CONVEYOR IDLER MAINTENANCE PRACTICES: IDLER MANAGEMENT SOFTWARE

Submitted by
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Final year research project report submitted in partial fulfilment of the coursework requirements for the degree of Bachelor of Engineering
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I. Abstract

The following report outlines the research completed, methodology used and details of an Idler Management Program that support smart conveyor idler maintenance practices. Modern conveyor belts are becoming larger, faster and capable of transporting increasingly larger volumes of product as demand increases. Finding a balance between performance and reliability is an area that the mining industry has been struggling with for a long time now. High coal prices have meant that production gets preference over maintenance, this is largely due to the time taken to perform most condition monitoring practices. However, recent times have seen large fluctuations in the demand for coal and as a result many mines have had to make every penny count so to speak. Improving conveyor maintenance practices can account for large savings for any mine site.

The main objective of this project was to develop idler management software that does improve conveyor maintenance practices and can assist in making significant savings for the mine. To reach this objective a staged approach was taken by first completing large amounts of research, then defining what the software should be capable of, and finally product development where many iterations of the software were tested and refined. The final product works by automating the process of analysing the data collected from condition monitoring, saving considerable time and identifying trends that would otherwise be missed.
II. Acknowledgement

The author would like to take this opportunity to acknowledge the work Cove Engineering have completed assisting the completion of this project. Their expertise in the mining industry, particularly conveyor system optimisation, has enabled the best possible outcome for this project.

The author would also like to thank Dr Abdul Mazid of Central Queensland University for his assistance in completing this project.
III. Declaration

I, Warwick Bell, certify that the main text of this thesis is entirely my own work and that such work has not been previously submitted as a requirement for the award of a degree at Central Queensland University (Australia) or any other institution of higher education.

Warwick Bell
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### V. Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBM</td>
<td>Time Based Maintenance</td>
</tr>
<tr>
<td>CBM</td>
<td>Condition Based Maintenance</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
</tr>
<tr>
<td>IMATS</td>
<td>Idler Management and Tracking System</td>
</tr>
<tr>
<td>Cove</td>
<td>Cove Engineering Pty Ltd</td>
</tr>
</tbody>
</table>
1. Introduction

I. Background

In 2010 alone Queensland coal mines produced over 264 million tonnes of raw coal, over 185 million was exported overseas [1]. Moving huge numbers of product like this is a possibility thanks to belt conveyors, without them the time and cost it would take to transport coal either from a mine to a coal handling preparation plant (CHPP), or a CHPP to a train loadout point would be significantly higher than it is today. With taxes in Australia continually increasing, particularly for the resource industry, it is essential that all costs and wastage is minimised.

Conveyor idlers are used to support the belt from pulley to pulley. They play a vital role in the functionality and performance of the conveyor system and require close attention to ensure they continue to operate as best they can after installation. There are many different types of conveyor idlers, each is applicable to a certain situation. Selecting the wrong idler type for any given application could result in major performance issues for the system.

Critical or catastrophic failure of an idler on a bulk handling conveyor has the potential to stop all of the production on a given site. On some sites idler related maintenance accounts for up to 40% of all the conveyor system maintenance costs [3]. Not only this, but they pose a threat to the safety of the personnel working around the conveyor and damage to the conveyor belt itself.
Correct condition monitoring and maintenance can eliminate failures such as this from occurring.

The most common reason for idler failure is bearing failure, this can be caused by a number of factors. Some of which are listed below:

- Manufacturing faults within the bearings.
- Environmental effects, extreme heat or cold.
- Seal failure, often results in moisture or dirt contamination.
- Belt slap or intermittent belt contact with the idler.

Today the industry is leaning towards CBM over TBM and run/operate to failure as the preferred method of maintenance on majority of machinery. One of the problems faced by companies adopting CBM is that large amounts of data regarding the relevant machinery and/or components are required to make effective maintenance decisions. An Overview of Time-based and Condition-based Maintenance in Industrial Application [4] defines condition based maintenance (CBM) as “a maintenance program that recommends maintenance actions based on the information collected through condition monitoring process”. Recent times have seen huge leaps forward in condition monitoring technology, previously expensive and hard to use monitoring techniques are now available at a reasonable price and easy to use. It is now a relatively simple task to monitor parameters such as vibration, temperature, lubricating oil contaminants and noise levels.

