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Analysis of Turnout Failure Modes in Revenue Service

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Summary

As part of Strategic Research Initiative (SRI) on Special Trackwork, Transportation Technology Center, Inc. (TTCI) analyzed revenue service turnout failure modes in North America from responses to a survey sent to several North American Class I railroads. From ~300 surveys completed and returned, TTCI identified the top failure modes of switches for mainline track and for railyard/industrial classifications. In addition, switch trouble ticket data provided by the railroads was analyzed for trends on switch failure modes. The goal of this work focused on future research endeavors to address commonly seen repeating modes of switch failures. Obviously, not all failure modes require new technology or maintenance methods to remedy.

Frontline signal and maintenance departments at each railroad, which are the primary entities responsible for switch maintenance and repair, responded to the survey. The level of response from the railroads was high. Help desk trouble ticket data received from the same railroads (typically 2 years' worth of trouble tickets for the entire network) provided additional data and insight into operational impacts caused by switch failures. Common switch failure modes identified among the Class I railroads include the following:

- Rail Running: Longitudinal movement of rail in the turnout that results in the switch operating rods becoming pinned or caught on switch timbers, which prevents the switch from lining properly when requested by the dispatcher. Proposed research includes an investigation into longitudinal movement of rail in switch points.
- Switch Obstructions: Foreign objects often become lodged in switch points and result in the inoperability of the switch. Typically, these obstructions are either intentionally placed by trespassers, or are simply debris that falls off a passing train. Proposed research would address the operational impact caused by obstructed switches by investigating a conceptual obstruction detection technology.
- Snow/Ice: Inclement winter weather overwhelms current switch heaters. Snow and ice build up in the switch points and prevent the switch from throwing properly. Proposed research includes an in-depth look at prevention of snow and ice buildup in turnouts using the switch heater/melter technologies available to the industry.

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INTRODUCTION

TTCI conducted a survey to identify causes of mainline switch failures, which are a major source of train delay and have serious detrimental operational effects. The failure of a single turnout can often set off a domino effect of compounding operational problems that can take hours to remedy. While the average life of turnout components is quite short compared to standard track, the variability of component lives in special trackwork is very large. This is due to the relative complexity of the special trackwork and the dynamic behavior of vehicles traveling over them.[1]

SURVEY OF SIGNAL AND MAINTENANCE OF WAY EMPLOYEES

TTCI compiled a survey composed of eight multiple choice questions related to switch failure modes. Questions were designed to obtain a solid database of information from frontline personnel directly responsible for switches and their failures. The composition of the questions was as follows:

- Two questions inquired about the employee's length of service with the railroad, and their area of specialty (signals or track).
- Two questions asked respondents to indicate the top three leading causes of switch failures. One question was in regard to mainline switches; the other question related to switch failures in railyards or industrial settings.
- Two questions gathered data on the frequency of switch inspections by respondents and the tools used during inspections to establish that responses from field personnel were creditable.
- Two questions gathered data on underlying factors that contribute to or prevent switch failures.

Figure 1 shows a plot of the responses received from five Class I railroads. The responses for the questions on top switch failure causes were used by TTCI to identify the top five causes of switch failures for mainline and yard/industrial categories: switch pumping, rail running, worn and broken components, defective switch timbers, and extreme weather conditions—snow/ice.

