

### Performance of Weld Repairs on Rail-bound Manganese Frogs in Heavy Haul Service

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TD95-002

#### Summary

Maintenance records of the Chicago & Northwestern Powder River Subdivision demonstrate that:

- The service life of in-track weld repairs of austenitic manganese steel frog castings is much shorter than the life of the original casting.
- Over the life of a frog, numerous weld repairs are made. The first repair survives about 26 MGT: 70 percent longer than subsequent repairs.
- The location of each additional repair generally overlaps the area of the previous repair.

These findings suggest that there are opportunities for improvements in welding materials or processes that can result in significant improvements in frog performance and subsequent service reliability.

The locations of the weld repairs on the frogs, although affected by the unique operating characteristics of the line, showed some variability. The lower loads on the diverging routes of the turnouts (i.e. empties at lower speeds) resulted in little or no required repairs to the side wings. Main wing repairs covered a range of about 60 inches. Frog nose repairs covered a range of about 40 inches. Research on how to best accommodate the wide range of service-worn wheels is needed.

Comparison of the locations of consecutive repairs on both the nose and main wing showed that repaired areas overlap about 90 percent of the time. This suggests that improvements in welding procedures and/or materials are needed.

The data is used as part of the Association of American Railroads' Heavy Axle Load Revenue Service Monitoring program. This digest looks at the performance of weld repairs, under the current baseline traffic of mostly 100-ton cars. As 110-ton car traffic is added, information will be provided on its effects on turnout frog performance. An earlier digest (TD94-001) reported on the life of rail-bound manganese frogs from this data.

#### **Suggested Distribution:**

Operating/Engineering Department —

- Maintenance of Way/Planning
- Planning and Analysis

Research and Development/Test Dept.



Association of American Railroads  
Research and Test Department

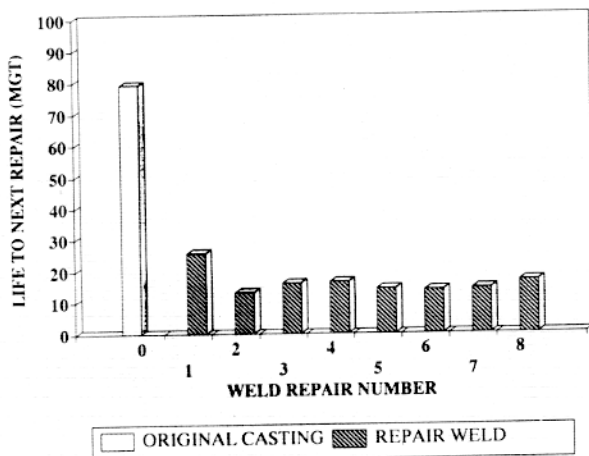


## INTRODUCTION AND CONCLUSIONS

In-track welding repair of rail bound manganese frogs is a commonly used maintenance practice. The frog is one of the most expensive components in a turnout and generally requires the most maintenance. About \$98 million is spent annually on turnout maintenance. Frog repair accounts for about \$21 million. Additionally, approximately 6000 frogs are replaced annually.

Fatigue of the running surfaces, by plastic flow, cracking and spalling, is a major cause of frog failure. In-track weld repairs are often done on the austenitic manganese castings. On high tonnage lines, often the repairs are done in intervals between trains. Thus, in-track repairs may create less train delay than frog replacement. However, when the deteriorated area becomes too large, the frog is replaced. Some railroads rebuild frogs; others scrap all frogs.

Exhibit 1 shows the various components of a frog's service life. The time to first repair is the largest component; averaging 79 million gross tons (MGT). The typical frog receives an average of 8 weld repairs with an average of 18 MGT between repairs. First weld repairs last 26 MGT on average. Subsequent repairs last an average of 15 MGT.



**Exhibit 1. Components of a Frog's Service Life.**

The life of special track work components is quite variable in general. The life of frog weld repairs is no exception. There are many factors which contribute to this variability including: quality of the frog casting; quality of the frog components and fabrication, turnout location, turnout track geometry, train operation scheme; frog maintenance (e.g. surfacing, bolt tightening, surface grinding), weld repair materials, weld repair procedure, and condition of frog.

