FAST Facility for Accelerated Service Testing
HAL Heavy Axle Load

WELCOME TO THE FAST/HAL OPEN HOUSE WORKSHOP

PHASE II

September 15-16, 1992

TRANSPORTATION TEST CENTER

PUEBLO, COLORADO

ACKNOWLEDGEMENT

The FAST program has been made possible through the dedicated efforts of many individuals and companies. The annual operating funding of $3.7 million comes jointly from the Association of American Railroads and the Federal Railroad Administration. Significant donations of materials and equipment are supplied by member railroads and supply companies. This saves the FAST program over $1.5 million in operating expenses each year.

Recognition is also given to the dedicated support staff at the Transportation Test Center. Their support is essential to the successful operation of FAST, along with staff members at the Chicago Technical Center and headquarters in Washington D.C. Finally, we would like to thank the FAST Steering Committee for the overall technical direction provided from its members of railroad, supply and government representatives.

The success of the FAST Program is made possible through the combined support of all these people, and the financial assistance received.

ASSOCIATION
OF AMERICAN
RAILROADS

FAST Facility for Accelerated Service Testing

HAL Heavy Axle Load

U.S. Department
of Transportation

**Federal Railroad
Administration**

**Transportation
Test Center**

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Part 1

FAST/HAL Overview

Where have we been ...
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...by Richard P. Reiff
FAST Manager

Where have we been...

The FAST program has been in operation since late 1976, accumulating well over 1 billion gross tons of traffic on various configurations of a closed loop. A significant data base on the response of conventional track materials has been gathered and published in numerous technical reports, as well as presented in a number of technical sessions.

The original FAST program was operated with conventional freight car equipment, using standard three-piece trucks and 100-ton capacity equipment. The consist for the first 11 years was made up primarily of 100-ton capacity cars of a standard design, with occasional introduction of cars with self steering trucks, along with TOFC, tank and other non-bulk commodity equipment for short test periods.

In 1985 funding for the FAST program, which had been solely provided by FRA, was supplemented with AAR funds. As FRA funding was gradually being reduced over the ensuing years, AAR funding was increasing. Now the annual FAST operating budget is equally shared between FRA and AAR. It should be pointed out that the railroad and supply industry contribute a significant amount to the program as well, in the form of donated/loaned equipment, materials and technical personnel.

The last 160 MGT of the 100-ton car era on FAST was conducted from 1985 to 1987. This introduced the shorter High Tonnage Loop, which was constructed in an effort to reduce costs and make FAST become more efficient in the application of MGT's. This last 160 MGT, using a consist of entirely 100-ton capacity equipment, became the "baseline" for comparison purposes when the axle load was to be increased.

In 1988 the FAST train was reconfigured to a heavier axle load, using what was considered at that time to be 125-ton capacity equipment. The axle loading, per car, increased from 33 tons to 39 tons. Subsequently, an identical 160 MGT comparison period was operated, where track experiments conducted during the last 160 MGT with 33-ton axle load equipment were repeated as closely as possible. Data was carefully collected and analyzed during these two periods.

Each 160 MGT period was operated over essentially the same track components, using the same maintenance techniques. Results provided insight into the effect of increasing axle loads on existing track structure.

Where are we now...

Results reported at the October 1990 open house indicated that heavier axle loads could be operated over conventional track, but that more rapid and severe deterioration would occur. Areas showing the most immediate impact included rail, turnouts, welds, and spot maintenance. Other areas of the track indicated possible effects, but could not be adequately defined in the limited 160 MGT period. Therefore, the FAST program was extended to define these areas, which include rail grinding, track support/maintenance, wood ties, concrete ties and ballast. Improved components also are being evaluated where a definite impact from HAL traffic was noted. Advanced design turnout geometry, frog materials, improved field welds, various rail metallurgies and heat treatments, and monitoring of subgrade loads under a variety of support conditions are included for the components tests.

New areas of investigation, such as concrete tie rail seat abrasion, observed on revenue service lines with heavy traffic, and the loads on crossing frogs also were added.

Where are we going...

Continued MGT application is scheduled until early 1994, at which time the present consist will be upgraded. New and improved components, which are designed to better withstand the rigors of the HAL environment, will be cycled into the FAST track for evaluation when they are offered and track space becomes available.

To date, all 33- and 39-ton axle load traffic has been applied using conventional, standard three-piece freight car trucks. The HAL train is essentially 100-ton type equipment "scaled up." This includes larger bearings, wheels and reinforced car bodies. However, there has been no change in suspension design from conventional equipment. The resulting dynamic loads into the track have been shown to be quite high, suffering in many cases from a basically crude suspension.

The future direction of FAST includes the complete replacement of existing trucks with those of improved design, but still supporting a 39-ton type axle load. The design of these trucks, several of which are currently undergoing evaluation, will reduce dynamic loads into the track structure.

The next phase of FAST, which is presently scheduled to start in late 1994, will repeat selected experiments on the track to determine the actual reduction in component wear, fatigue, and track maintenance, when a HAL train of "advanced" suspension is operated. Thus the present operation of HAL will become the new baseline for comparing future data under a train of superior trucks.

TODAY'S AND TOMORROW'S AGENDA

Today we will be hearing updates from all major test programs being conducted on the FAST loop. These updates represent major findings since the October 1990 open house, which reviewed data for the back-to-back comparison periods of 33- to 39-ton axle loads.

Many tests include significant new material, such as turnouts and concrete ties, and this data will also be included.

Tomorrow you will have the chance to observe firsthand the track components and train that has created the information presented. TTC's FAST engineering staff will be available on the track to answer specific questions and to point out details on components under test, or in some cases components removed from test due to failure.

I trust that these two days will be of benefit to you not only for your current operations, but useful in planning and preparing your railroad for future increases in axle loads.

FAST/HAL OPEN HOUSE

SEPTEMBER 1992

Results of evaluating improved track components under heavy axle load traffic... an update

Association of American Railroads

U.S Department of Transportation Federal Railroad Administration

FAST/HAL PROGRAM OVERVIEW

WHERE HAVE WE BEEN?

- FAST history
- HAL overview, objectives
- Summary of first 160 MGT of testing

FAST/HAL PROGRAM OVERVIEW

Phase I

Goal: To measure the performance of the track structure subjected to traffic from 315,000 lb. cars, and to compare that performance to earlier FAST tests.

Phase I

Plan: To operate at least 150 MGT of heavy axle load traffic on the FAST High Tonnage Loop, duplicating, as closely as possible earlier FAST experiments.

FAST/HAL PROGRAM OVERVIEW

Phase I

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Plan: To operate at least 150 MGT of heavy axle load traffic on the FAST high tonnage loop, duplicating, as closely as possible earlier FAST experiments.

FAST/HAL PROGRAM OVERVIEW

Consist History

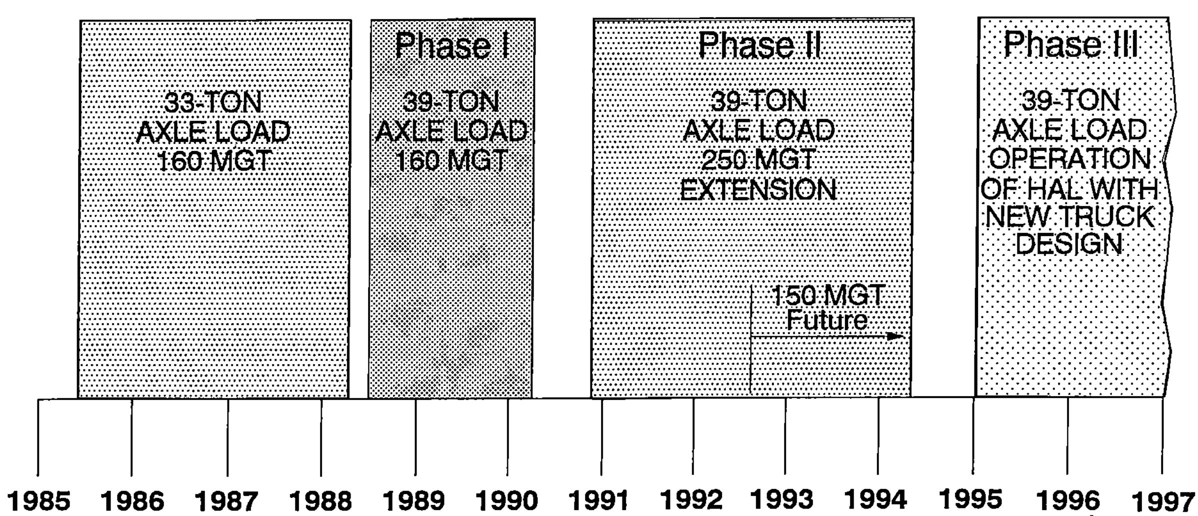
100-ton capacity car train: 1976-1988

1976-1985 Full 4.78 mile loop

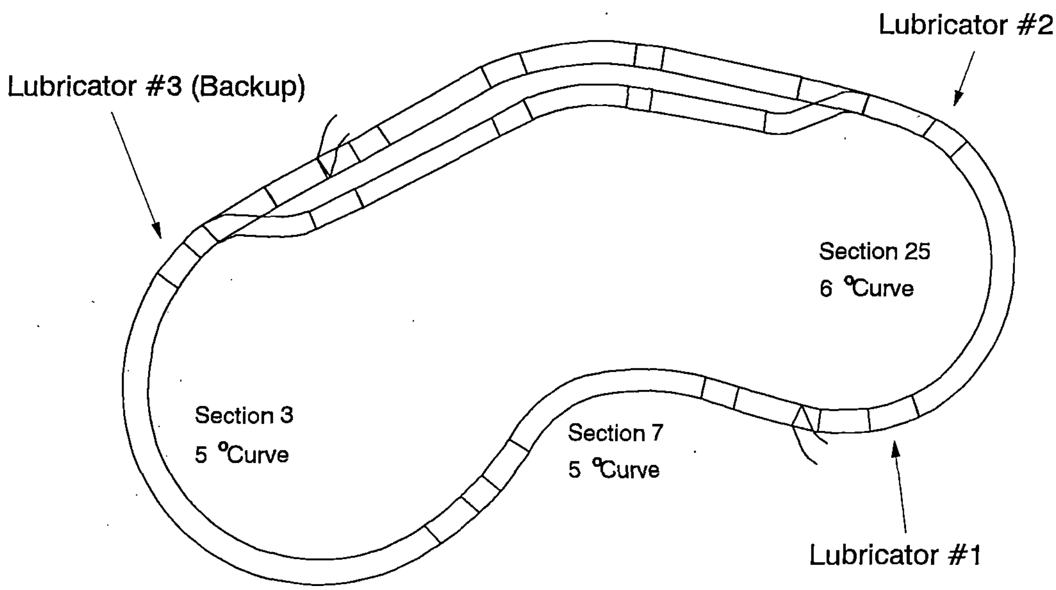
1985-1988 Shortened 2.7 mile loop "HTL"

125-ton capacity car train: 1988 to present, on "HTL"

FAST HIGH TONNAGE LOOP MILESTONES



High Tonnage Loop (HTL)



HOW MUCH DOES A "100-TON CAR" WEIGH?

Glossary of terms for car weights and axle loads

Common Name	Actual Configuration
100-Ton Car	100 Tons of Lading
	31.5 Tons of Empty Car Weight
	131.5 Tons on the Rail
	263,000 lbs on the Rail
	33,000 lbs per Wheel (33 KIPS)
	36" Diameter Wheel
	33-Ton Axle Load

FAST/HAL PROGRAM OVERVIEW

HOW MUCH DOES A "125-TON CAR" WEIGH?