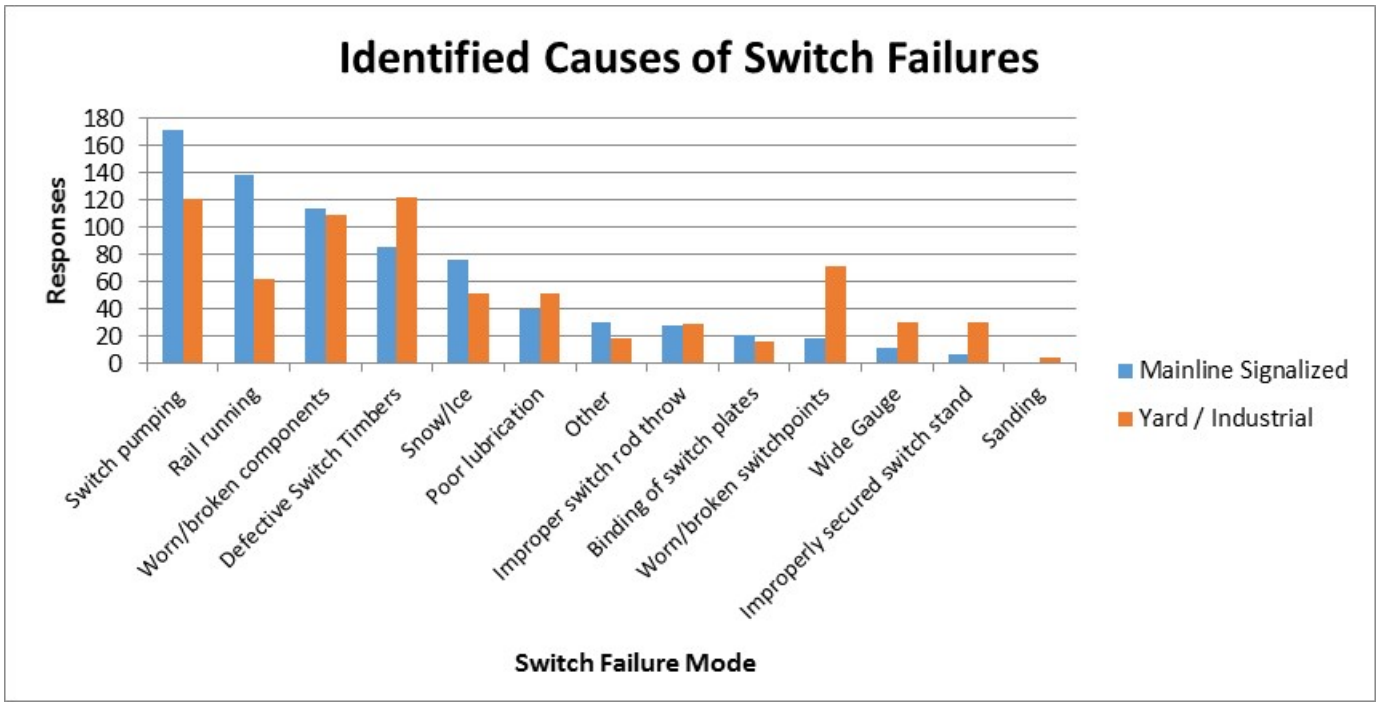

Figure 1. Causes of Switch Failures from Survey of Six Class I Railroads

ANALYSIS OF FAILURE MODES

Table 1 lists the top five failure modes for each category of switch (mainline or yard/industrial).

Table 1. Top Five Failure Modes by Classification of Switch

Rank	Mainline	Yard/Industrial
1	Switch Pumping	Defective Switch Timbers
2	Rail Running	Switch Pumping
3	Worn/Broken Components	Worn/Broken Components
4	Defective Switch Timbers	Worn/Broken Switch points
5	Snow/Ice	Rail Running

Several of the failure modes show up as high ranking in both mainline and yard classifications of switches. Timber failures contribute to poor alignment, wheel failures, and accidents. The current designs of switch timbers are difficult to install and maintain. These support problems result in poor surface, ballast degradation, and condition based speed restrictions. Longitudinal movement problems (e.g., rods binding on tie) are common. They contribute to switch point chipping and switch operation failures. The switch rods are attached to the switch points, whereas the ties are attached to the stock rails. As the points move longitudinally relative to the stock rails, the rods and timbers can interfere, affecting switch operation.[2]

These top ranked failure modes as indicated by field personnel were compared against an index of documented trouble tickets from the railroads; the comparison showed an agreement between what people in the field are seeing and what the railroad is actually documenting in terms of problems.

