Insulated Joint Studies

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ABSTRACT

Insulated joints fail long before the continuously welded rail (CWR) in the field. The end post in the current insulated joints causes an impact every time a wheel passes over it, causing the insulated joint to become battered. It is difficult to determine the service life of an insulated joint before failure. There are many different designs and depending on where they are, they may have a shorter or longer service life. A new lower impact insulated joint has been created that will support higher tonnage than the current design. 250 of these long miter joints have been installed in the track this year with promising results. 400 insulated joints have been inspected in the field and some interesting results have been determined from the data. So far, long miter cut insulated joints have been effective and some have a life span of 1.5 billion gross tons. Our in track inspections have determined life spans of insulated joints based on curvature, years and tonnage. Life span improvement due to slotting has been determined. These studies will produce an insulated joint that will have longevity closer to that of the CWR. Furthermore, the inspection of insulated joints has determined life spans depending on how the IJ was maintained and the characteristics of the track it is in. Knowing the life spans of different insulated joints will allow us to install the insulated joints in the track where they will perform the best.

1. INTRODUCTION

Degradation and failure of insulated joints (IJ’s) is a major railroad maintenance problem. The current focus of the Union Pacific Railroad is to obtain the longest service life out of an insulated joint based on the conditions of its location in the track while being able to justify the cost. The track conditions that affect the life of the insulated joints include tonnage, grade, curvature, temperature extremes and tie type. Insulated Joint service life is going to become even more important due to the projected increase in volume and reduced track maintenance windows.

The first phase in this study was to determine the service life of IJ’s that are currently in the track. This was completed through field observations of nearly 400 insulated joints. The joints were rated and compared to the track tonnage in order to develop the service life expectancy of an insulated joint based on the conditions of its location in the track. In addition, other observations such as slotting and how well the slotting work was done were made in order to determine the effectiveness of slotting.
The second phase revolves around testing and monitoring of new insulated joint technologies both in the track and in the lab. These IJ’s have proven to produce a longer service life during in track testing.

This paper discusses the service life of multiple insulated joints and the impact of maintenance practices on the insulated joints’ service lives. The goal is to construct a tiered standard in order to use the correct insulated joint based on the conditions of the track and the initial cost of the IJ.

2. IN-TRACK OBSERVATIONS

An inspection was completed in 2012 of 399 insulated joints on five different subdivisions. The subdivisions were the Caliente, Canyon, Marysville, Kearney and the South Morrill. These were chosen because they are a mix of all the possible combinations of different track conditions. The conditions that affect the service life of the insulated joints are tonnage, grade, curvature, temperature extremes and tie type.

2.1 Insulated Joint Rating and Projected Service Life

These insulated joints were given a rating of one through four based on the condition of the IJ. A rating of one represents a new joint, a rating of two means replace in 5-10 years, a rating of three means replace in less than five years and a rating of four represents a joint that needs to be replaced ASAP. The ratings along with the year the insulated joints were installed and the total tonnage or million gross tons (MGT’s) over the joints were used to determine the projected service life of the insulated joints.

The box plot below (Figure 1) depicts the distribution of the projected service life of each IJ that was observed. The box represents the service life of 68% of the IJ’s observed on the subdivision. The single line above and below the box represents the projected service lives of the remaining IJ’s that are not represented in the box.
Based on the inspections of IJ’s in the track, the following average service lives (Figure 2) have been determined for the following separate categories of track. These categories were developed based on tonnage and conditions across the UPRR’s system that cause extra strain on the track structure. The UPRR system’s tonnage was evaluated to determine the percentage of miles that fall within tonnage ranges. 32% of the track miles are over 40 MGT per year, 34.5% are between 20 and 40 MGT per year and 33.5% of miles are under 20 MGT per year. Each of these tonnage ranges represent roughly one third of the entire system.
2.2 Insulated Joint Bolt Holes

The number of bolt holes were compared to service life. Eight hole bars produce an estimated service life that is 64 MGT’s less than a six hole bar. This data corresponds with the strain gage data that was collected from instrumented IJ’s during the in track testing that will be discussed in Section 3.1.

2.3 Insulated Joint Insulation

A comparison was made between kevlar insulation or fiberglass insulation and the insulated joint projected service life. The analysis shows that kevlar joints have a service life that is 132 MGT’s higher than fiberglass insulated joints.

2.4 Insulated Joint Slotting Analysis

The slotting of the insulated joints was also observed. Any IJ that showed signs of being slotted was recorded as being slotted. Furthermore, it was noted if the IJ was slotted properly or if it was excessively slotted. IJ’s that were slotted had a service life that was 80 MGT’s longer than an IJ that showed no evidence of being slotted (Figure 3). Of the IJ’s that were slotted, the IJ’s
that were properly slotted had a service life that was 100 MGT’s longer than the excessively slotted IJ’s.