Cove Engineering specialises in the optimisation of conveyor systems, among their long list of services is conveyor idler management programs. These programs typically involve Cove personnel inspecting conveyor systems on-site using some of the above mentioned technology for defective idlers, in recent times Cove has also had an increasing demand for idler management software that simplifies the data analysis aspect of the condition monitoring process. As a result this project was undertaken to develop such a product.
II. Objective of the Research
The ultimate goal for this project is to develop simple and functional idler management software that can be marketed predominantly to the coal mining industry. The objective of the software is to automate the typically time consuming process of analysing the data collected during the condition monitoring process. Automating this process encourages smart conveyor idler maintenance practices, some of the benefits of using these methods are:

- Reduce downtime associated with conveyor idler failures
- Increase idler life
- Increase belt life (through reduction of belt damaging idler failures)
- Reduced maintenance costs

III. Significance of the Research
The mining industry is notorious for its production driven attitude that often leaves smaller, yet still important, processes by the way side. Often this creates large amounts of product wastage and unreliability issues with machinery, conveyors being at the forefront of this issue. Conveyor idlers could be considered one of these “smaller” processes as they are all but forgotten about when attempting to push maximum tonnage. The reason for this is simple, their individual cost isn’t high enough to warrant a lot of attention when planning maintenance procedures, not helping their case is the time it takes to perform smart conveyor idler condition monitoring, let alone the time it takes to analyse the data collected.

As discussed in Section I. Background ignoring conveyor idlers can have huge consequences that could simply be avoided by putting in the effort to monitor them properly. The research performed for this project will result in a product that encourages this monitoring process by making the process significantly easier. When in place mines stand to save huge amounts of money that can be better spent elsewhere.

IV. Structure of the Thesis
This document is presented to the reader in a logical and neat manor that doesn’t at any point leave the reader left without any information that might be a pre-requisite the appropriate section. The literature review is at the start of the document to provide background information and some ground theory, the methodology explains the process and techniques that was used to attain the project objectives. The results and discussion then provide details of the product that was developed, naturally the conclusion sums up the work that was completed for the project and the appendices provide additional reading material if the reader deems necessary.
2. Literature Review

To best understand the current maintenance practices used for conveyor idlers it is necessary to study the specifics of both machinery maintenance and bearing maintenance. Conveyor idler maintenance is then a combination of both these practices.

In recent times we have seen large fluctuations in the demand for the resource industry. This uncertainty has resulted in industries not simply cutting costs but adjusting their maintenance strategies to ensure there is minimal wastage with regards to time and componentry. This means that industries are adopting more condition based maintenance (CBM) strategies rather than time based maintenance (TBM) [5].

One of the problems faced by companies adopting CBM is that large amounts of data about the relevant machinery and/or components are required to make effective maintenance decisions [5]. Depending on the equipment in question this sort of information may not be available, this is where experienced maintenance personnel can make a huge difference in the effectiveness of the given maintenance strategies. They are able to make informed decisions rather than having a guess or replacing the component just in case, which of course would be considered wastage if the component still had a significant functional life remaining.

An article titled *An Overview of Time-based and Condition-based Maintenance in Industrial Application* [4] discusses why certain maintenance strategies are used over others. The bathtub curve shown in Figure 5 below is an important tool when understanding the life cycle of most forms of machinery and componentry.