Switch Trouble Ticket Data

TTCI requested logs of switch trouble ticket data from all the railroads that provided survey responses. This was done to add additional data to analyze for trends on switch failure modes. TTCI received over 53,000 trouble desk tickets from an approximate 2-year window from the railroads that responded. Table 2 shows the top 10 trouble ticket categories from two of the responding railroads. Again, several of the same switch failure modes show up highly ranked on both sets of data from the Class I railroads. It should be noted that since each railroad has separate trouble ticket systems, the cause codes are organized and distributed differently. The data in Table 2 reflects this. Railroad #2 broke down all out of adjustment tickets to reflect specific elements of the switch, whereas Railroad #1 lumped all adjustment tickets together into one category.

Table 2. Top Ten Switch Trouble Ticket Cause Codes from Two Class I Railroads

Railroad #1 Resolution Code	Percent	Railroad #2 Resolution Code	Percent
Rail Running	14.7%	Adjusted Due to Running Rail	24.7%
Out Of Adjustment	14.3%	Obstruction Removed - Points/Rods	14.5%
Obstruction In Switch	13.3%	Ice/Snow in Points Switch Heater Malfunction	13.7%
Planned Work	7.9%	N/A	9.1%
Not Dispatched	7.5%	Graphited/Swept Switch Points	8.0%
Switch Circuit Controller	6.6%	Adjusted/Replaced Due to Mechanical Wear on Switch	4.9%
Snow/Ice	6.5%	Adjusted Due to Ballast Conditions	3.3%
Broken/Damaged Equipment	3.4%	Adjusted Due to Crosstie Conditions	3.1%
Duplicate Ticket	3.1%	Adjusted Due to Wedges	2.1%
Working as Intended	2.8%	Repaired/Replaced Contacts - Status	2.0%

CONCLUSIONS & PROPOSED FUTURE WORK

TTCI's analysis of switch failure modes identified more work that can be performed to improve switch performance and decrease the operational impacts from switch failures. Based on the results of the survey data, TTCI would like to focus on a few specific failure modes in future research endeavors. The following suggested research work has the potential to remediate a significant number of switch failures in revenue service. If the following three failure modes could be remediated, the operational impacts and resulting train delays caused would decrease substantially. These failure modes were selected because they are complex failures that combine multiple variables that result in a switch failing to operate properly. Also, methods available to remediate these failure modes perform with variable degrees of success. Even with regular inspection and maintenance these three failure modes continue to persist, indicating that there may be additional underlying issues that need to be addressed. The three proposed areas of additional research are discussed in further detail:

1. Longitudinal movement of rail in switch points (Figure 2) causes a substantial amount of failures and train delays, but relatively little research has been performed to date on how rail moves in a turnout based on daily fluctuations in temperature. TTCI would like to study this phenomenon more and address the unwanted movement of the rail that results in improper switch operation.

Figure 2. Longitudinal Movement in Rail

2. Another leading cause of switch problems is due to the buildup of snow and ice in the switch points (Figure 3). The railroads use various types of switch heaters to try and address these weather-based issues with varying degrees of success. TTCI would like to take an in-depth look at addressing the prevention of snow and ice buildup in switches and study the impact of environmental variables.

Figure 3. Snow and Ice in Switch Point

3. Foreign objects become lodged in the switch point area (Figure 4) and prevent proper operation. TTCI would like to explore methods of detecting and preventing switch point obstructions before they cause train delays. While some work has been performed on detecting obstructions at grade crossings and in open stretches of track, little has been done on detecting obstructions in switch points.

Figure 4. Foreign Object in Switch Point

TTCI will continue additional work on subgrade, timbers/crossties, and switch components as part of the Special Trackwork and Heavy Axle Load research programs.

REFERENCES

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2. Davis, David D., Vincent R. Terrill, and Daniel B. Mesnick. "Railroad Switch Design and Failure Mode Analysis." *Technology Digest* TD-02-015. AAR/TTCI, Pueblo, CO. July 2002.