TECHOLOGY DIGEST

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Grinding Tests on Standard Rail in a 6-degree Curve at FAST

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Summary

Grinding tests on standard rail in the 6-degree curve at the Facility for Accelerated Service Testing (FAST), Pueblo, Colo., have demonstrated that grinding can be successfully used to reduce internal rail defect development and improve rail surface conditions. Two grinding practices are being evaluated by Transportation Technology Center, Inc., along with rail that is not ground. The test rails have accumulated 292 MGT as of October 15.

Major findings from the test include:

- Grinding on standard rail has reduced internal rail defect development and improved surface conditions.
- Grinding standard rail to remove surface damage has increased rail life in the test curve at FAST, based on criteria typically used in determining when rail should be replaced because of defects.
- Metal loss has been higher in the ground zone. Extended grind intervals could likely reduce this penalty without increasing defect development.

The tests have been conducted on the 2.7-mile High Tonnage Loop at FAST. A train, consisting of 70 loaded coal hopper cars, each weighing approximately 315,000 pounds, is being operated. The cars are equipped with three-piece trucks typical of those widely used in revenue service. The grinding test rails were rolled in 1999 from clean, continuously cast standard steel with hardness of 320 Bhn.

The tests are being performed through a joint effort between the Association of American Railroads (AAR) and the Federal Railroad Administration (FRA). The rail-grinding test is part of a larger overall program that examines the effect of heavy axle load cars on various track components. The goal is to improve railroad safety and productivity.

Suggested Distribution:

- ❑ Maintenance of Way
- ❑ Planning & Analysis
- ❑ Track Maintenance
- ❑ Safety

Work performed by TTCI Transportation Technology Center, Inc.
a subsidiary of the Association of American Railroads

INTRODUCTION AND BACKGROUND

A number of rail grinding experiments have been conducted at FAST to examine the effects of different rail grinding strategies on rolling contact fatigue on rail with different metallurgies.[1] During the early tests, rail surface defects, shells, and detail fractures occurred on both the standard and premium rails available at that time, regardless of the grinding strategy. Results of these tests were inconclusive as they varied as a function of rail cleanliness, rail lubrication, and track curvature.[1] A more extensive test began in 1994 and showed that clean premium rail is resistant to internal fatigue defects. None of the rail in the 5- and 6-degree test curves, whether ground or non-ground, developed any internal fatigue defects, but the surface condition of the rail that had been ground was better.[2] The non-ground rail still in the 5-degree curve has now accumulated 875 MGT and had less total metal loss than the ground rail did when it was removed.

As the tonnage on the premium rail in the 6-degree curve at FAST approached 550 MGT, and profile grinding on this type of rail appeared to improve surface conditions, the Heavy Axle Load Research Committee (HALRC) directed TTCI engineers to plan the next test. The test would examine the effects of various grinding practices on current generation standard rail. Though premium rail is typically installed in curves on high tonnage lines, a significant amount of standard rail is still in place.

A technical advisory group (TAG) was formed to provide direction in the development of the test. A 2,080-foot portion of the 6-degree curve was divided into three zones (Exhibit 1) to evaluate the grinding practices recommended by the TAG:

1. Preventive Zone: lightly ground at 17.5-MGT intervals.
2. Corrective Zone: ground when surface conditions warrant.
3. Control Zone: not ground unless safety would otherwise be compromised.

RESULTS OF CURRENT GENERATION STANDARD RAIL

To date, the rail has accumulated 292 MGT of traffic. This rail is harder (320 Brinell Hardness) and cleaner (continuous cast) than the standard rail used in previous tests. Two grinding practices are being evaluated, along with rail that is not ground.