Glossary of terms for car weights and axle loads

Common Name	Actual Configuration
125-Ton Car	124.5 Tons of Lading
	33 Tons of Empty Car Weight
	157.5 Tons on the Rail
	315,000 lbs on the Rail
	39,000 lbs per Wheel (39 KIPS)
	38" Diameter Wheel
	39-Ton Axle Load

OPERATION OVERVIEW

- 2.7 mile loop
- 40 MPH
- 1 MGT in each direction
- Train orientation changed every 2 MGT
- Lubricated, except to dry down every 3 MGT for rail flaw inspection
- Train configuration:
  - 70-75 39 ton axle load cars
  - 3-5 33 ton axle load cars
- 5 locomotives
- Average of 13,500 tons per trains

FAST/HAL PROGRAM OVERVIEW

Typical Rail Coefficient of Friction Values
Measured at Various Locations on the HTL

Location	Low Rail Head	High Rail Head	High Rail Gage Face
Sec. 03	0.45	0.33	0.20
Sec. 07	0.36	0.50	0.35
Sec. 25	0.35	0.30	0.15
Sec. 31	0.35	0.35	0.20

LIMITATIONS OF DATA FOR ALL EXPERIMENTS

- All loaded traffic - no empties, light cars
- Same speed for all trains - 2" overbalance all curves
- Balanced loaded traffic in each direction
- Lubricated rail
- No train braking
- Conventional 3 piece trucks

FAST/HAL PROGRAM OVERVIEW

Major Test Areas:

- Rail
- Ties
- Fasteners
- Ballast
- Turnouts
- Track Support and Geometry
- Wheel Performance

Phase I - 160 MGT of traffic

- Comparison with a similar period using 100 ton consist
- Back to back testing of components
- Conventional materials, methods

FAST/HAL PROGRAM OVERVIEW

Summary of First 160 MGT

Heavy Axle Loads can be operated over conventional track, using existing maintenance techniques

However:

- Where deterioration occurred
  - accelerated degradation
  - more severe degradation

Maintenance Issues

- Inspection techniques
- Track time to permit quality work
- Upgrading/training of personnel
- Premium materials
- Component quality

FAST/HAL PROGRAM OVERVIEW

General observations in operating 125-ton train vs. 100-ton train

- Significant and rapid degradation of all track components with surface anomalies
    - Turnouts, frogs
    - Mechanical joints (insulated and bolted)
    - Low spots
    - Engine wheel burns
- Rail lubrication more difficult to maintain

General observations and results of test

- Maintenance demand increased
    - Increased out of face grinding
    - Increased welding (buildup)
    - Spot items require more immediate attention -- cannot be "deferred" until next shift
    - Increased failure rate of field welds

FAST/HAL PROGRAM OVERVIEW

HAL test results identified key areas where increased axle loads had definite effect on performance of existing components:

Turnouts

- design
- materials

Field Welds

- materials
- personnel training
- techniques

New test areas where first phase of HAL test results indicate that possible problems could exist. New tests address:

Low Modulus Track

- track maintenance
- rail fatigue
- geometry retention

Concrete Tie Rail Seat Abrasion

Alternative Wood Tie Design/Materials

AGENDA FOR THE REST OF TODAY

- **FAST/HAL Experiment Reviews**
  - Update of experiments from 1990 Open House - 100 MGT update
  - Review results of new experiments
- **Future FAST/HAL Investigations**
- **Summation**
  - Conclusion and General Questions Session

Part 2

FAST/HAL Experiment Reviews

Since the 160 MGT Open House

"Rail Grinding Experiment," by Jon S. Hannafious
"Rail Wear Experiment," by Glenn H. Brave
"Rail Weld Performance Experiment," by Glenn H. Brave
"Wood Tie and Fastener Experiment," by M. Carmen Trevizo
"Concrete Tie Rail Seat Abrasion Experiment," by Scott E. Gage
"Ballast Experiment," by M. Carmen Trevizo
"Low Track Modulus Experiment," by David M. Read
"Load Path Evaluation Experiment," by M. Carmen Trevizo
"Turnout Performance Experiment," by Jon S. Hannafious
"Frog Performance Experiment," by Jon S. Hannafious
"Crossing Frog Experiment," by Duane E. Otter
"Mechanical Component Performance Experiment," by Robert L. Florom
"Rail Rollover Derailment Experiment," by Stephen E. Mace
"HAL Alternative Suspension System Experiment," by Curtis L. Urban
"New Car and Truck Performance Experiment," by Robert L. Florom

FAST HAL

RAIL GRINDING EXPERIMENT

By Jon S. Hannafious
Experiment Manager

TRANSPORTATION TEST CENTER
PUEBLO, COLORADO

FAST/HAL RAIL GRINDING EXPERIMENT

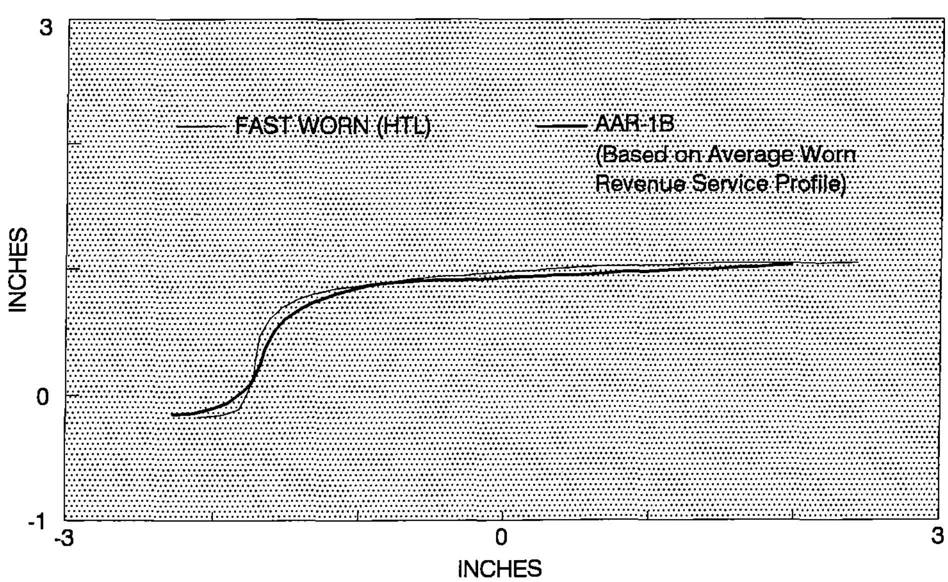
OBJECTIVE: To gain insight into optimizing rail life through varying rail grinding practices.

More specifically, the objective is to determine the effect of the following on the occurrence of fatigue defects (in standard 300 BHN rail in 5-6 degree curves under lubricated conditions):

- Rail Profile: Two point and conformal high rail contact
- Metal removal rate: 2mm/100 MGT and 4mm/100 MGT
- Grinding interval: 12.5 vs. 25 MGT

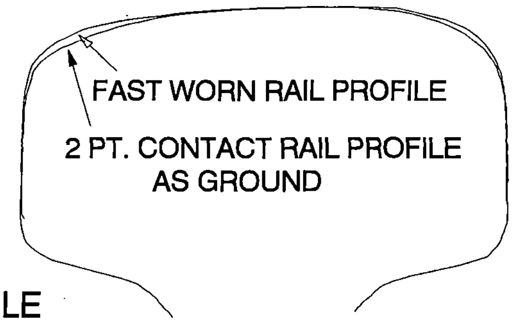
Note: Standard rail was used in order to obtain quick results.
If Head Hardened rail was used, experiment could last up to 500+ MGT.
Test is currently at 100 MGT.

FAST WHEEL PROFILE VS. AAR1B WHEEL PROFILE



Profiles are different probably due to large percent of curves on HTL.
New wheels are AAR 1:20. Used wheels were turned to AAR1B.

PROFILE DESCRIPTIONS



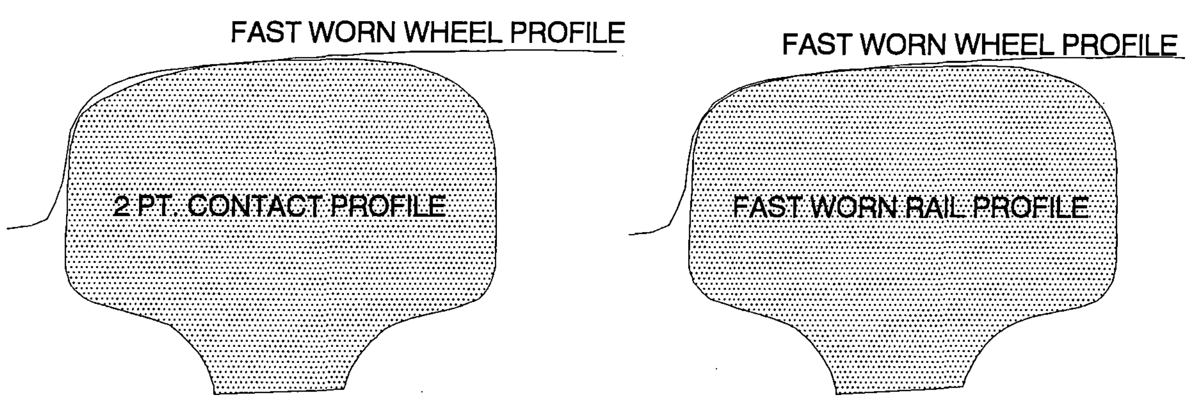
WORN PROFILE

Distributes contact stresses evenly
Grinding is controlled with the use of a metal removal gage

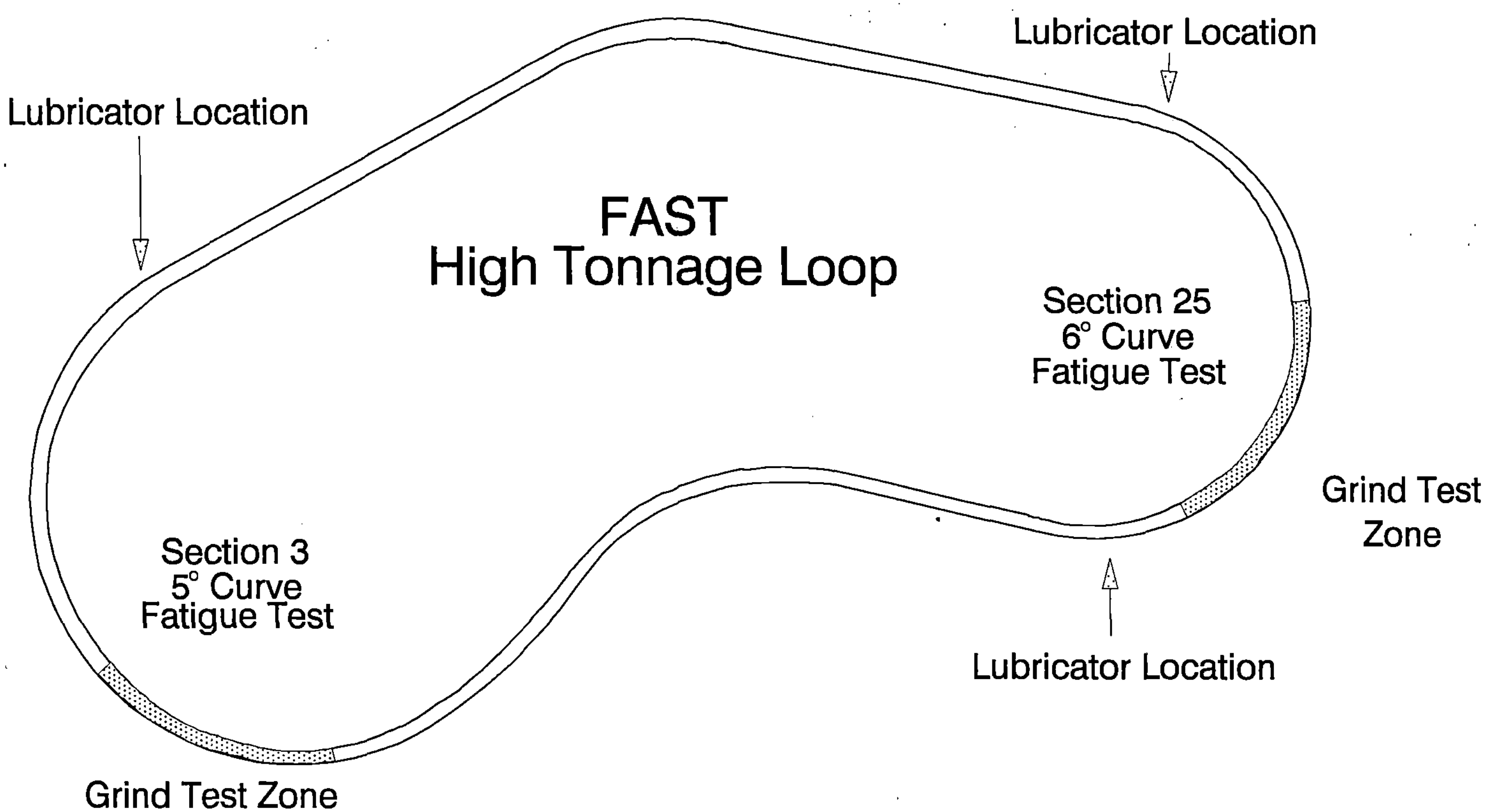
2 PT. CONTACT PROFILE

Protects gage corner by unloading
Recommended by Loram, developed by NRC
Polled RRs for profile, difficult to obtain recommendation
Not designed for FAST, but does create 2 point contact
Practiced by several major railroads
Grinding performed with the Loram Bar gage which is essential