Because of the unique operating pattern on the line, weld repairs occurred almost exclusively on the frog nose and main wing. The side wing, used by diverging route moves, suffered little damage. The loaded trains, all traveling eastbound, always hold the mainline at meets. Only empty trains use the diverging routes (sidings). The number of nose and wing repairs was about equal (150 to 131). Exhibit 2 shows the location of the leading edge of each repair (facing point move) as measured from the nose tip. One can see the wide range of repair locations from -20 to +20 inches on the wing and from 0 to 20+ inches on the nose. The locations of the leading edges of the wing repairs is centered on the frog nose point. The frog nose repair locations suggests a bi-modal distribution. There is a large mass of data at the tip of the nose and another mass centered at 8-12 inches. With average lengths of repair of 15 and 19 inches, the range of repaired areas is about 60 inches on the wing and 40 inches on the nose. This wide range suggests that the lateral location of the wheel on the rail and frog is not fixed; nor is the lateral location of the contact area on the wheel. Research into the design of frog/turnout rail surface profiles to accommodate service worn wheels is needed. The effects of hollow tread (i.e. "false flange") wheels are present in this data. However, they could not be isolated from the variables measured.

The approximate dimensions of weld repairs are presented in Exhibit 3. Some repairs extend through the full thickness of the casting. Exhibit 4 shows the repair material volume distribution by repair location. A significant portion of this volume is devoted to "building up" the running surface (i.e. replacing metal flow).



Further analysis of the repairs involved looking at each location separately. The data was divided into nose and wing repairs because investigation of the

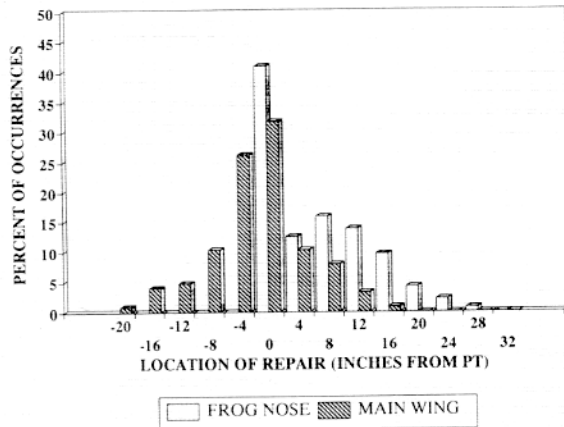


Exhibit 2. Location of Weld Repairs (Leading Edge).

Location	Nose	Main Wing
(Dist from nose tip) (in)	6	-3
Length (in)	15	19
Width (in)	0.8	1.4
Depth (in)	0.9	0.9
Volume (cu. in)	10.8	23.9
Weight (lbs)	3.1	6.8

Exhibit 3. Approximate Dimensions of Frog Weld Repairs.

short lived repair intervals showed that many were multiple day repairs. Often the frog nose was repaired one day and the main wing was repaired the next. Exhibit 5 shows the distribution of repair life (i.e. tonnage between repairs) for the nose and main wing. There is little difference in the life of main wing and frog nose repairs. They are 14.9 MGT and 16.9 MGT, respectively. The "tail" of the

distribution is most interesting in that these are the repairs that survived more than twice the average life.

The repairs that lasted less than one MGT are multi-day repairs on the nose or main wing. Some are repairs large enough to require two days. Others are repairs that cracked during or shortly after welding. These "early failure" repairs are symptomatic of lines that have insufficient track time available for in-track repairs.

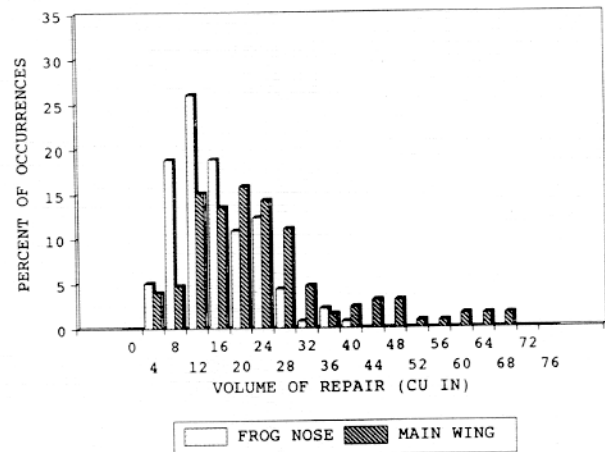


Exhibit 4. Volume of Weld Repairs.