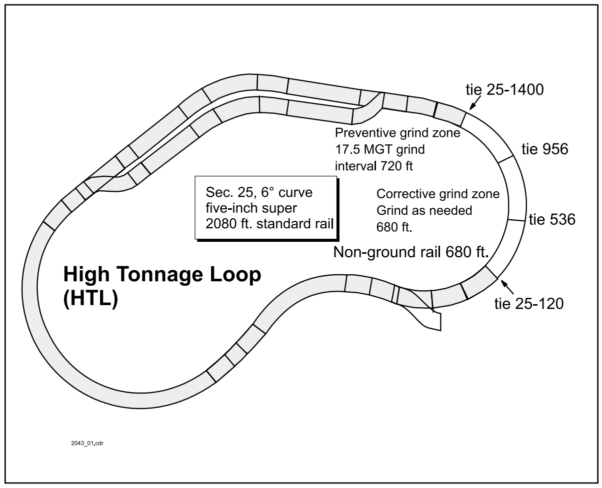

Exhibit 1. Standard Rail Grind Test Locations on HTL

Preventive Grind

The preventive grind zone was ground every 17.5 MGT for the first 200 MGT. At that time, the grind interval was increased to 25 MGT to reduce total metal loss. The gage corner of the high rail was lightly ground, and slight metal flow to the field side was removed. The low rail was ground to restore an 8-inch crown radius. There have been no fatigue defects in the preventive ground zone. The surface condition of the rail in this zone is better than in the other zones, as Exhibit 2 shows, and was generally good even at the time of grinding (at both the 17.5 and 25 MGT intervals). There is more total metal loss (combination of wear and grinding) in this zone compared to zones 2 and 3 (Exhibit 3). However, this does not mean that rail life would be shorter than that of the non-ground rail. Many railroads remove rail when defect rates reach or exceed three to four defects per mile per year. Based on this criterion, the rail in the non-ground zone would have been removed, while the preventively ground rail still had over one-half of its wear life remaining.

Corrective Grind

The corrective zone was ground at 135 and 239 MGT to remove gage corner checking and metal flow to the field side on the high rail. The low rails were quite flat both times the rail was ground, and there was flaking on the field side. The crown radius of the low rails was restored to 8 inches. Some light corrugations on the low rail near a field weld were removed during the first grind. One 80-foot rail was removed from this zone