![Bathtub Curve](image)

*Figure 5 - A conventional bathtub curve. [4]*

Preventative maintenance is in fact a form of TBM (time based maintenance). The intervals that maintenance tasks occur on are based on the perceived failure rate of the given equipment. This assumes that the failure rate can is predictable [4]. This paper also talks frequently about the
importance of experienced maintenance personnel. Although most OEM’s will state a time period for maintenance to occur, it is unrealistic to think that these recommendations can apply to all the units in service. Typically each unit will be subject to conditions that are unique in their own way. Essentially the OEM recommendations attempt to ensure that equipment does not breach the “Wear-out” section of the bathtub curve (Figure 5). Not only does this dramatically reduce the risk of unplanned catastrophic failure, but it allows the maintenance cost to be consistently predictable. The down-side to this predictable budget is that sometimes equipment is replaced or repaired before the end of the “Useful life” section of the bathtub curve (Figure 5).

An Overview of Time-based and Condition-based Maintenance in Industrial Application [4] defines condition based maintenance (CBM) as “a maintenance program that recommends maintenance actions based on the information collected through condition monitoring process”. Recent times have seen huge leaps forward in condition monitoring technology, previously expensive and hard to use monitoring techniques are now available at a reasonable price and easy to use. It is now a relatively simple task to monitor parameters such as vibration, temperature, lubricating oil contaminants and noise levels. This revolution has seen CBM surge forward in popularity in an effort to develop refined maintenance programs. An Overview of Time-based and Condition-based Maintenance in Industrial Application [4] states that 99% of equipment failures are preceded by certain signs, conditions, or indications that a failure is going to occur. This is verified by An Alternative Time-Domain Index for Condition Monitoring of Rolling Element Bearings – A Comparison Study [5] which states that particularly rolling element bearings progress through a number of intermediate states before catastrophic failure. It also talks about soft and hard failures, soft failures allow the component to stay in service and take measures to maximise its lifespan whereas hard failures have reached the point of catastrophic failure and need immediate replacement. Combine this theorem with the previously mentioned leap in condition monitoring technology and CBM is fast becoming the smart way to perform maintenance.

When comparing information gathered from the large amount of literature available on maintenance practices it is surprising to see little of these techniques transferred successfully into the mining industry. Through experience it has been seen that often there is good intention to perform CBM but more often than not the desire to produce as many tonnes of coal as possible overrides the initial intention. There are simply too many factors to take into consideration to pinpoint exactly why this is but a possible reason is the high turnover rate that occurs in management at most Bowen basin mine sites. As discussed earlier experienced maintenance personnel can make or break a maintenance plan, without experience it is unlikely that accurate judgement calls are being made.
3. Methodology
In order to ensure the best possible idler management product for the project it was necessary to make a staged approach so that nothing was missed during the development and refinement of the product. The staged approach used to achieve this product is discussed below.

I. Research
As with any project large amounts of research had to be performed to gain a thorough understanding of the background technical information surrounding conveyor idler bearings. There is little literature relating specifically to conveyor idlers, therefore bearing and machinery component maintenance was studied individually, a combination of these two practices would satisfactorily describe conveyor idler maintenance theory.

Possibly the most valuable form of research was conducted through working in the industry. This involved talking to maintenance personnel on a number of mine sites and observing the practices they performed first hand, often the latter provided a more realistic representation of the practices that where in place.

There are a number of variations of idler management software on the market today. In order to develop a product that surpasses anything else the competition needed to be investigated. Cove Engineering’s IMATS was the initial focus as it was the program to be superseded. It was found that IMATS outputs could be improved significantly in order to deliver significantly more useful information to the user. From an operational point of view it required a computer programmer to be employed when the program had to be modified for a new client, this was a facet of the program which was highlighted as something that must be rectified. Other market leading forms of software were very expensive, especially considering the limited or hard to read/understand information that is displayed on the outputs.

II. Define Goals
The research conducted enabled any problems found throughout the industries conveyor maintenance practices to be identified. From this potential solutions to these problems were hypothesized.

Condition based maintenance (CBM) is decidedly the smartest way to conduct conveyor based maintenance, so the question was why wasn’t it the prominent form of maintenance across the industry.

Some of the negatives of CBM include costs, effort, and the difficulty of summarising the collected data. By looking at some of these problems individually we see relatively simple ways to either solve them or find/develop technology to step in and make the task simpler.