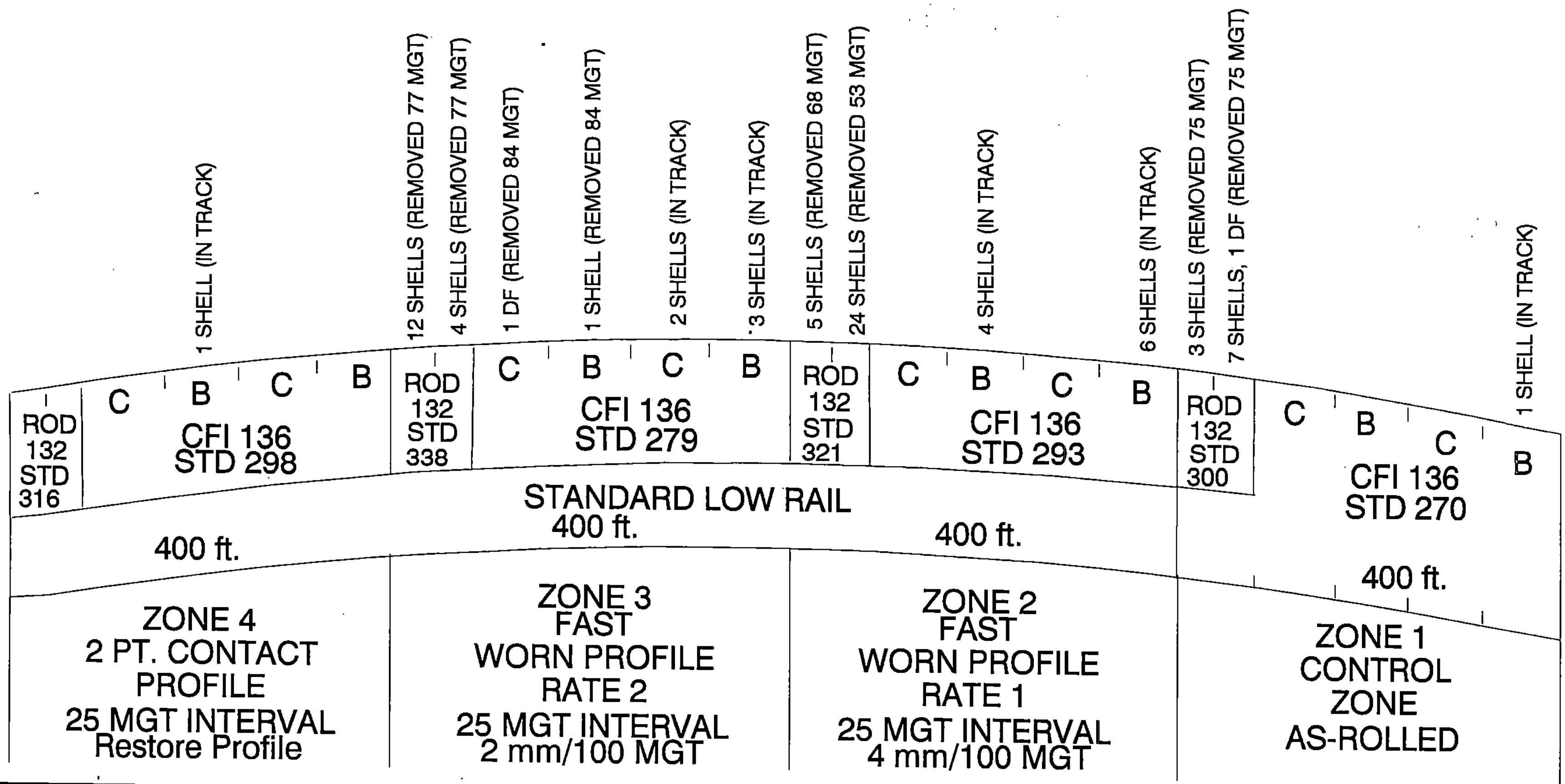
FAST WHEEL PROFILE OVERLAID ON TEST RAIL PROFILES



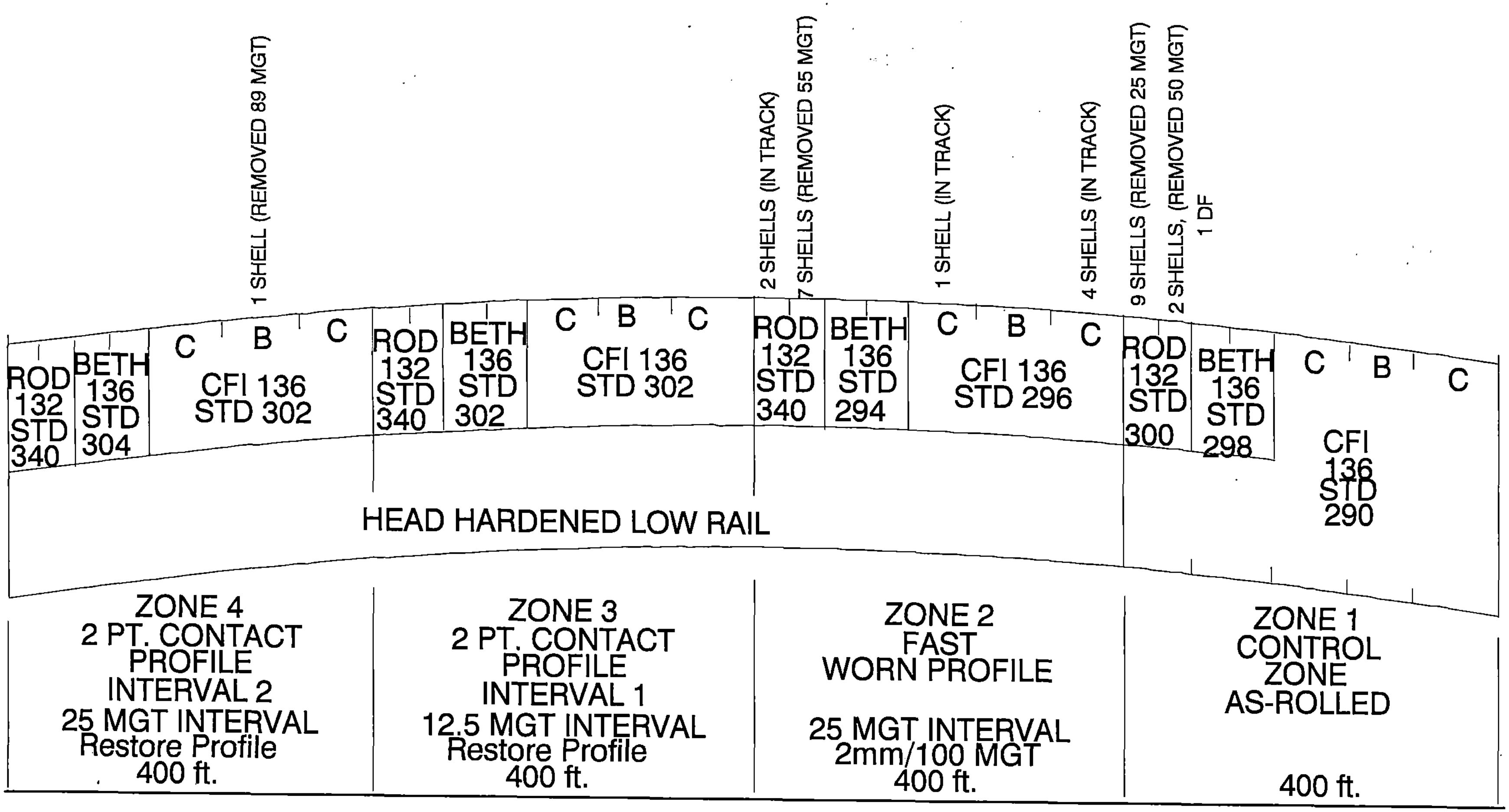
LOCATION OF TEST ZONES



SECTION 25 TEST ZONE, 100 MGT FATIGUE RESULTS



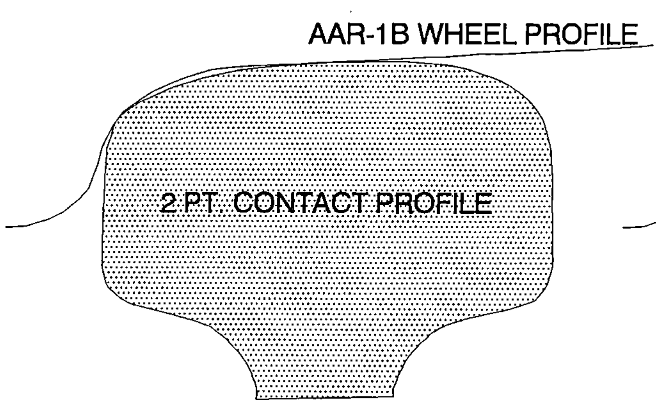
SECTION 3 TEST ZONE, 100 MGT FATIGUE RESULTS

