chart, by enabling the inspections to recognise and respond to an elevated hazard rather than a realised risk of a hot idler

With consideration to **Figure 3 below**, Fire Risk Reduction Measures extracted from MDG1032 guideline for the prevention, early detection and suppression of fires in coal mines, the **Hot Spots®** aim to assist in the minimising risk of the fire initiation through –

1. DESIGN

- **Operator Warning Systems.** Clear visual representation of an escalating hazard before turning into an unacceptable risk.

2. ADMINISTRATIVE CONTROLS

- **Maintenance.** Allow maintenance inspections to be clear on the condition and priority of idlers to be changed during scheduled maintenance or for immediate rectification. Enable both maintenance personnel and Statutory Officials to make mutual decisions and conclusions based on common findings.
- **Competent People.** Ensure competent coal mine workers, maintenance personnel and Statutory Officials completing inspections have the systems and tools to make confident and informed decisions.
- **Safe Work Procedures.** Give risk management documents credibility with systems that allow for accurate and informed decision making, not generic controls that offer only speculation of opinion when trying to determine the thermal state of a conveyor idler.
- **Regulations.** Allow for proactive, resilient compliance to Fire Risk Management from the threat of an ignition source from an overheated conveyor idler. Maintain resilient compliance to the legislated maximum allowable surface temperature of <150°C.
- **Audit.** Audit and inspection of conveyor idler compliance and safety with greater confidence. Document and review the data gained from the activation of Hot Spots™ to better understand the true reliability and compliance of your conveyance system.

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Figure 3 - Fire Risk Reduction Measures

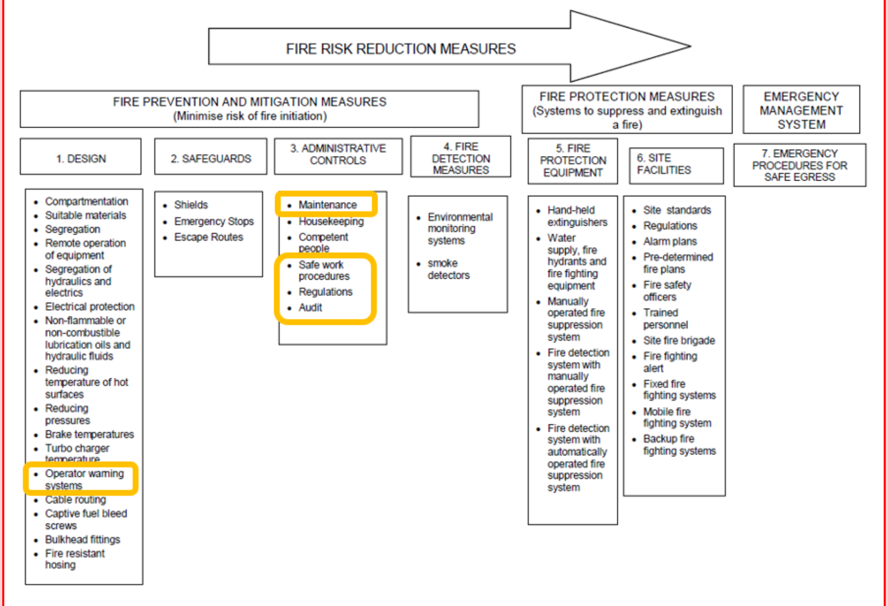

Figure 3 - Fire risk reduction measures

(Resourcesandenergy.nsw.gov.au, 2018)

Extract from MDG 1032 guideline for the prevention, early detection and suppression of fires in Coal Mines.

The Production Aspect

The Hot Spots® *predict to prevent approach* has the benefit of a **value proposition** that whilst focusing and improving mine safety, the flow on effect is a positive effect on conveyor uptime, improving production availability.

Most high performing mining operations utilising belt conveyance systems for the transportation of bulk materials, have a reliance on the high availability of their conveyors. Unscheduled downtime on the conveyance systems can cost operations in the range of $100,000 - $500,000 AUD per hour.

Unplanned downtime of a conveyor is generally attributed to the belting or rotating components such as idlers, rollers and pulleys. Often the failure or damage to the belting is a direct result of failed, damaged or seized idlers, leading to belt tracking and rubbing into structure and or belt sliced or shredded, post bearing failure from worn through idler casings as per below right.