Costs associated with CBM are related to the purchase of various forms of condition monitoring equipment. However, as discussed previously the technology needed to perform these tasks is becoming increasingly available and as a result the cost of such equipment is reducing. The cost of labour needed to perform the condition monitoring is unfortunately unavoidable but relatively small when compared to the potential savings CBM offers.
The difficulty of summarising the collected data presents a perfect opportunity to develop a product that will summarise it for us. For both ease of installation and its flexibility Microsoft Excel was used to develop such a product, which is discussed in further detail in both section III. Product Development and 4. Results and Discussion.

The idler management software that will be developed with the above goals in mind must be an affordable package that is easy to install and understand. The software should be able to reduce the negative aspects of CBM significantly for it to be justified. The outputs of the software must be informative, at the same time as being easy to read and understand.

III. Product Development

Once the decision was made to utilise Microsoft Excel the process began of learning the finer details of the program and understanding how they could be used to help achieve the goal of developing a program that takes the difficulty out of understanding the data collected during the condition monitoring process.

Soon after this the very first iteration of the program was created. At this stage it was very basic and was more of a working canvas to be modified and refined to the finest detail.

The testing and refinement processes are naturally closely related. This is because any refinement that is made would be a result of feedback given by the persons involved with testing. The main goal of the testing product was to ensure that the software was simple yet informative, the functionality and outputs had to be understandable to all levels of users. The process of testing and refinement is of crucial importance as any shortcuts taken here will most likely result in reliability and functionality issues once the product reaches the market.

As with majority of products across any industry the refinement process is ongoing, the intention in this case is to never rest on laurels and improve or change the product as they market demands it.
4. Results and Discussion

The result of the previous steps is a Microsoft Excel based program developed by the collaboration of Warwick Bell and Cove Engineering that enables condition based maintenance to be practiced on conveyor idlers without the hassle of timely analysis of the large amount of collected data.

At first glance the program is very simple, however this is by intention and certainly not indicative of the effort required to achieve this appearance. The challenge was to make a simple looking program that provides a detailed analysis of conveyor idler failure data in a manner that could be understood by maintenance personnel/tradesman to engineers. The input page of the software contains a number of tools that allow the user to generate a number of different, yet equally valuable reports. Each button has large amounts of coding/macros attached to it that is activated by a mouse click. Where possible the input fields have drop down lists so that typos can be avoided, where drop down couldn’t be used validations have been placed on the cells so that only dates can be entered into the date columns and only numbers can be entered into the tag number column.

![Figure 6 - Layout of the idler management software’s input page.](image-url)

“ADD NEW ROW” is a button that allows the user to enter a new row of failure data. This button can be seen immediately to the right of the Cove Engineering logo in Figure 6. The functions here forth will now be discussed in order of the position from left to right.

“DELETE ROW” is a self-explanatory function that allows the user to remove an entry. This function should seldom be used as even old data is important in the data trending process and should be deleted. The coding behind this button tells Excel to select the entire row of the selected cell and delete it, if multiple rows are selected then they will all be deleted.

“IDLER SUMMARY BY CONVEYOR” generates a one page summary of the selected conveyor’s inputted failure data. This report displays information regarding the idler failures of a specific conveyor. This is depicted by two graphs and a diagram.
The graph in Figure 7 shows the idler defect temperature above ambient temperature against the leg or frame number. This graph can identify problem areas where idlers have a tendency to run hot, without this graph identifying this trend would be extremely difficult by looking at the raw data. The graph shown is a simple “X Y Scatter”, however the graph only shows information related to the selected conveyor. The coding tells Excel to filter the raw data based on the conveyor shown in the “Select Conveyor” drop down box.