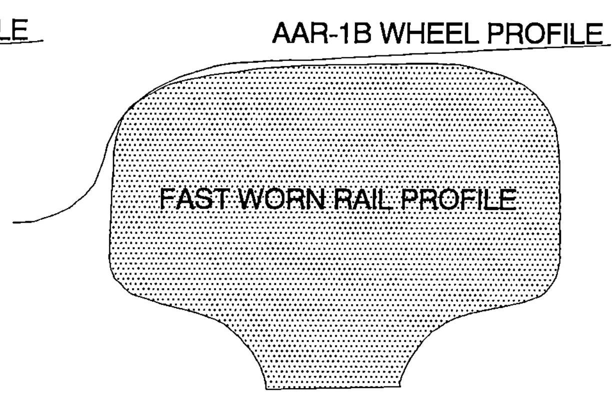


SEQUENCE OF EVENTS

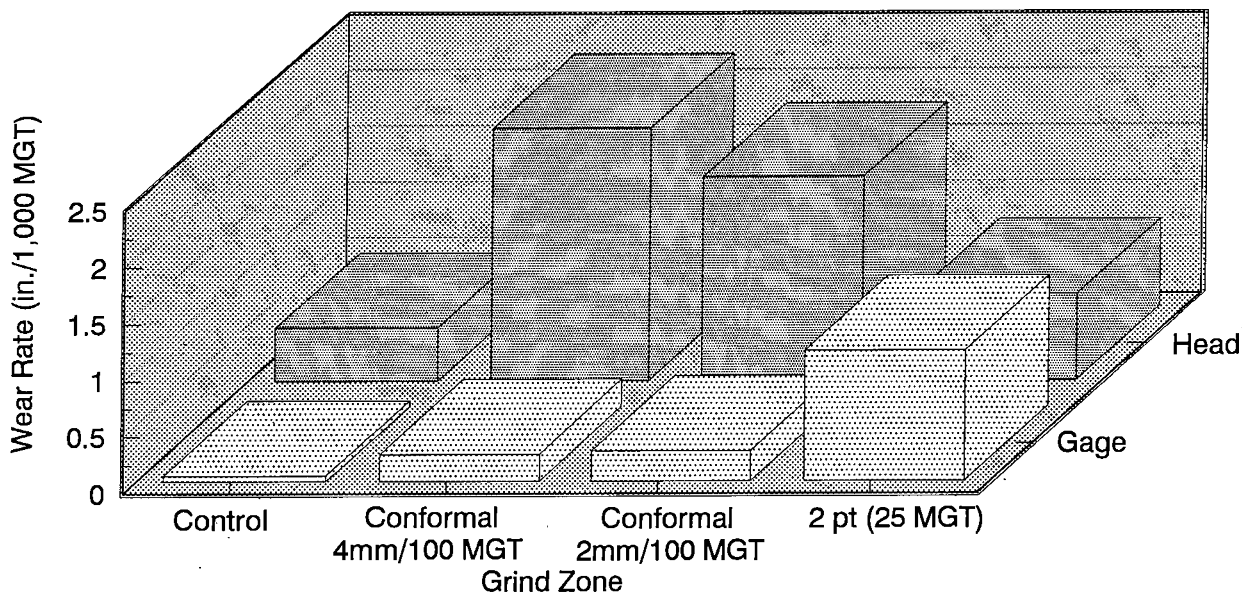
DATE	MGT	EVENT
12-04-90	0 MGT	First grind was performed with Pandrol Jackson J-4.
12-16-90	0 MGT	Began operating the FAST/HAL train on the grind test. Noticed that 132 lb. profile was different in the FAST worn profile zones, i.e. slightly 2 point contact.
03-10-91	13.3 MGT	Introduced 16 new UP gondolas and 4 wheel test gondolas. UP gondolas has worn wheels but not FAST worn wheels. Suitable wheel templates were not available at that time.
04-10-91	24.1 MGT	Noticed shells in 132 lb. Rodange rail.
07-15-91	50.9 MGT	Received Pandrol Jackson J-1 donation.

AAR1B WHEEL PROFILE OVERLAID ON TEST RAIL PROFILES

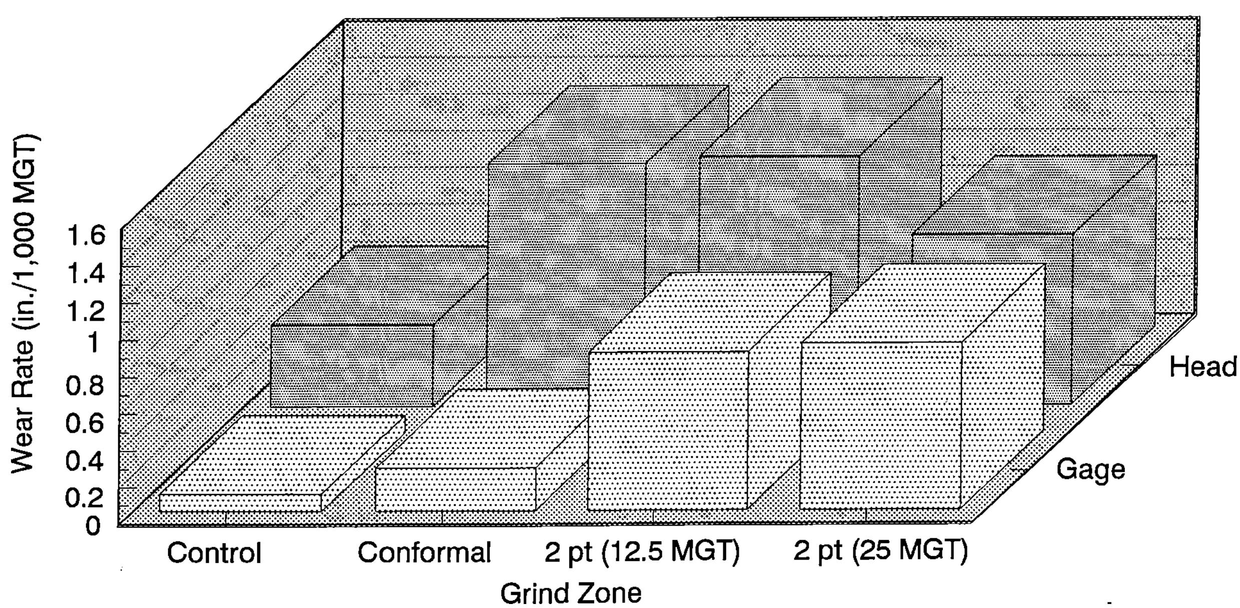




SECTION 25 GRIND TEST WEAR RATES
CFI High Rail at 100 MGT



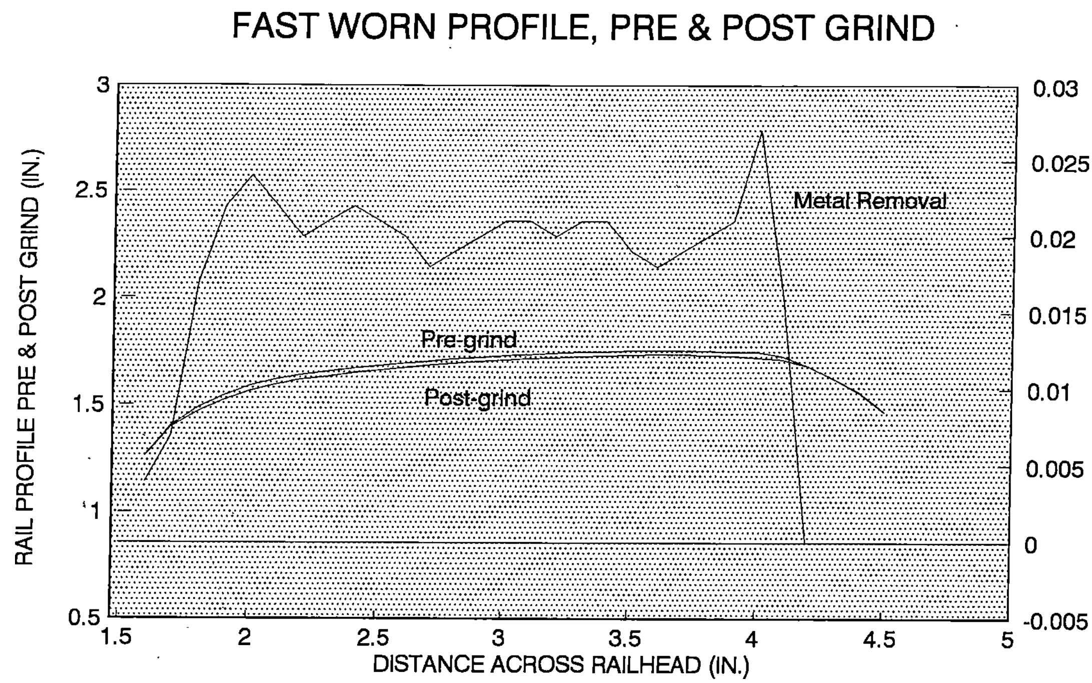
SECTION 3 GRIND TEST WEAR RATES
CFI High Rail at 100 MGT

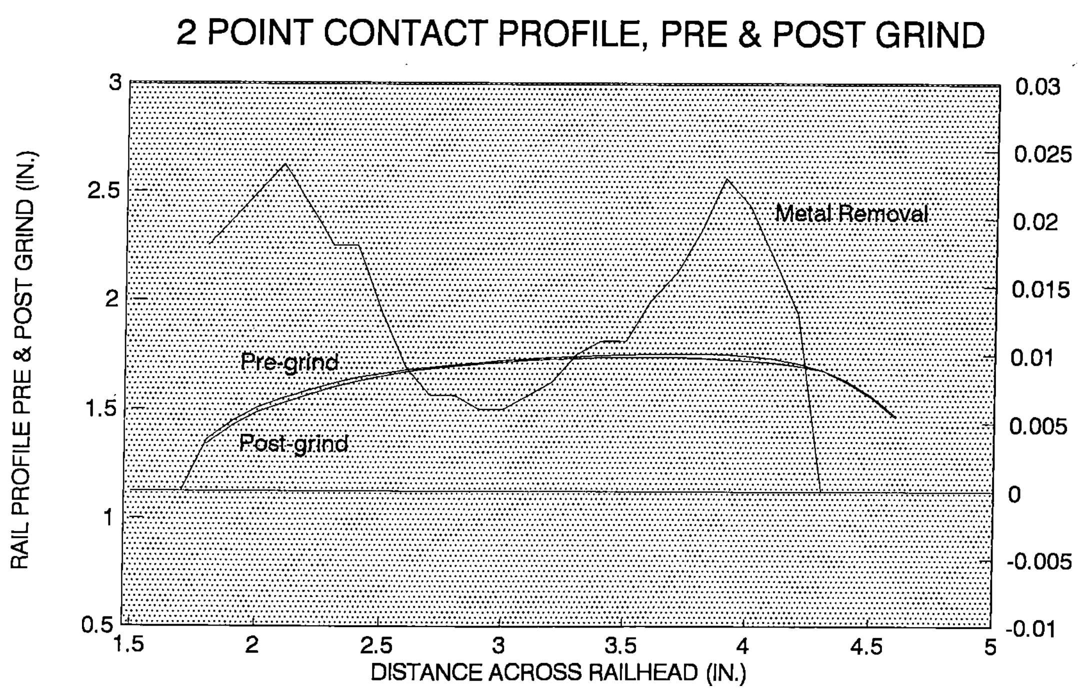


OBSERVATIONS/CONCLUSIONS
Based on 100 MGT of operations

- The introduction of a significant number of wheels other than FAST worn wheels has likely influenced the results.
- A worn profile is difficult to achieve through grinding, i.e. too much metal is easily removed from the gage corner.
- The rail grinder settings were controlled based on the 136 lb. rail profiles. In the worn profile zones, the 132 1b. rail was ground to a combination worn/2 pt. contact profile that possibly promoted shell development. This is currently under investigation.
- The 132 lb. rail, manufactured with the latest technology (vacuum degassed and in-line heat treated) was harder and yet developed the most defects.
- The use of 2 pt. contact is accompanied by higher gage face wear rates.
- Shells have appeared frequently in the Worn Profile Zones.
- Only two shells to date in 2 point contact zone. One has turned to detail fracture.
- Section 25 results are indicating "B" rails are more subject to shelling.
- In the 136 lb. rail, the control zones are performing the best in terms of wear and as good as any ground zone in terms of fatigue.
- Additional tonnage is required to determine the performance of the test practices.

DATA NOT INCLUDED IN THE PRESENTATION


FAST WORN PROFILE, PRE & POST GRIND
Metal Removal
Pre-grind
Post-grind
RAIL PROFILE PRE & POST GRIND (IN.)
METAL REMOVAL (IN.)
DISTANCE ACROSS RAILHEAD (IN.)


2 POINT CONTACT PROFILE, PRE & POST GRIND
Metal Removal
Pre-grind
Post-grind
RAIL PROFILE PRE & POST GRIND (IN.)
METAL REMOVAL (IN.)
DISTANCE ACROSS RAILHEAD (IN.)