(Resourcesandenergy.nsw.gov.au, 2018)

Condition monitoring is common place for conveyor belting, pulleys and drives, however due to the large volume (in excess of 8000 idlers/KM) of idlers on a standard bulk materials handling conveyance system, the wide-ranging distances covered, scale of infrastructure required to support an automated real time monitoring system and large cost of installing and maintaining such a system, the number one cause for concern with matters of health, safety and reliability of a conveyance system being its rolling mass of idlers, goes largely without an effective predictive or preventive maintenance strategy.

The Hot Spots™ prediction and early detection of deteriorating idler bearings, aids in greatly improving the reliability and availability of the conveyance system by –

- Allowing the replacement of the idler pre-failure in a scheduled manner.
- Allowing informed decisions based on a repeatable engineered solution.
- Allowing decisions to "run to maintenance" or "drop the idler out" based on a visual tell tail.
- Allowing maintenance personal and idler change out crews target the correct idlers with greater confidence on maintenance days, adding to the efficiency and effectiveness of the maintenance strategy, converting into operational uptime.
- Allowing for informed planning of resources during maintenance periods.
- Reduce the opportunity for the idlers to have a damaging influence on the conveyor belting.
- Reduce the opportunity for the idlers to enter a state of being a potential ignition source.
- Mining workers confidence in the process and systems keeping them safe.

Typically, the **theoretical** life cycle of a conveyor systems installed standard idlers can be assessed with the below bathtub curve. The life cycle can be categorised into three stages –

1. **Early life.**
2. **Useful life.**
3. **Wear out period.**

Unfortunately, the complexity and working environments of bulk conveyance systems do not allow such a predictable life cycle of such systems installed idler rolling masses, as it would on a uniform component installed in multitude, in identical working environments and conditions.

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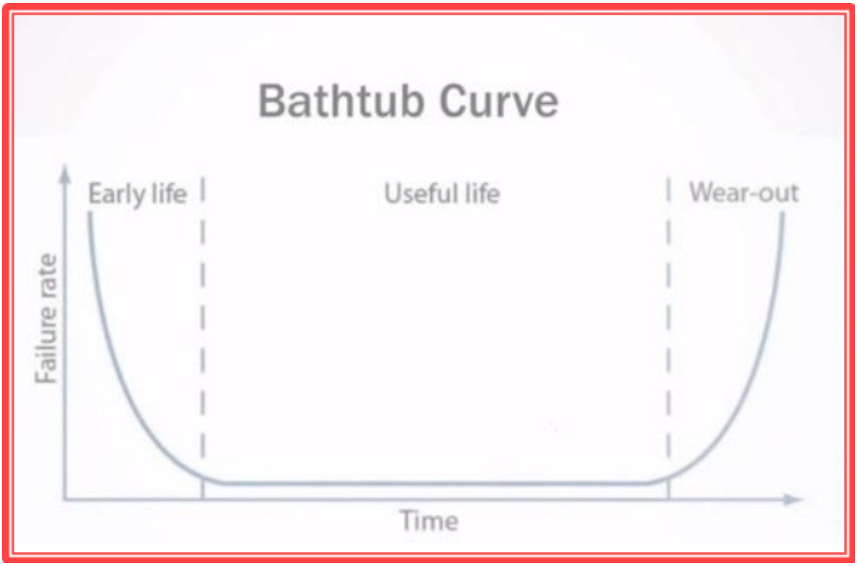
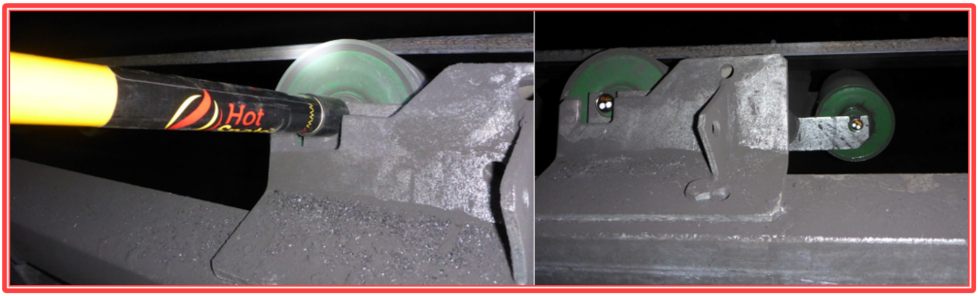


(Mararchief.tudelft.nl, 2018)



Conveyor idler predictive lifetime rating influence factors –

- Manufacturer of the idlers.
- Conveyor design – installed power and ratings.
- Storage of the idlers and time sitting still.
- Change of profiles, transitions and line and levelling of the conveyor.
- Spacing of idlers and idler frames.
- Angle of idler and trough angles.
- Idler position and type – trough / centre, wing, return, long flat, transition, impact, servo.
- Location of idlers with regards to drives, loop take ups, winches and tail/ends effecting tensions placed on the idlers.
- Immediate environment the idlers are subjected to. (spillage, humidity, temp, geology).
- Type of conveyor belt, sag and rolling resistance.
- Mechanical fasteners / clips in the belting creating metal to metal impact and spillage.
- Condition of belt cleaners and scrapers.
- Percentage of operational performance.
- Tonnes per hour vs operational time.
- Overloading and underloading.
- Moisture content and corrosiveness of the product being conveyed.

