TECHNOLOGY DIGEST

Timely Technology Transfer

"THE EFFECT OF FLANGE BEARING FROGS ON LOCOMOTIVE OPERATION"

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TD 97-009

Summary

The Association of American Railroads (AAR) is examining an Advanced Crossing Diamond program concept called the Flange Bearing Frog (FBF) to determine its effects on locomotive wheel slip and control circuits for a range of locomotive types. Although locomotive control circuits are affected, data suggests locomotives can be safely operated over FBFs provided existing operating restrictions for conventional crossing diamonds remain in effect. This includes throttle reductions when locomotive trucks are over the FBF limits. Tests were conducted at the Transportation Technology Center, Pueblo, Colorado as part of a larger program evaluating the FBF.

Test results indicate state-of-the art AC and DC locomotives incorporating sophisticated wheel slip controls are less affected when operating over a FBF than older DC locomotives, which incorporate more conventional wheel slip and power controls. At speeds greater than 25 mph, all locomotive types show less effect over FBFs and could be operated with fewer restrictions.

Present rules followed by most railroads for DC traction locomotives operating over crossing diamonds are based on recommendations from locomotive builders. The primary restriction requires reducing throttle position to notch 4. If throttle position is already at 4 or less, a reduction by 1 notch is recommended. The intent of this rule is to reduce power to the traction motors; thus, preventing traction motor brush flashover when traveling over the gap associated with conventional crossing diamonds.

No metallurgical damage or control system damage was noted during testing, even when brief wheel slip, sliding, or other adverse conditions occurred. Before the FBF concept can be considered a viable alternative to conventional crossing diamonds, other issues must be addressed. Train operations, wheel flange damage, FBF materials, and design issues are other areas which are being evaluated by the AAR.

Suggested Distribution:
- ❑ Operating Department
- ❑ Engineering Department
- ❑ Mechanical Department
- ❑ R&T Department

Association of American Railroads
Railway Technology Department

March 1997

INTRODUCTION/CONCLUSIONS

The Association of American Railroads (AAR) is evaluating the Flange Bearing Frog (FBF), an Alternative Crossing Diamond research program concept, for potential use in heavy haul freight railway applications. Tests were conducted at the Transportation Technology Center, Pueblo, Colorado as part of a larger program evaluating the FBF. The use of FBFs could significantly reduce track maintenance and track delays by eliminating running surface gaps associated with conventional crossing diamonds. Industry users and suppliers of locomotives raised concerns that the use of FBFs, due to the need for tread-to-flange transitions, would adversely affect the locomotive control circuits and could induce wheel slip.

In this test, the FBF concept was evaluated for potential damage to locomotive control circuits and for its tendency to introduce wheel slip; AC locomotives were of specific concern. It was anticipated that tread-to-flange transitions over a FBF could disrupt the synchronous control of wheels needed to provide maximum tractive effort.

No metallurgical damage or control system damage was noted during testing; even when brief wheel slip, sliding, or other adverse conditions occurred. Areas of train operations, wheel flange damage, FBF materials, and design issues are also being evaluated by AAR. These issues must be addressed before the FBF concept can be considered a viable alternative to using conventional crossing diamonds.

LOCOMOTIVE MATRIX

A technical team of railroad, AAR, and locomotive builder representatives was formed to develop a test plan and specify the locomotive types to be tested. Proprietary control systems of state-of-the-art locomotives from General Electric (GE) and Electro-Motive Division (EMD) were considered to be sufficiently unique from one another that an example of each technology should be evaluated. As testing progressed, it became apparent that older type locomotives (DC) would also require evaluation and were added to the test matrix. Most locomotives utilized for this test were loaned to the AAR by its member railroads. Locomotives not being tested were utilized as braking units to simulate the resistance of trailing tonnage. Locomotives types tested were:

GE-C44AC-9 (AC traction)
EMD-SD90MAC (AC traction)
GE-C44-9
EMD-SD70
EMD-SD40-2, with Maxi-trac
EMD-GP9
EMD-GP38
GE-U30C

TEST RUN MATRIX

A test matrix was formulated to replicate operating rules currently in effect over crossing diamonds. If no locomotive control problems occurred, additional test runs were planned to determine if fewer or no restrictions over FBFs would be necessary. A survey of railroad operating practices over conventional crossing diamonds indicates operating rulebooks frequently require locomotives, when in throttle position over 4, to reduce to position 4 eight to ten seconds before a crossing diamond. If in notch 4 or less, rulebooks require a reduction by 1 notch. Trains may return to normal operation after all locomotives have completed travel over the crossing diamond. The primary reason for reducing throttle position and using less power over the crossing diamond is to reduce electrical power being applied through the DC traction motor brushes while crossing the transverse rail of the crossing.

During TTC tests, all locomotives were operated over a simulated full-length FBF at speeds from 5 mph to 60 mph. All locomotives were operated through the following test matrix:

- Coasting (idle throttle position)
- Approach in power, reduce to notch 4 over FBF

- Dynamic brake operation: full and notch 4
- Full throttle (notch 8)
- Operation with purposely contaminated flangeway

In order to generate full-throttle power while limiting tonnage over the FBF, trailing car weight was created by using a consist of locomotives in various dynamic brake and throttle positions.

CONFIGURATION OF THE SIMULATED FBF

The simulated FBF consisted of custom-machined filler blocks and guard rails. The filler blocks were modular; thus, a variety of ramp rates and FBF lengths could be simulated. Most test runs were conducted with 20 foot ramps (1-inch rise in 20 feet) and a 6-foot level center section that simulated the possible running surface profile of a typical 90-degree FBF crossing. Exhibits 1 and 2 refer to these test conditions.