SECTION 25 - METAL REMOVAL RATE FROM WEAR AND GRINDING
Ground every 25 MGT

TEST ZONE	RAIL TYPE	ORIGINAL HARDNESS (BHN)	GAGE FACE WEAR RATE (IN./1000 MGT)	HEAD HEIGHT LOSS RATE HIGH RAIL (IN./1000 MGT)
Control Zone	CFI	270	0.050	0.476
	ROD	300	0.066	0.175
Worn Profile 4mm/100 MGT	CFI	293	0.239	2.250
	ROD	321	0.253	1.828
Worn Profile 2 mm/100 MGT	CFI	279	0.268	1.808
	ROD	338	0.511	1.723
2 pt contact	CFI	298	1.152	0.766
	ROD	316	1.072	0.562

SECTION 3 - METAL REMOVAL RATE FROM WEAR AND GRINDING

TEST ZONE	RAIL TYPE	ORIGINAL HARDNESS (BHN)	GAGE FACE WEAR RATE (IN./1000 MGT)	HEAD HEIGHT LOSS RATE HIGH RAIL (IN./1000 MGT)
Control Zone	CFI	290	0.096	0.446
	BETH	298	0.136	0.392
	ROD	300	-0.362	0.108
Worn Profile 2mm/100 MGT (25 MGT interval)	CFI	296	0.236	1.313
	BETH	294	0.347	1.141
	ROD	340	0.639	1.018
2 pt contact (12.5 MGT interval)	CFI	302	0.860	1.350
	BETH	302	0.722	1.140
	ROD	340	1.069	0.890
2 pt contact (25 MGT interval)	CFI	302	0.906	0.924
	BETH	304	0.944	0.873
	ROD	340	1.065	0.683

FAST HAL

RAIL WEAR EXPERIMENT

By Glenn H. Brave
Experiment Manager

TRANSPORTATION TEST CENTER
PUEBLO, COLORADO

FAST/HAL RAIL WEAR TEST

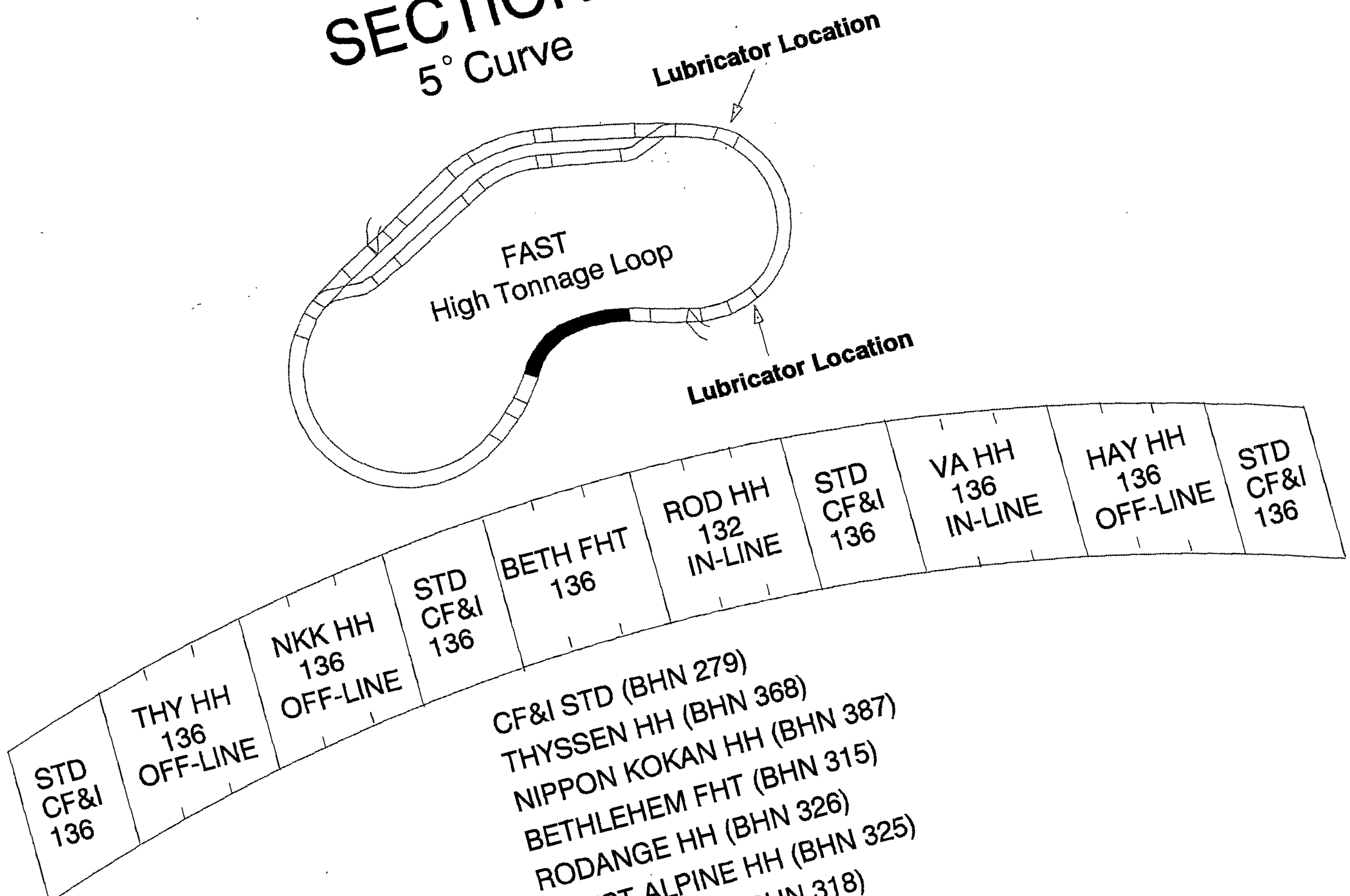
OBJECTIVE:

To determine relative wear performance of various rail types under low lubrication conditions by measuring wear rates.

Also:

To investigate position-in-curve effect under bi-directional operations.

SECTION 7
5° Curve



CF&I STD (BHN 279)
THYSSEN HH (BHN 368)
NIPPON KOKAN HH (BHN 387)
BETHLEHEM FHT (BHN 315)
RODANGE HH (BHN 326)
VOEST-ALPINE HH (BHN 325)
HAYANGE HH (BHN 318)

FAST/HAL RAIL WEAR TEST

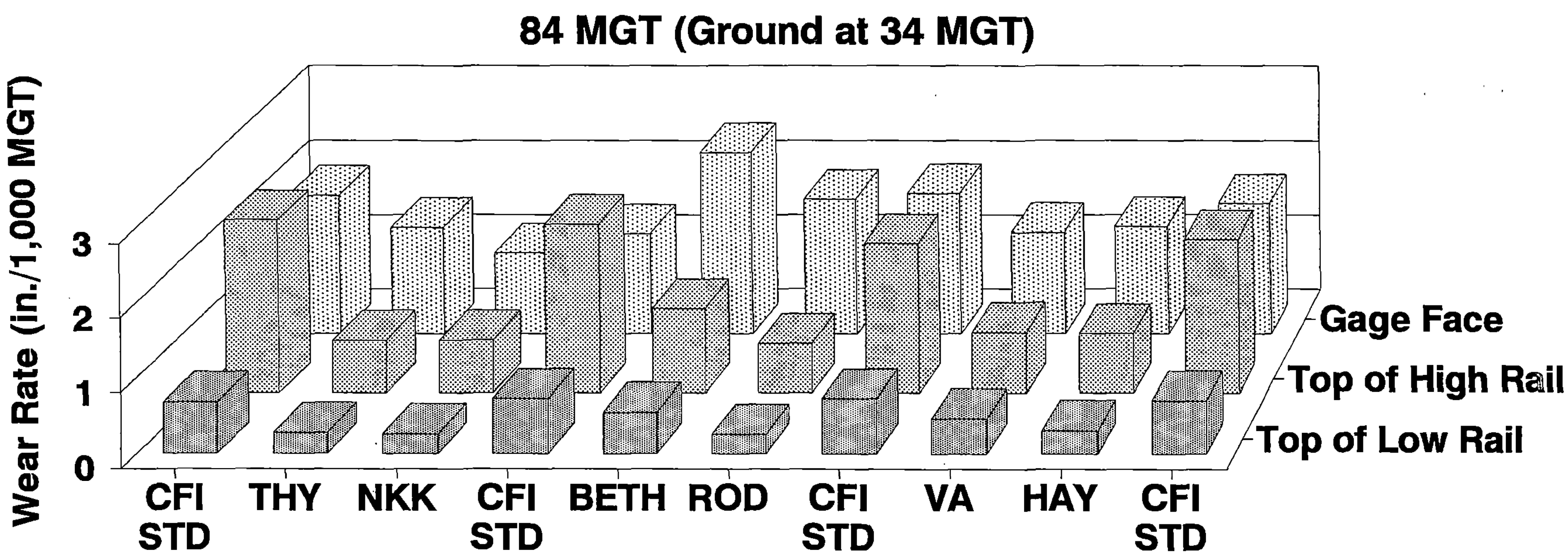
WEAR RESULTS

Wear Rates (in./1000 MGT) or (.001in./MGT)

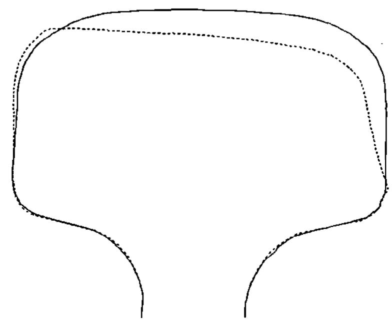
RAIL TYPE	0-26 MGT			0-84 MGT			55-84 MGT		
	HIGH	LOW	GAGE	HIGH	LOW	GAGE	HIGH	LOW	GAGE
CFI STD	2.310	1.254	1.338	2.331	0.686	1.861	2.436	0.107	1.454
THY HH	0.367	0.044	1.844	0.707	0.283	1.434	0.241	0.073	1.817
NKK HH	0.110	0.002	1.925	0.714	0.261	1.091	0.152	0.046	1.598
CFI STD	2.648	1.405	1.123	2.276	0.725	1.346	1.970	0.006	0.877
BETH FHT	1.249	0.764	3.446	1.140	0.548	2.439	0.420	0.008	2.071
ROD HH	0.230	-.164	1.827	0.667	0.258	1.811	0.245	0.131	2.002
CFI STD	2.283	1.375	1.596	2.007	0.721	1.889	1.854	0.082	1.235
VOEST-ALP	0.578	0.604	2.274	0.823	0.460	1.361	0.102	0.047	1.587
HAY HH	0.331	-.057	1.787	0.806	0.307	1.446	0.105	0.027	2.031
CFI STD	2.267	1.143	1.299	2.063	0.702	1.754	1.705	0.101	1.408

Note: Negative wear rates are due to metal flow

Section 7 Wear Rates



EFFECT OF METAL FLOW ON MEASURED WEAR RATE



FAST - HEAVY AXLE LOAD PROGRAM

WEAR TEST OBSERVATIONS/CONCLUSIONS TO DATE

- Harder rails resist wear rates better than softer rails
- No strong position in curve effect has been observed
- Metal flow has reduced the measured gage face wear rate in standard carbon rails