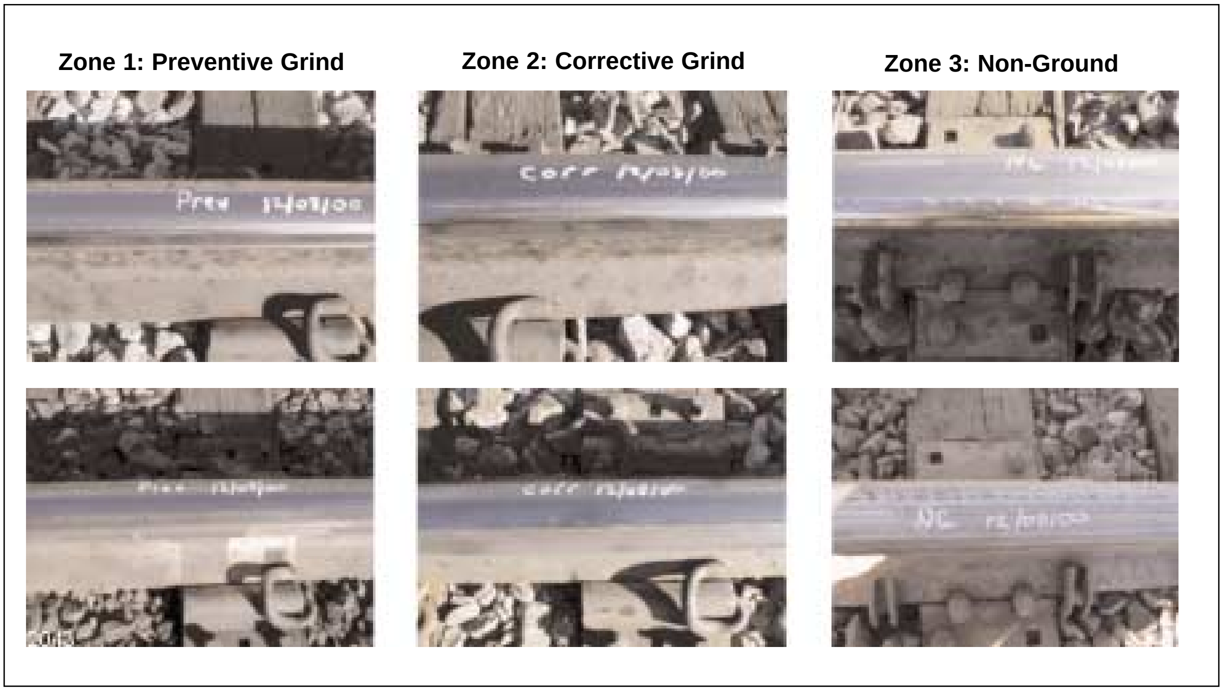

Exhibit 2. High (top) and Low (bottom) Rail Surface Conditions

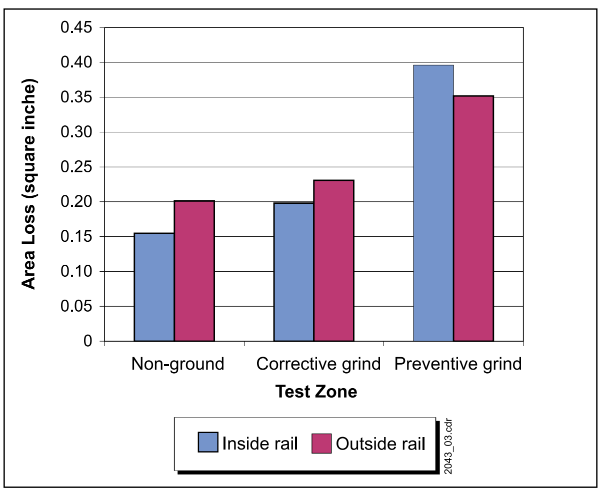

Exhibit 3. Area Loss Comparison for Grind Zones

after 132 MGT due to numerous gage corner defects and one shell. Given that similar defects did not develop on the adjacent rails, is likely that this rail was not as clean as the rest of the rail in the test. Metallurgical evaluations conducted by the manufacturer were inconclusive, but the manufacturer also believes that rail cleanliness was a factor. There have been no other rails removed from the corrective zone due to fatigue defects. The surface condition of the rail tends to be better than in the non-ground zone, and not as good as in the preventively ground zone (Exhibit 2).

Non-Ground

The "non-ground" rail was ground after 239 MGT. Four gage corner defects had been removed from this zone at the time of grinding, with the first defect occurring at 129 MGT. One defect has occurred since the rail was ground. In addition, the rail in this section had the worst surface conditions prior to grinding (Exhibit 2). The low rail was very flat with flaking on the field side, and there was heavy gage corner checking and light spalling on the high rail. Grinding removed most of the damage on the high rail, but some cracks remained. The low rail was restored to an 8-inch crown radius, and again most, but not all, of the surface damage was removed.

CONCLUSIONS

Both grinding practices being evaluated at FAST — preventive and corrective — reduced the occurrence of fatigue defects in standard rail in a 6-degree curve.

- The life of standard rail can be extended with profile grinding.
- The preventive grinding practice provided the best surface conditions and the most metal loss. Extended grind intervals could likely reduce this

penalty without increasing defect development. Rail condition has been as good with the rail ground at 25 MGT intervals as when it was ground at 17.5 MGT intervals, and metal loss (by grinding) was reduced.

OBSERVATIONS

(From this test and other tests.[3])

- There is no one-size-fits-all grinding strategy that can produce optimum results. Local conditions to be considered include:
  - Rail quality and condition
  - Curvature
  - Environmental (moisture) conditions; moisture may increase crack growth, and the need for grinding
  - Load environment
  - Wheel profiles
- Other tests have shown that where the wheel and rail profile do not match due to excessive high-rail gage corner grinding, curving performance can be degraded. Railroads should closely monitor and evaluate their wheel/rail profile maintenance practices to avoid hampering beneficial vehicle curving forces.

FUTURE GRINDING TESTS AT FAST

The next grinding test is being planned, again at the direction of the HALRC. Previous profile grinding tests at FAST have indicated that premium rail is resistant to internal fatigue defect development whether ground or non-ground, but that grinding does improve surface conditions. Rail wear testing at FAST has shown that bainitic rail is more resistant to surface damage than premium pearlitic rail, but wears faster under very lightly lubricated conditions. Testing in revenue service has also shown better surface conditions for bainitic rail, but less of a wear penalty when the rail is well lubricated. The next test will evaluate three conditions/practices:

1. Premium rail in a lubricated 6-degree curve, preventive grind
2. Premium rail in a lubricated 6-degree curve, non-ground
3. Bainitic rail in a lubricated 6-degree curve, non-ground

This test should help answer some of the remaining questions on the performance of bainitic rail relative to ground and non-ground premium pearlitic rail.

REFERENCES

1. Sawley, Kevin, August 1999,"North American Rail Grinding: Practices and Effectiveness," AAR, TTCI report No. R-928, Pueblo, CO.

2. LoPresti, Joseph and Semih Kalay, May 1999. “Effects of Rail Grinding Practices on Wheel/Rail Performance under 39-ton Axle Loads,” *Technology Digest*, TD99-015, AAR, TTCI, Pueblo, CO

3. Sawley, Kevin. January 1999,”North American Rail Grinding on Curves in Track,” *Technology Digest*, TD99-004, AAR, TTCI, Pueblo, CO.

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