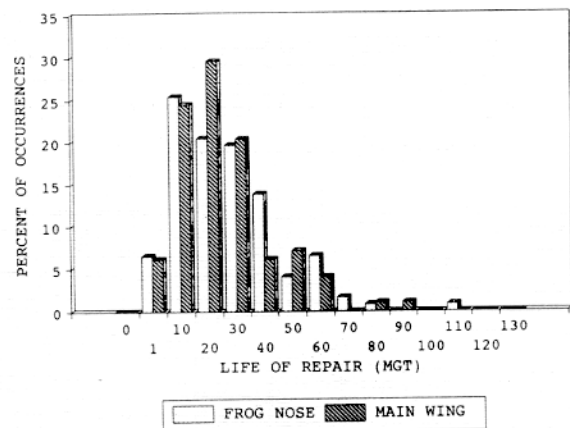


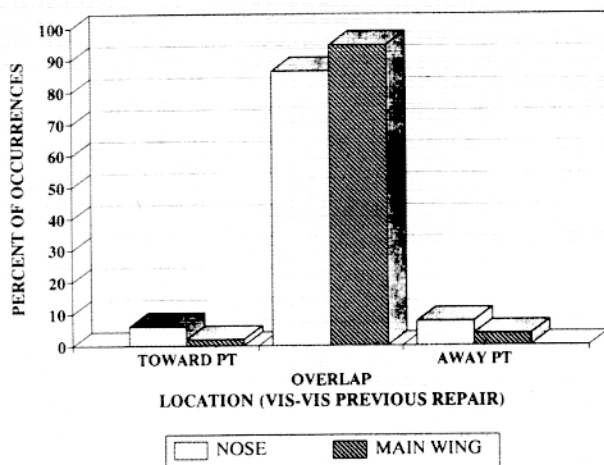
Exhibit 5. Life of Weld Repairs.

Comparison of the locations of consecutive repairs on the nose and main wing showed that repaired areas almost always overlap (Exhibit 6). Possible explanations for this phenomenon include:



- Weld repairs are incomplete. All of the damaged material is not replaced.
- The weld material is inferior to original casting.
- The weld repair process damages the underlying material.
- While the location varies from frog to frog, traffic on a given frog tends to damage the same areas, before and after repairs.

The effect of traffic direction was investigated and found to be negligible. Frogs that had loaded facing point moves behaved in the same manner as frogs with loaded trailing point moves.



**Exhibit 6. Location of Weld Repairs in Relation to Previous Repairs.**

The effect of season on weld repair performance was also investigated. However, no significant effect was found.

## TRAFFIC, TRAIN OPERATIONS, AND MAINTENANCE PRACTICES

Data presented in this digest was collected by C&NW on the Powder River Subdivision, between Horse Creek, Nebraska, and Shawnee Junction, Wyoming, over the past 10 years of operation. Traffic is almost exclusively unit coal trains. Annual tonnage for 1994 is expected to exceed 150 MGT on this line.

The line is single track with sidings. Speed limit on the line was originally 40 mph in each direction, but over the past two years it has been raised to 45 mph for loads and 50 mph for empties. Through the diverging routes of the No. 20 turnouts, speed is limited to 25 mph. As a general practice, when trains meet, loads hold the main line.

Several improvements have been made in frog maintenance on this line, including installation of longer guard rails, frog gage plates, larger frog base plates, and elastic fasteners. Warped switch ties are promptly replaced and tamping, welding, and grinding practices are continuously improving.

The maintenance practices on this line are considered to be among the best in the industry. Quality control is emphasized in field maintenance. A frog is removed from service when it is deemed more economical to replace than repair in track. Frog life results could be considerably different on routes with different traffic mixes, tonnage characteristics, and operating and maintenance practices.

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Note: Contact David D. Davis at (312) 808-5851 with questions or comments about this document.

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