FAST
HAL

RAIL WELD PERFORMANCE EXPERIMENT

By Glenn H. Brave
Experiment Manager

TRANSPORTATION TEST CENTER
PUEBLO, COLORADO

FAST - HEAVY AXLE LOAD PROGRAM

RAIL WELD PERFORMANCE EXPERIMENT

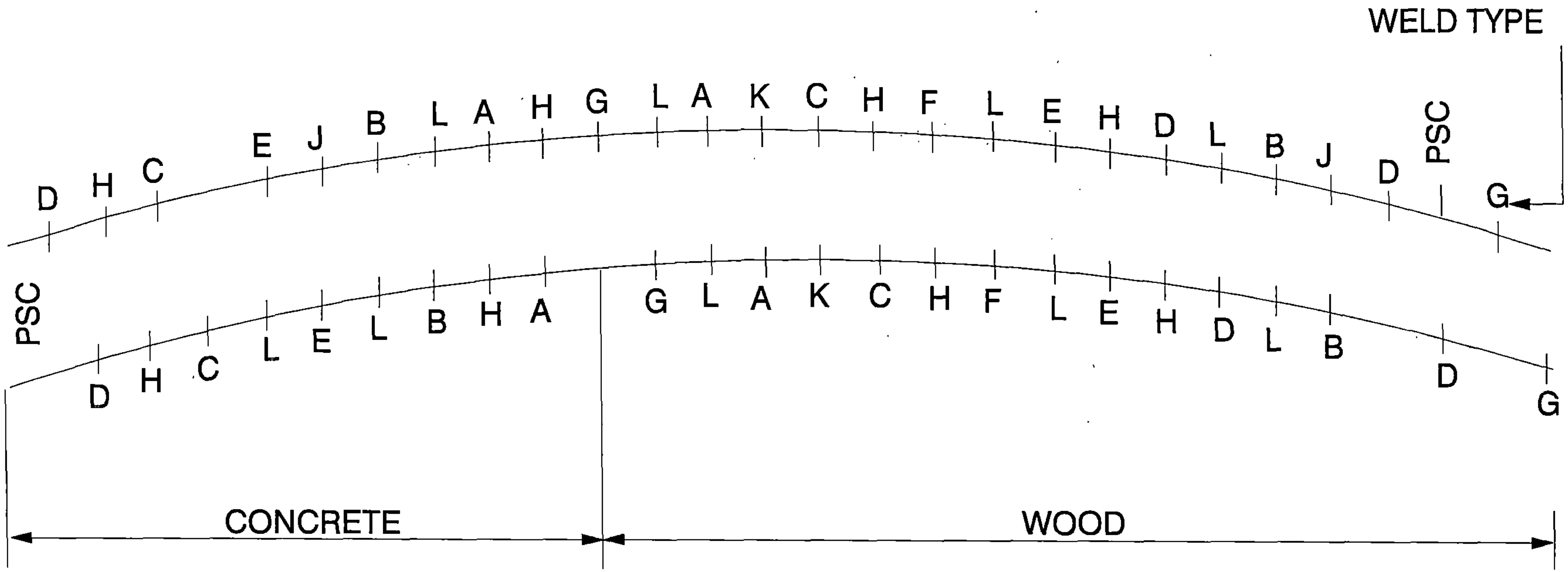
OBJECTIVES:

Evaluate the performance of a variety of thermite welds, electric flash butt shop and portable welds, and build-up repair welds on rails under 39-ton axle loads. The performance criteria will include one or more of the following:

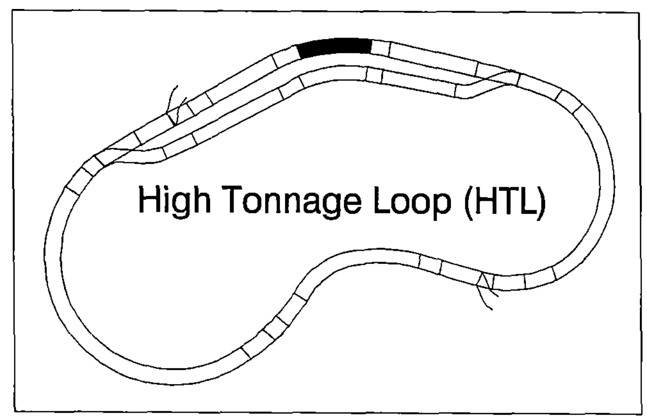
- Fatigue Defects
  - Shelling
  - Detail Fractures
  - Horizontal Split Webs
  - Base Failures
- Wear
  - Weld Batter
  - Surface Fatigue (spalling/metal flow)

WELD PERFORMANCE TEST

SECTION 31, 5 DEGREE CURVE, 500', STANDARD HH RAILS, THERMITE WELDS



A. Premium - Gusset Mold (Exp.)
B. Premium - Standard Mold
C. Premium - Repositioned Riser Mold I (Exp.)
D. Premium - Standard Mold/PWHT
E. Premium - Repositioned Riser/PWHT (Exp.)
F. Standard - Hardface - Standard Mold
G. Standard - Standard Mold (Revenue Service Railroad)
H. Standard - Control - Standard Mold (TTC)
J. Standard - Gage Corner Ground
K. Standard - Zircon Mold
L. Premium - Repositioned Riser Mold II



TOTAL PREMIUM THERMITE WELDS (LOW & HIGH) FAILURES/MGT RANGE

WELD ID	NO. INSTALL	0-20 MGT	20-40 MGT	40-60 MGT	60-80 MGT
A	4	0	0	0	2
B	4	0	0	0	1
C	4	0	0	0	2
D	6	0	0	0	2
E	4	0	0	0	0
L	9	2	1	2	2

A. Premium - Gusset Mold
B. Premium - Standard Mold
C. Premium - Repositioned Riser Mold
D. Premium - Standard Mold/PWHT
E. Premium - Repositioned Riser/PWHT
L. Premium - Repositioned Riser Mold

TOTAL STANDARD THERMITE WELDS (LOW & HIGH) FAILURES/MGT RANGE

WELD ID	NO. INSTALL	0-20 MGT	20-40 MGT	40-60 MGT	60-80 MGT
F	2	1	0	0	1
H	8	0	0	2	2
J	2	0	0	0	1
K	2	0	0	0	0
G	4	0	3	1	0

F. Standard - Hardface - Standard Mold
H. Standard - Control- Standard Mold (TTC)
J. Standard - Gage Corner Ground
K. Standard - Zircon Mold
G. Standard - Standard Mold (Revenue Service Railroad)

PREMIUM THERMITE WELD FAILURES AFTER 80 MGT, SECTION 31, 5 DEGREE CURVE

WELD ID	NO. INSTALLED		NO. FAILED		PERCENT FAILURE		TOTAL % FAILURE
	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW & HIGH
A	2	2	0	2	0	100	50
B	2	2	0	1	0	50	25
C	2	2	0	2	0	100	50
D	3	3	0	2	0	67	33
E	2	2	0	0	0	0	0
L	5	4	3	4	60	100	78

A. Premium - Gusset Mold
B. Premium - Standard Mold
C. Premium - Repositioned Riser Mold
D. Premium - Standard Mold/PWHT
E. Premium - Repositioned Riser/PWHT
L. Premium - Repositioned Riser Mold

STANDARD THERMITE WELD FAILURES AFTER 80 MGT, SECTION 31, 5 DEGREE CURVE

WELD ID	NO. INSTALLED		NO. FAILED		PERCENT FAILURE		TOTAL % FAILURE
	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW & HIGH
F	1	1	1	1	100	100	100
H	4	4	0	4	0	100	50
J	0	2	0	1	0	50	50
K	1	1	0	0	0	0	0
G	2	2	2	2	100	100	100

F. Standard - Hardface - Standard Mold
H. Standard - Control - Standard Mold (TTC)
J. Standard - Gage Corner Ground
K. Standard - Zircon Mold
G. Standard - Standard Mold (Revenue Service Railroad)

FAST - HEAVY AXLE LOAD PROGRAM

THERMITE WELD OBSERVATIONS AT 80 MGT

Thermite weld problems are not completely solved but alternative procedures and materials appear promising

- The combination of premium welds and new design molds prevented horizontal split web defects
- Shell defects were the only mode of failure for all premium welds
- When going from standard to premium thermite welds 20 percent fewer failures occurred after 80 MGT of service

FAST - HEAVY AXLE LOAD PROGRAM

TRACK MAINTENANCE REPAIR WELDING

OBJECTIVES:

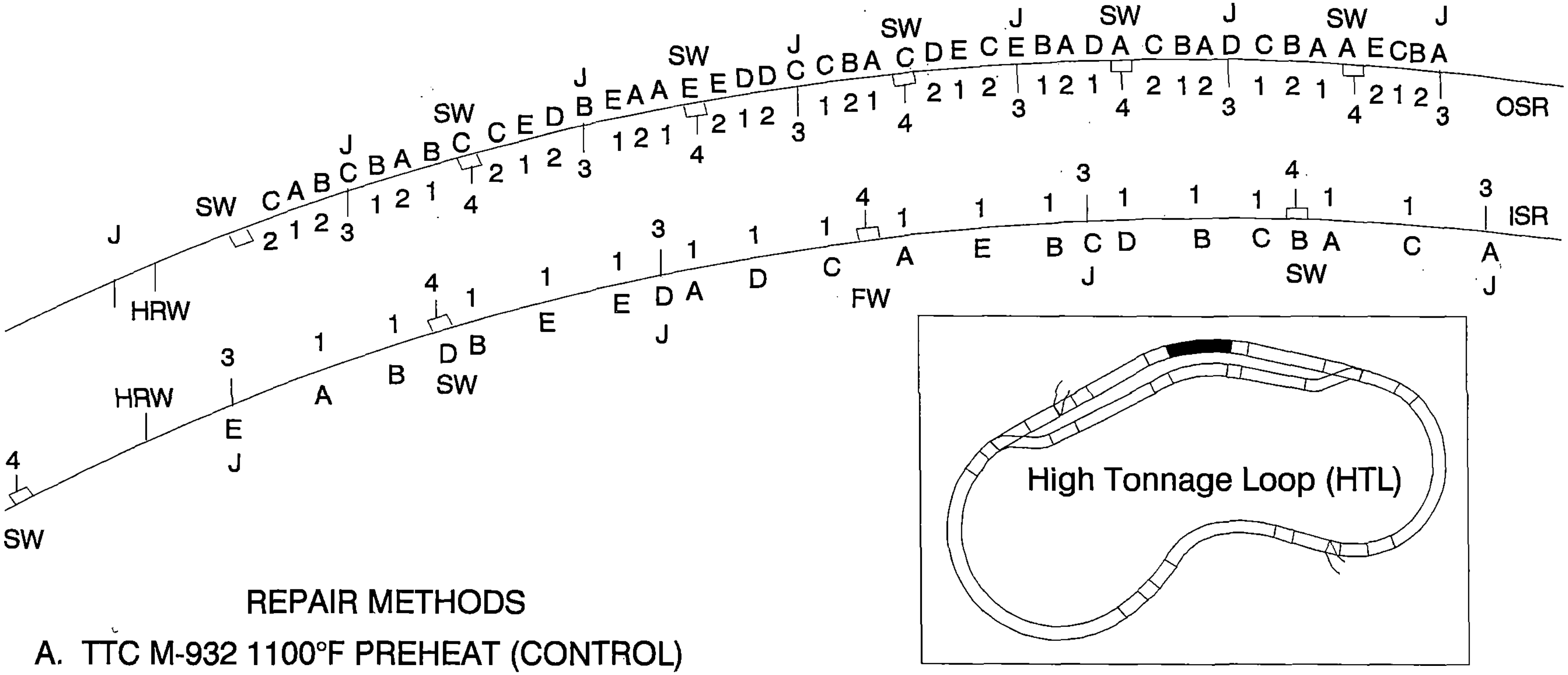
- Obtain quantitative engineering performance data on alternative methods and conditions for rail maintenance repair welding in the field

PRODUCT/PROCESS

- Determine the advantages of using flux cored wire or electric arc welding on the quality of weld build-up repairs
- Determine welding electrode chemistry that offers ideal wear and impact resistance
- What advantages do thermite preheating blocks offer over conventional gas torch preheating?
- Investigate Head Repair Weld (HRW) method using thermite material in the repairing of rail surface defects

SECTION 31 - WELD REPAIR BUILD-UP TEST

5 DEGREE CURVE - 280 FT.



REPAIR METHODS

A. TTC M-932 1100°F PREHEAT (CONTROL)
B. TTC M-932 THERMITE PREHEATING BLOCKS
C. McKAY 880-0 WIRE 1100°F PREHEAT
D. STOODY TRACKWEAR 1100°F PREHEAT
E. STOODY 932 1100°F PREHEAT
HRW - HEAD REPAIR WELD