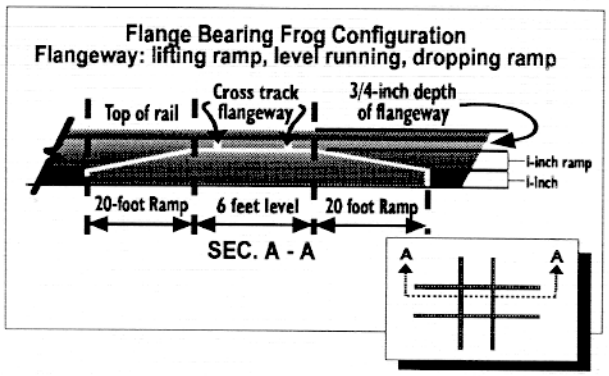

Exhibit 1. Cross Section Showing Running Profile

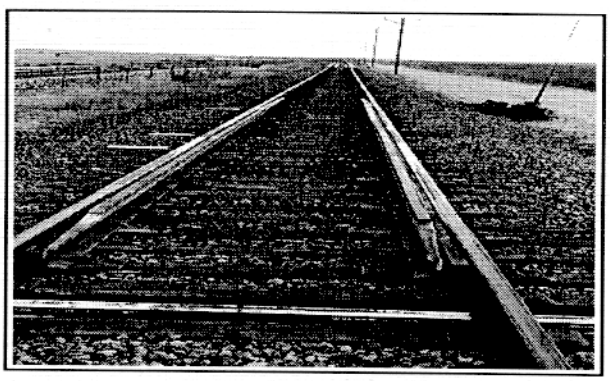

Exhibit 2. Simulated FBF Components

MEASUREMENTS AND DATA

Before and after testing, all locomotive wheels where inspected visually and with NDT magnetic particle techniques. They were also measured for cross section profiles. Data collection for the two AC locomotives (SD-70 and C44-9) was performed by representatives from their respective builders, GE and EMD. This included tractive effort, traction motor current and/or voltage, wheel slip, wheel speeds, and other proprietary information. These characteristics were collected directly from on-board control systems for analysis after testing. Only generic findings are presented as this data includes proprietary information on critical locomotive control systems. Data was collected on the older generation DC locomotives by visual observation and logging of traction, dynamic brake ammeter indications, and wheel slip indicator.

Exhibit 3 shows the average truck speed for an AC locomotive during a 40-mile per hour run. The time period between approximately 2.2 seconds and 2.6 seconds indicates a drop in effective wheel rpm; this represents the time a truck would be over a FBF. When transitioning from tread to flange bearing, the diameter of the wheel suddenly increases by 2-3 inches (5-7 percent of a 40-inch diameter wheel). The wheel's rotation rate decreases by a corresponding amount.

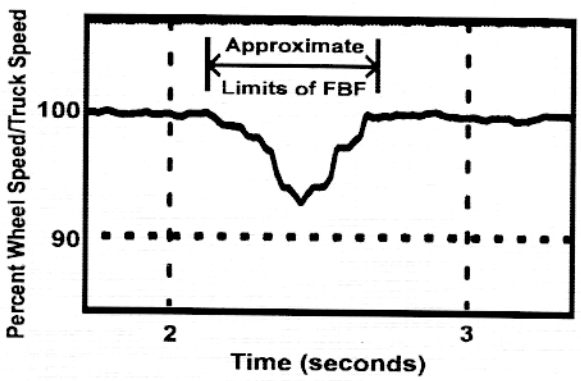

Exhibit 3. Sample Data from AC Locomotive Truck

The effect of operating on wheel flanges instead of wheel tread is interpreted by the control system as a slower moving truck, although the truck never

changes speed with respect to the ground. This apparent momentary slow down of wheel speed was a concern; especially with AC locomotives. However, neither locomotive vendor reported any adverse effects to the control systems from these short duration events.

Older DC locomotives were not equipped with computerized control systems; thus, manual reading of ammeters was required. Notes were made of downrating, amperage, and wheel slip during each run. An example of a series is shown in Exhibit 4.

Exhibit 4. Amperage of DC Locomotive During FBF Transitions at Different Speeds

Location on FBF	Ammeter at throttle/speed setting		
	4/5	8/5	8/20
Prior to FBF	650	1050	640
Over FBF	425	0*	240
20 feet past FBF	475	*	240
300 feet past FBF	550	*	640

*Throttle position 8/5 mph caused locomotive to stall; download to 0 amp within first 5 feet of FBF ramp.

RESULTS

Results of testing indicate the following restrictions and concerns when operating locomotives over flange bearing frogs:

- All locomotives can be operated at speeds of 20 mph to 60 mph without throttle restrictions.
- At speeds of under 20 mph, DC locomotives should follow existing throttle reduction guidelines.
- Similar performance was observed under dynamic braking.
- Coasting causes no problems with any locomotive type.
- AC locomotives are less affected than DC locomotives.
- Older DC units exhibit rapid derating at high tractive effort/low speeds.
- Contaminated flangeways increase tendency for wheel slip and derating.

The introduction of FBFs will not adversely effect locomotives and they could be incorporated into the existing population of conventional diamonds by maintaining current throttle reduction rules. Should a railroad wish, more specific rules could allow all locomotives to be operated at speeds greater than 20 mph over FBFs without restriction. This would require train crews to know the location of FBFs and act accordingly.

Note: Contact Rich Reiff at TTC (719)584-0581 with questions or comments concerning this document (E-mail: richard_reiff@aar.com).

A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH THE AAR, PUBLICATION ORDER PROCESSING, 50 F STREET, NW, 5TH FLOOR, COG, WASHINGTON, D.C.,20001