These influence factors to name a few are what makes the failure of conveyor idlers appear to be random in nature, when in fact, each influence will have its own engineering factor that will impact on the calculated life span of each individual idler bearing.

To add further complexity to this, each bearing manufacturer will give an expected lifetime rating according to the Bearing Lifetime Theory. Some will even allow for as much as a 5% early failure rate of idler bearings with respects to the lifetime rating, due to manufacturing variances and such factors. Considering there are 2 bearings per idler this number becomes quite significant.

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Conclusion

Hot Spots® offer an inexpensive low effort means of condition monitoring for the conveyor system idlers, assisting in the reduction of the ineffective and inconsistent diagnosis of conveyor idlers condition.

Additional to the safety benefits, reputation and confidence in the processes associated with the Site Health and Management System, and resilient compliance to legislative requirements, comes the operational and production flow on benefits that are enjoyed with a reliable compliant conveyance system.

Hot Spots® come conveniently packaged in the purpose made spring loaded **Hot Spots® 100** *bulk applicator* and **Hot Spots® 12** *everyday dispenser*, allowing for ease of transportation and application. **Hot Spots**® are applied with the tap and slide method, direct from the dispenser to the idler shaft end or dispensed individually into your hand for placement as preferred. The **Hot Spots**® disks are a powerful unidirectional potted Neodymium copper / nickel coated rare earth magnet, that ensure a positive connection to a clean uniform ferromagnetic surface allowing for the effective transfer of heat energy, to the thermochromic heat indication l abel completing the device. Always ensure that site isolation requirements are met when working near or in the confines of a conveyor, being aware of pinch and nip points and remember, safety first.

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As **Hot Spots**® are intended to be mounted on the shaft end of the conveyor idlers, rollers and pulleys, a lag period exists between the core temperature of the failing bearing, to the **Hot Spots**® located on the end of the shaft or side face. Once the increasing temperature has been transferred to the **Hot Spots®**, the thermochromic white dots will become **clear** at the prescribed temperatures of **≥90°C** for the single spot **Hot Spots**® or **≥60°C** as first warning and **≥100°C** for final warning on the 2 spot **Hot Spots®**, revealing the orange and **or** red temperature emblazoned spots beneath.

Hot Spots® should not be used or stored in full direct sunlight **or in high temperatures above 50°C.** With the average operating temperature of a healthy conveyor idler in the hotter regions of underground mining ranging from **25°C to 40° C**, the **Hot Spots®** activation **temperatures** gives an adequate tolerance in operational conditions and load variations, to determine that the bearing is in fact in a deteriorating state.

As always, use and trust all your senses whilst performing conveyor inspections, using **Hot Spots®** as an additional identification and verification tool, to add to your hazard control strategy.

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Heat Transference

Hot Spots® heat detection methods are not restricted to the idler shaft end or idler bearing face. It can be observed below that typically that the heat generated within the failing bearing can be seen to migrate to the opposite end of the idler shaft and additionally onto the frame housing the idlers.

This is an important point to note as a frequently asked question is what if one end of the idler shaft is not visible whilst the conveyor is not positively isolated for access.

"How can I tell if the bearing is heating in this situation using Hot Spots® ?"

As the following thermal images will show, heat is transfered to the adjacent framework supporting the idlers, as well as transferring through the idler shaft to the opposite visible end of the idlers. The transference through the steel shaft to the opposite end is particularly suited to an idler, given the idler shafts containment from the effects or influence of the surrounding environment, by means of the idler shell.

Given that **Hot Spots®** are not a real time electronic monitoring device, the time it takes for the transference of this heat energy to adjacent positions or locations of **Hot Spots®**, allows time for activation between inspections during the course of a shift. With Underground Coal Mines twice daily equally spaced inspections by competent people is a legislated requirement, giving 14 additional opportunities to spot a heating on a roller in between maintenance activities.