DEFECT TYPES

1. WHEEL BURN
2. SHELL
3. MECHANICAL JOINT REPAIR
4. WREB (WELDED RAIL END BATTER)

SECTION 31 - WELD REPAIR BUILD-UP TEST
5 DEGREE CURVE

WHEEL BURN DEFECTS

REPAIR	NO. INSTALLED		TOTAL % FAILURE	NO. FAILED		PERCENT FAILURE		MGT	
METHOD	LOW	HIGH	LOW & HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
A	4	4	50	3	1	75	25	28 28 28	18 -- --
B	4	4	50	4	0	100	0	18 28 28 28	-- -- -- --
C	3	3	67	2	2	67	67	18 28	18 18
D	1	1	100	1	1	100	100	15	18
E	4	4	25	2	0	50	0	28 28	-- --
HRW	1	1	0	0	0	0	0	--	--

REPAIR METHODS

A. TTC M-932 1100 F PREHEAT (CONTROL)
B. TTC M-932 THERMITE PREHEATING BLOCKS
C. McKAY 880-0 WIRE 1100 F PREHEAT
D. TRACKWELD RAILEND 540
E. STOODY 932 1100 F PREHEAT
HRW - HEAD REPAIR WELD

SECTION 31 - WELD REPAIR BUILD-UP TEST
5 DEGREE CURVE

SHELL DEFECTS

REPAIR	NO. INSTALLED		TOTAL % FAILURE	NO. FAILED		PERCENT FAILURE		MGT	
METHOD	LOW	HIGH	LOW & HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
A	0	4	50	0	2	--	50	-- --	28 28
B	0	4	50	0	2	--	50	-- --	18 28
C	0	5	40	0	2	--	40	-- --	18 28
D	0	2	100	0	2	--	100	-- --	18 18
E	0	2	50	0	1	--	50	--	18

REPAIR METHODS

A. TTC M-932 1100 F PREHEAT (CONTROL)
B. TTC M-932 THERMITE PREHEATING BLOCKS
C. McKAY 880-0 WIRE 1100 F PREHEAT
D. TRACKWELD RAILEND 540
E. STOODY 932 1100 F PREHEAT

SECTION 31 - WELD REPAIR BUILD-UP TEST
5 DEGREE CURVE

MECHANICAL JOINT REPAIR DEFECTS

REPAIR	NO. INSTALLED		TOTAL % FAILURE	NO. FAILED		PERCENT FAILURE		MGT	
METHOD	LOW	HIGH	LOW & HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
A	1	2	0	0	0	0	0	--	--
B	--	--	--	--	--	--	--	--	--
C	1	2	33	1	0	100	0	28	--
D	1	0	100	1	0	100	--	28	--
E	1	2	0	0	0	0	0	--	--

REPAIR METHODS

A. TTC M-932 1100 F PREHEAT (CONTROL)
B. TTC M-932 THERMITE PREHEATING BLOCKS
C. McKAY 880-0 WIRE 1100 F PREHEAT
D. TRACKWELD RAILEND 540
E. STOODY 932 1100 F PREHEAT

SECTION 31 - WELD REPAIR BUILD-UP TEST
5 DEGREE CURVE

WREB (WELDED RAIL END BATTER)

REPAIR	NO. INSTALLED		TOTAL % FAILURE	NO. FAILED		PERCENT FAILURE		MGT	
METHOD	LOW	HIGH	LOW & HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
A	0	1	0	0	0	--	0	--	--
B	1	0	100	1	0	100	--	28	--
C	0	2	0	0	0	--	0	--	--
D	1	1	0	0	0	0	0	--	--
E	0	1	100	0	1	--	100	--	28

REPAIR METHODS

A. TTC M-932 1100 F PREHEAT (CONTROL)
B. TTC M-932 THERMITE PREHEATING BLOCKS
C. McKAY 880-0 WIRE 1100 F PREHEAT
D. TRACKWELD RAILEND 540
E. STOODY 932 1100 F PREHEAT

FAST - HEAVY AXLE LOAD PROGRAM

WELD REPAIR BUILD-UP TEST OBSERVATIONS AT 45 MGT

Because of limited tonnage over the build-up repair weld test, firm conclusions cannot be derived at this time, and trends can only be observed after 45 MGT of service

- Alloy welds appear to have slightly lower failure rates than non or low alloy welds for shell defects
- More tonnage is required for weld repair test to adequatly determine service performance under heavy axle loads

FAST
HAL

WOOD TIE AND FASTENER EXPERIMENT

By M. Carmen Trevizo
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PUEBLO, COLORADO

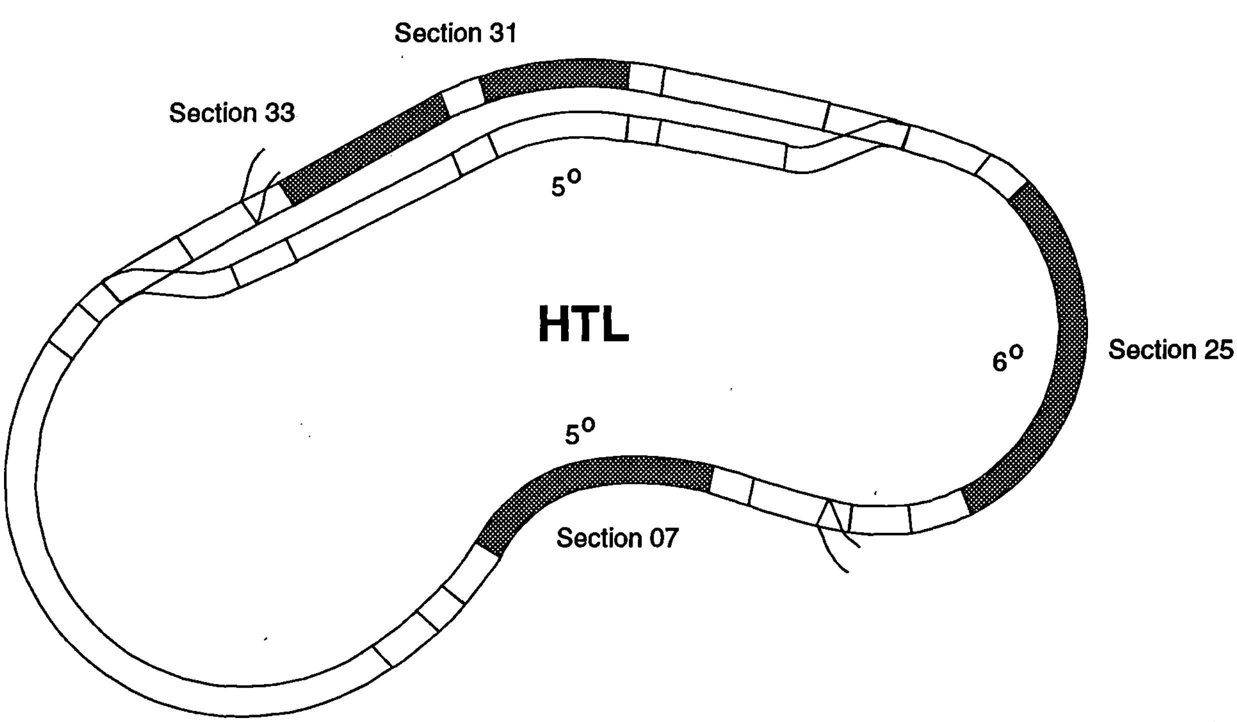
INTRODUCTION

With the increase in axle load from 33-ton to 39-ton, lateral/vertical force ratios and tie stresses will increase which could result in an increase in tie degradation; thus, selected wood species and fasteners may not be adequate under heavier axle loads. The Wood Tie and Fastener Experiment will provide tie and fastener performance under the HAL traffic and where possible compare previous 33-ton test data.

OBJECTIVE

The objective of the Wood Tie and Fastener Experiment is to quantify the performance of wood ties and various rail fasteners under 39-ton axle loads.

TEST LOCATION



MEASUREMENTS

- Lateral railhead and base displacement
- Track geometry
  - Gage
  - Alinement
- Tie plate cutting

SUMMARY AFTER 160 MGT OF HAL TRAFFIC

- Under static vertical and lateral forces equivalent to a L/V ratio of 0.5, the cut spikes allow more lateral railhead displacement and rail rotation, than any of the elastic fasteners in test.
- At static L/V ratios of less than 0.25, there is no measurable difference in the lateral restraint capabilities of any of the fasteners in test.
- There is no significant difference in the measured and observed performance of the four and five spike systems in test.
- There is no significant degradation in track geometry in the tie test zones. Neither Section 07 nor 25 was surfaced or lined during the initial 160 MGT of HAL traffic.
- Lateral railhead displacement measured on Azobe ties with cut and elastic spikes is consistently less than that measured on the domestic hardwood ties in test.

UPDATE

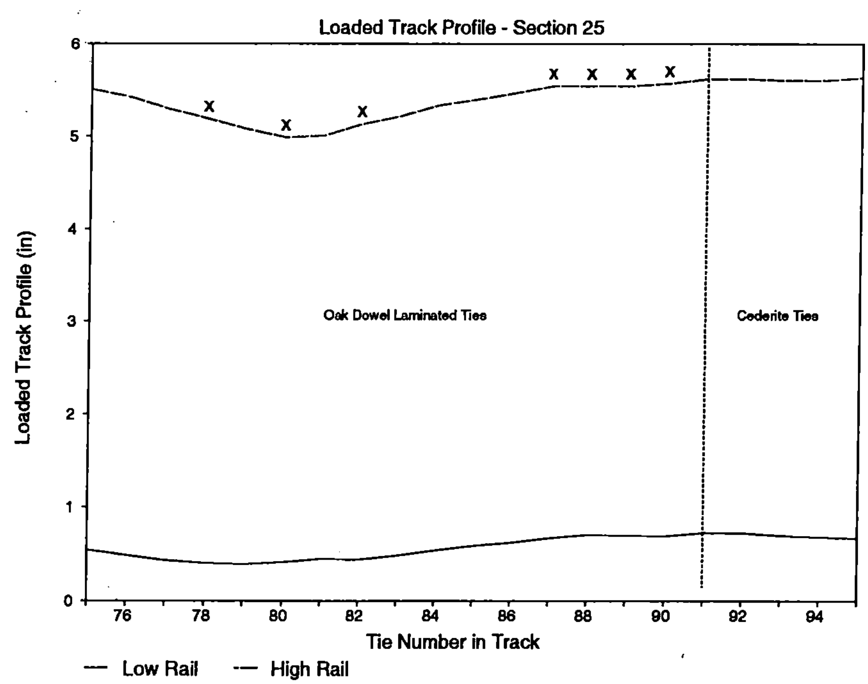
Section 07

- Installed laminated ties (6 laminations) @ 160 MGT

Section 25

- Additional test ties installed @ 160 MGT
- Broken lock spikes on the dowel laminated ties
- CN softwood ties replaced after 65 MGT of traffic
- Out-of-face surfacing @ 260 MGT due to other test requirements