Figure 3

Figure 4 is an example of a poorly slotted insulated joint. This causes higher stress on the joint and shortens the service life.
2.4.1 Insulated Joint Slotting Intervals

After analyzing the data from insulated joint inspections it can be determined at which point slotting should be performed on each track. When slotting was evident early in the IJ’s service life, the IJ had a lower projected service life than an IJ the same age that had not been slotted. When slotting occurred later in the service life of an IJ, it had a longer projected service life than an IJ that was the same age and not slotted. The intersection of the lines that represent the projected service lives of slotted and un-slotted IJs in the charts below help visualize when slotting should be performed (Figure 5).
3. INSULATED JOINT TESTING

Beginning in 2009 the UPRR Methods and Research Engineering group began installing test insulated joints. At this point 109 insulated joints have been installed for testing from four manufacturers. The insulated joints being tested include alternative post designs, various bar designs and long miter cut insulated joints (Figure 6).
Sixteen insulated joints have been instrumented with strain gauges. The analysis of the data was performed by Muhammad Akhtar of the Transportation Technology Center, Inc. (TTCI). The analysis showed that there was less stress on the long angle cut insulated joint than both the six holed and eight holed joints (Figure 7). The data collected in the visual inspection verifies this analysis. The inspection data shows that an eight hole bar produces an estimated service life that is 100-200 MGT’s higher than a six hole bar on flat and straight territories on wood or concrete ties. In this study, the six hole bar insulated joint produced a service life that was 80 MGT’s higher on concrete ties on mountainous territories. Further study needs to be completed to determine if this was an anomaly or not.
In addition to the in-track testing, an experiment has been performed regarding the identification markings of insulated joints. Using an infrared temperature thermometer, the temperature of five separate bars was measured on a sunny day at 1400 in the afternoon with the ambient temperature being 70° F. The bars were in direct sunlight for four hours. Figure 8 below shows that there was a significant temperature difference between the paint colors. The black paint produced a temperature 37° F above the ambient temperature while the white bar produced a temperature 15° F above the ambient temperature.

<table>
<thead>
<tr>
<th>BAR COLOR</th>
<th>AMBIENT TEMP. (F)</th>
<th>BAR TEMP. (F)</th>
<th>TEMPERATURE DIFFERENCE</th>
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</thead>
<tbody>
<tr>
<td>BLACK</td>
<td>70</td>
<td>107</td>
<td>37</td>
</tr>
<tr>
<td>UNPAINTED</td>
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<td>98</td>
<td>28</td>
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<tr>
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<td>70</td>
<td>85</td>
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Figure 9 below shows the bars as they were arranged for the test.

4. CONCLUSIONS

Based on the evaluations of the insulated joints in track, test insulated joints and their service lives, a tiered standard can be developed for the categories of track. The additional costs of the IJ’s will have to be evaluated to make sure the additional cost justifies the added service life.

The goal is to increase the service life of insulated joints by 44%. It is believed that the service life of insulated joints can be increased by using specific IJ’s from different suppliers in the separate categories of track, slotting properly and updating the insulated joint identification markings. The service life chart with the implemented IJ changes would resemble Figure 10 below.
In addition, the current warranty on insulated joints is 500 MGT. With these findings and goals, 500 MGT is not high enough on heavy tonnage subdivisions. 88 of the 400 IJ’s had a projected service life less than 500 MGT but all of those were on heavy grade, high curvature track with lower tonnage. It is proposed that a time in track be added to the warranty. A warranty should be up to 1000 MGT or 10 years in track, whichever comes first.

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REFERENCES
Insulated Joint Studies

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Insulated Joint Studies

Background

- It has been difficult to determine the service life of insulated joints.
- The Union Pacific purchases approximately 6,500 insulated joints per year.

Strategic Objectives

- Determine the service life of Insulated Joints (IJ’s).
- Develop a slotting procedure.
- Evaluate next generation insulated joints.
- Establish a tiered standard for insulated joints.

IJ Inspections

- Inspected approximately 400 insulated joints.
- On five separate subdivisions with different characteristics.
- Determined lifespan of IJ’s based on a 1-4 rating scale.

Service Life by Track Category

- Current Service Life of Insulated Joints (MGT)

Service Life Based on Slotting

- MGT’s by Subdivision Slotted VS Unslotted
Insulated Joint Studies
Service Life Based on Slotting

Slotting increased the service life of an IJ by 80 MGT's.
Properly slotted IJ’s had a service life that was 100 MGT's higher than an excessively slotted IJ.

Service Life Based on Slotting

There is a correlation between the current tonnage on an IJ, if it has been slotted and its projected lifespan.

Insulated Joint Studies

Slot IJs at 400 MGT

Slot IJs at 350 MGT

Slot IJs at 180 MGT
TTCI has processed strain gauge data from a dozen IJ’s on the South Morrill Megasite.

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- Develop an insulated joint for more demanding locations.
- Further evaluate and improve the next generation IJ’s.
Special Thanks

- UPRR - Ed Kohake
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