The graph displayed in Figure 8 depicts information regarding all the different forms of inspection methods using a column graph generated by a PivotTable. The PivotTable takes the raw data that has been entered and counts how many times a failure has occurred on each leg or frame. It then plots this information on a column graph against the relative leg or frame number. At a glance it is possible to identify problem areas along the system by looking for clusters of failures within close vicinity of each other. If further detail is required the user can hover their mouse over the desired failure and the exact count and leg or frame number will be displayed.
Figure 9 depicts the frame layout of the selected conveyor. Above each idler is a number which represents the count of the amount of failures per each idler on the selected conveyor. The number is produced by a “COUNTIF” function which counts different groups of failures depending on the conveyor displayed in the “Select Conveyor” drop down box. This diagram is a quick way of identifying where the distribution of faulty idlers is in relation to the frame. An example of how this information may be used is if all of the idlers are being tagged on the left hand side of the conveyor only, then it may be worth investigating the cause, which could be attributed to poor tracking or off-centre loading etc. An example of how this output would be presented to the client can be viewed in Appendix II – Conveyor Idler Summary.

“CHANGEOUT LIST” is probably the most immediately practical function at first glance. The coding that runs when this button is selected collects the failure data entered and searches for blanks in the “Date Replaced” column. The rows that return blank in that column are then filtered to display only the failures that occurred on the conveyor displayed in the “Select Conveyor” drop down box. This output is designed to be used as a work order type of document that will be handed to maintenance personnel on down days. It provides a quick and easy way to identify any upcoming maintenance. Equally important is the return of the signed off work order to the appropriate supervisor. As when the supervisor receives the work order he will then enter a date into the “Date Replaced” column of the software so that the next Outstanding Idler Report that is generated does not contain any idlers that have already been changed out. What the “CHANGEOUT LIST” is lacking is the ability to provide trending and tracking information that will increase the performance and reliability of the given conveyor, this responsibility lies with the other functions of the program. An example of how this output would be presented to the client can be viewed in Appendix III – Outstanding Idler Report.
“IDLER SUMMARY BY SITE” is used to generate an overview for all of the mines conveyor systems. This output can be used to prioritise which conveyors most urgently need maintenance or should be investigated to improve reliability.

The graph shown in Figure 11 displays the amount of failures on each conveyor. This graph which is generated using a PivotTable may be useful when allocating maintenance resources as a conveyor that is experiencing a significantly higher amount of failures may require more resources. However,
you should note that this graph does not incorporate the length of each conveyor. This should be considered before dedicating extra resources to a conveyor as it would be expected that longer conveyors will experience more idler failures.

Figure 12 - Idler failure diagram displayed on the "IDLER SUMMARY BY SITE" report.

The diagram in Figure 12 is the same as the diagram in Figure 9, except this diagram incorporates failures from all of the sites conveyors. An example of how this data may be useful, if the diagram indicates that the majority of the failures are on the return frame than it may be a good idea stock more of that type of idler.

Figure 13 - Idler failure graph displayed on the "IDLER SUMMARY BY SITE" report.

The graph in Figure 13 depicts the count of failures against the failure type. This graph is also produced by a PivotTable, the table gathered the raw data and counts the amount of each type of failure and displays the results in the graph seen above. If site is experiencing a large amount of thermographic failures (i.e. Hot Bearing, Hot Bearing & Shaft, or Hot Shaft) than it might be necessary to spend more time performing thermographic idler inspections.

The Site Summary also provides a number of statistics regarding the performance of the sites conveyors. Information such as “Conveyor Length”, “Carry Idler Spacing”, “Return Idler Spacing”, “Total Carry Idler Failures”, Total Return Idler Failures”, “Failures per month”, “Failures per year”,

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“Mean time between failures” and “Failures per 100 frames” are displayed in an easy to read tabulated form.

The total number of carry and return idler failures is calculated by adding the values of appropriate values on the idler failure diagram (Figure 9) for the conveyor displayed in the “Select Conveyor” drop down box.