Additionally, thought must be given to when offline inspections and maintenance are being completed and access to these non visual areas is allowed, the persons completing the inspections will have a quick means to determine the state of the normally difficult to view Hot Spots®, leading to effective and informed maintenance decisions.

Underground Coal Mines must have an effective and compliant system in place, to identify and change out idlers on a conveyance system. Hot Spots®, developed to bridge the current gap within the industry.

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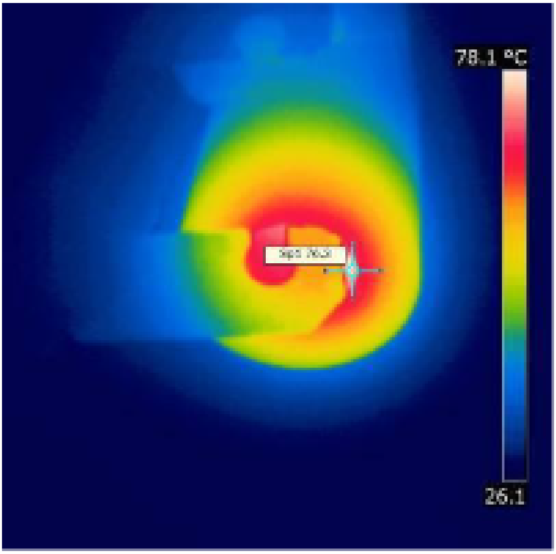
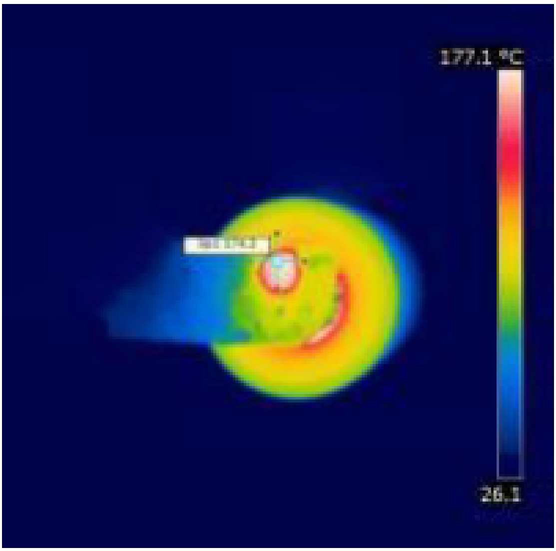


Heat transfered into the framework supporting the idlers



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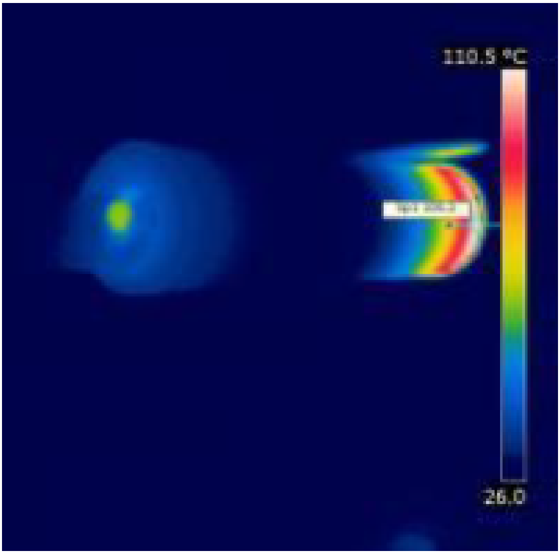
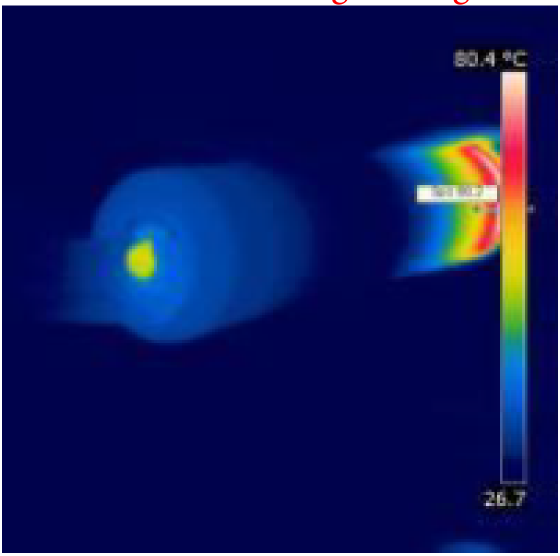


Heat transfered internally through the idler shaft to the opposite end of the failing bearing.



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