The rest of the statistics are generated by the following formulas:

\[
\text{Failures per month} = \frac{\text{Carry Idler Failures}}{12 \left( \frac{\text{Inspection Range}}{365} \right)}
\]

\[
\text{Failures per year} = 12 \times \text{Failures per month}
\]

\[
\text{Mean time between failures} = \frac{\text{Inspection Range}}{\text{Total failures}}
\]

\[
\text{Failures per 100 frames} = \frac{\text{Total failures}}{\text{Conveyor length} \times \text{Idler Spacing} \times 100}
\]

All of the above values are calculated according to whether they are representing the carry or return set of idlers. An example of how this output would be presented to the client can be viewed in Appendix IV – Site Idler Summary.
5. Conclusion
The idler management software that has been developed as a result of this project undertaking was brought on by industry demand. Conveyor idlers are often overlooked when developing maintenance strategies, yet they are accountable for a large amount of unplanned downtime at most sites. The aim was to provide software that was both simple to use and flexible in its outputs.

Simplicity: The software collects the tag information that is entered by the user, and has the ability to generate work orders and trending graphs all at the click of a button. The work orders contain a list of all the faulty idlers that have been tagged and not replaced, these work orders can then be handed straight to maintenance personnel to complete the necessary replacements.

Flexibility: For the standard Idler Management Software Cove has included a number of trending graphs and summarising statistics that we thought would be most useful to site personnel. However, it is possible for Cove to provide any extra statistics or trends that may be drawn from the tag data as an output with a very short lead time.

It is clear to see that the product that has been developed has satisfied the objectives of this project. The process of analysing condition monitoring data has been automated in an easy to use and affordable Microsoft Excel based program.

There are a number of recommendations that can be made for further work on this project. Regarding the software, there is an opportunity to improve the outputs so that they provide intuitive feedback in the form of recommended maintenance actions based on the trends that are occurring on the outputs. This style of output would be difficult to achieve in Microsoft Excel but is certainly possible. Regarding the research, bearing failure is at the heart of conveyor idler maintenance and to better understand this it is recommended that further study be undertaken on how bearings fail. This could be achieved by performing a large number of experiments where conveyor idlers of varying specifications are placed under simulated loads until failure. Once failure is close it would be necessary to monitor the heat, sound and vibration signatures of the bearings to produce a more detailed version of the bathtub curve.
6. References


7. Appendices

Appendix I – Confirmation of Deposition

CONFIRMATION OF DEPOSITION

(To be appended to the thesis on submission of hard bound copy to the University Library)

PART A  (Candidate to complete. Please print in black ink).

Candidate’s Name: Warwick Bell  

Degree: Bachelor of Engineering (Mech) / Diploma of Professional Practice

Thesis Title: Conveyor Idler Maintenance Practices: Idler Management Software

PART B  (Office Use Only)

As at the date recorded below and in keeping with the Requirements for the Submission, Presentation and Deposition of Research Theses, the thesis described above has been deposited in the University Library.

_________________________________________  __________________________
Signature                                       Date

(Director, Division of Library, Information & Media Services (or nominee))

(The signed Confirmation of Deposition must be forwarded directly to the Research Services Office).
DECLARATION TO ACCOMPANY THE DEPOSIT OF A DISSERTATION

Author: Warwick Bell

Dissertation Title: Conveyor Idler Maintenance Practices: Idler Management Software

Date: 01/06/2012

Author's Declaration:

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This dissertation may not be copied in whole or part without my permission.

Signed
Appendix II – Conveyor Idler Summary

Example Mine
Example Conveyor Idler Summary
22/03/2011 - 30/05/2012

Idler Failures (Thermography Inspections)
Inspection date range: 22/03/2011 - 22/02/2012

Idler Failures (All)
Inspection date range: 22/03/2011 - 22/02/2012

This summary can be used as a quick way to identify trends that may be occurring on Example conveyor.

TCP: This graph depicts the position and temperature of idlers tagged during thermographic inspections.

MIDDLE: This graph shows the number of failures per leg number. This includes tags from all inspections.

LEFT: This diagram is a representation of the distribution of idlers, tagged during all forms of inspection, relative to their position on the frame.

Cove Engineering (07) 49 525 242
Appendix III – Outstanding Idler Report

Example Mine
Example Outstanding Idler Report
Current to: 30/05/2012

Looking Outside

<table>
<thead>
<tr>
<th>Leg or Frame No.</th>
<th>Carry or Return</th>
<th>JB/OB</th>
<th>Idler No.</th>
<th>Comments</th>
<th>Laid Out</th>
<th>Date Replaced</th>
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<tr>
<td>324</td>
<td>Return</td>
<td>Inbye</td>
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<td>340</td>
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<td>528</td>
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Appendix IV – Site Idler Summary

Example Mine
Idler Failure Summary

This summary can be used as a quick way to identify trends that may be occurring on Example Mine’s conveyor systems.

ABOVE: This graph depicts the number of idlers tagged during all forms of inspections.

LEFT: This diagram is a representation of the distribution of idlers, tagged during all forms of inspection, relative to their position on the frame.

BELOW: This graph depicts the number of failures relative to the failure type.

Idler Failures per Defect Type

These graphs provide a detailed analysis of the most common defects and their associated failures.
Example Mine
Idler Failure Statistics

CONVEYOR SPECIFICATIONS

<table>
<thead>
<tr>
<th></th>
<th>GCV001</th>
<th>GCV002</th>
<th>GCV003</th>
<th>GCV004</th>
<th>GCV005</th>
<th>GCV006</th>
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<tbody>
<tr>
<td>Conveyor Length (m)</td>
<td>222</td>
<td>333</td>
<td>443</td>
<td>1328</td>
<td>2912</td>
<td>2891</td>
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<tr>
<td>Carry idler Spacing (m)</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
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<tr>
<td>Return idler Spacing (m)</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
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<td>3</td>
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<tr>
<td>Approx. Number of Frames</td>
<td>148</td>
<td>355</td>
<td>296</td>
<td>886</td>
<td>1918</td>
<td>1927</td>
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IDLER FAILURE STATISTICS

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<th>GCV004</th>
<th>GCV005</th>
<th>GCV006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Carry idler failures</td>
<td>8</td>
<td>14</td>
<td>32</td>
<td>63</td>
<td>27</td>
<td>27</td>
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<tr>
<td>Total Return idler failures</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>8</td>
<td>8</td>
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IDLER FAILURE STATISTICS SUMMARY

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<th>GCV001</th>
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<th>GCV003</th>
<th>GCV004</th>
<th>GCV005</th>
<th>GCV006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failures per month</td>
<td>CARRY</td>
<td>0.72</td>
<td>1.26</td>
<td>2.89</td>
<td>5.69</td>
<td>2.44</td>
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<td>-</td>
<td>0.09</td>
<td>0.27</td>
<td>0.72</td>
</tr>
<tr>
<td>Failures per year</td>
<td>CARRY</td>
<td>8.66</td>
<td>15.16</td>
<td>36.66</td>
<td>68.23</td>
<td>29.24</td>
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<td>1.08</td>
<td>3.25</td>
<td>8.66</td>
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<tr>
<td>Mean time between Failures (days)</td>
<td>CARRY</td>
<td>42</td>
<td>24</td>
<td>11</td>
<td>5</td>
<td>12</td>
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<td>337</td>
<td>112</td>
<td>42</td>
</tr>
<tr>
<td>Failures per 100 frames</td>
<td>CARRY</td>
<td>5.41</td>
<td>3.94</td>
<td>10.84</td>
<td>7.12</td>
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<td>-</td>
<td>0.68</td>
<td>0.58</td>
<td>0.82</td>
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</tbody>
</table>

Statistic | Definition
--- | ---
Failures per month | The quantities of carry and return idler failures for each conveyor, per month.
Failures per year | The quantities of carry and return idler failures for each conveyor, per year.
Mean time between failures | The average number of days between idler failures - high numbers indicate a long time between failures.
Failures per 100 frames | The number of idlers which have failed, for every hundred idler frames on the conveyor. This is a quick way to compare the performance of conveyors which are not the same length.