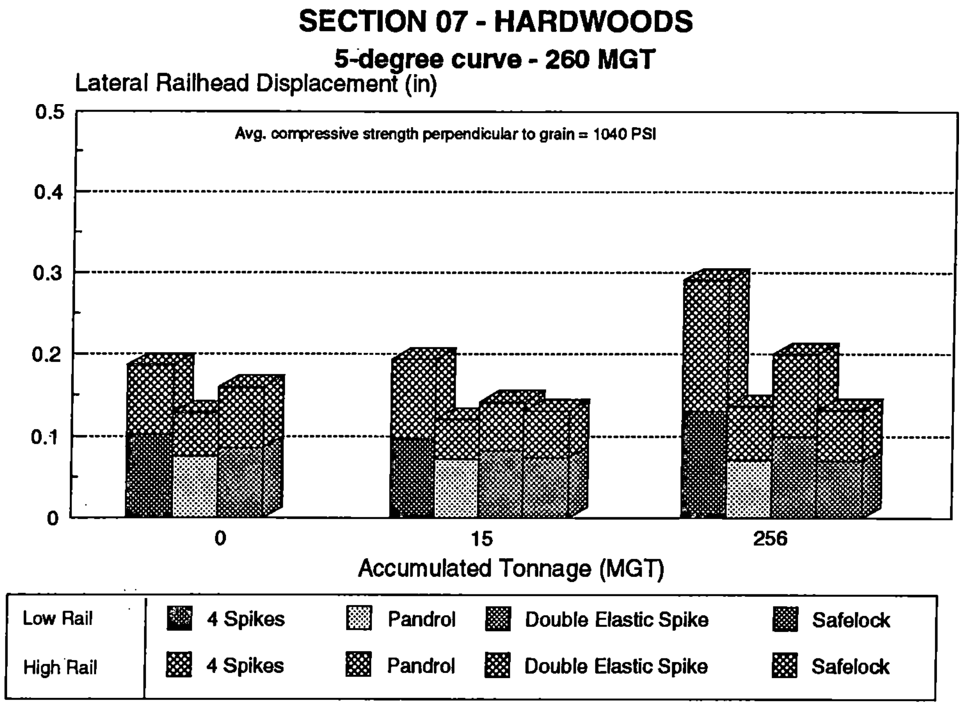
Loaded track profile where the highest number broken lock spikes were found:



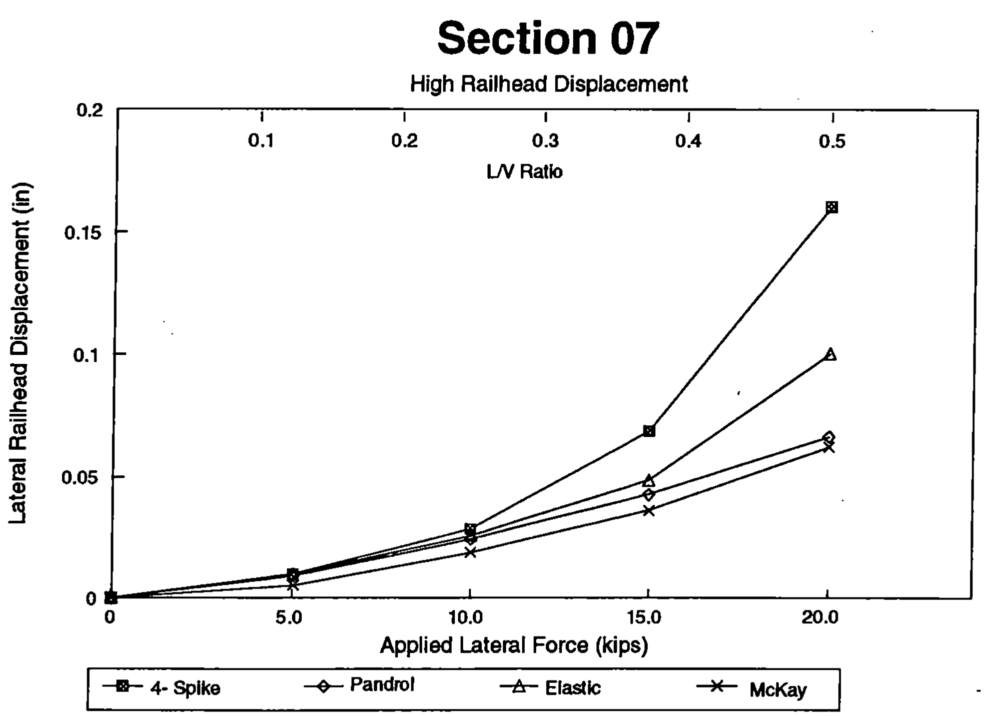
Section 33

- Installed Cedrite reconstituted ties after 160 MGT (24" spacing/tan)

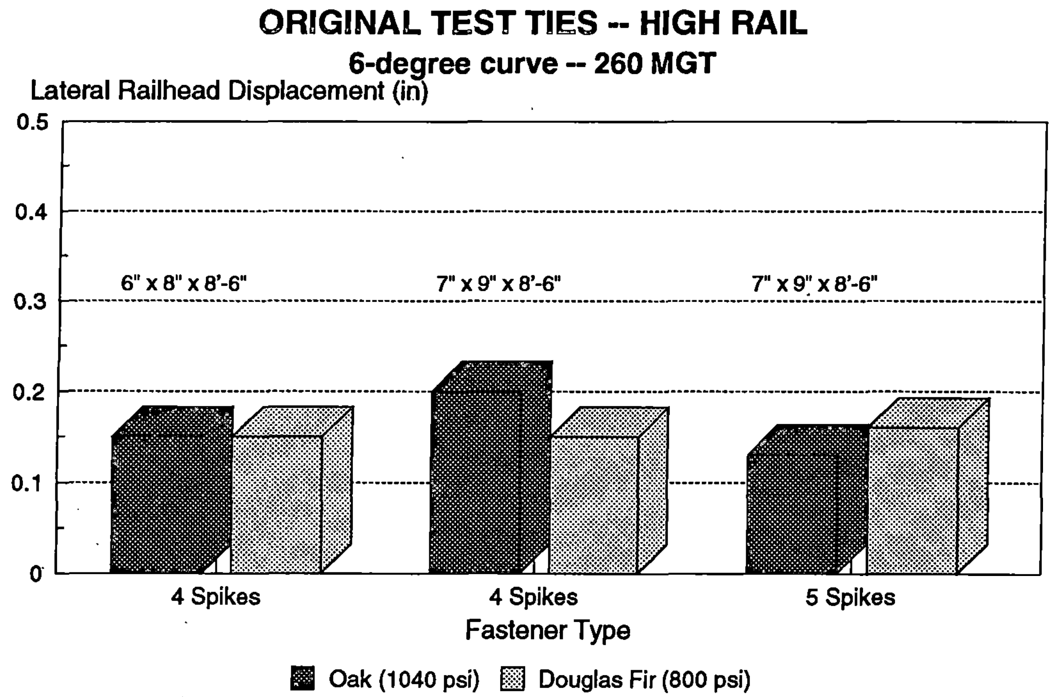
DATA



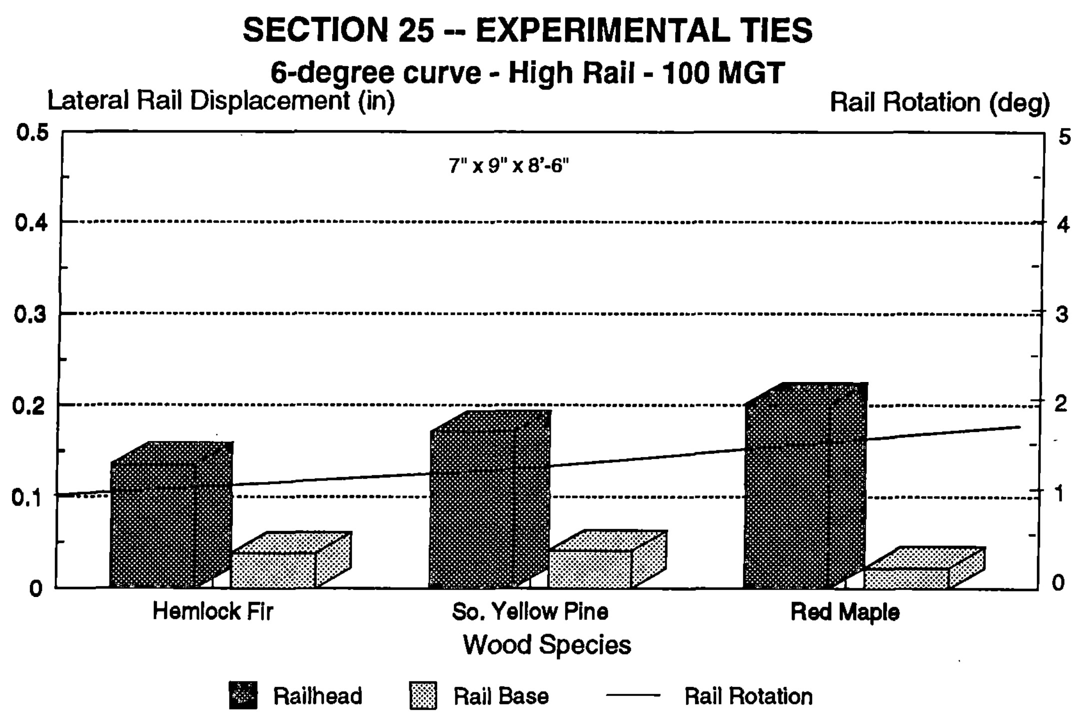
SECTION 07 - HARDWOODS
5-degree curve - 260 MGT
Lateral Railhead Displacement (in)
Avg. compressive strength perpendicular to grain = 1040 PSI
0.5
0.4
0.3
0.2
0.1
0
0
15
256
Accumulated Tonnage (MGT)
Low Rail
High Rail
4 Spikes
Pandrol
Double Elastic Spike
Safelock
4 Spikes
Pandrol
Double Elastic Spike
Safelock



Section 07
High Railhead Displacement
0.1
0.2
0.3
0.4
0.5
L/V Ratio
Lateral Railhead Displacement (in)
0.2
0.15
0.1
0.05
0
0
5.0
10.0
15.0
20.0
Applied Lateral Force (kips)
4- Spike
Pandrol
Elastic
McKay

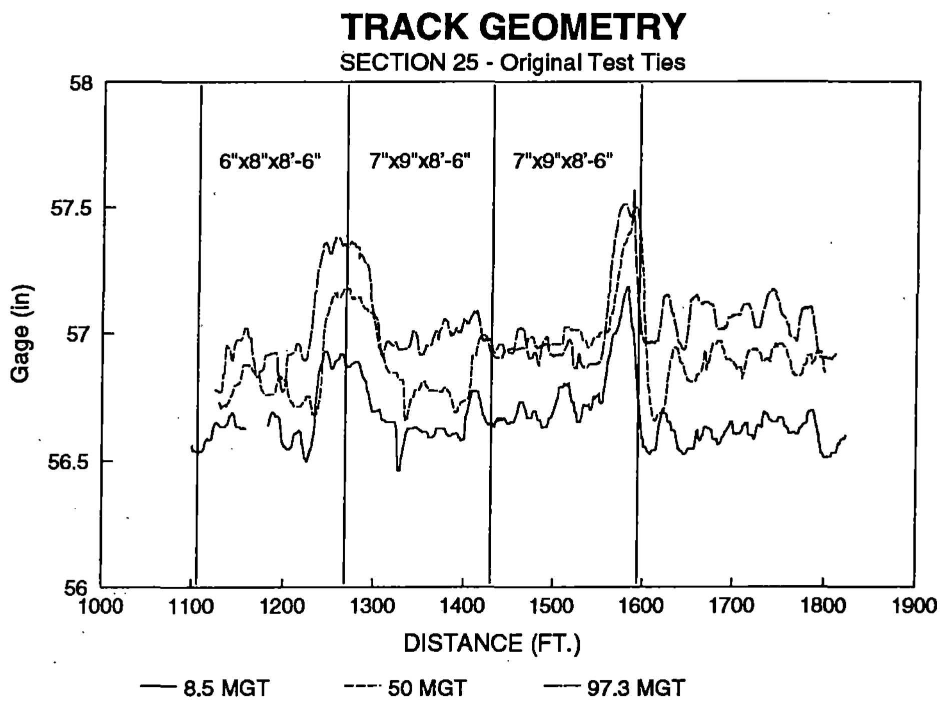


ORIGINAL TEST TIES -- HIGH RAIL
6-degree curve -- 260 MGT
Lateral Railhead Displacement (in)
0.5
0.4
0.3
0.2
0.1
0
6" x 8" x 8'-6"
7" x 9" x 8'-6"
7" x 9" x 8'-6"
4 Spikes
4 Spikes
5 Spikes
Fastener Type
Oak (1040 psi)
Douglas Fir (800 psi)



SECTION 25 -- EXPERIMENTAL TIES
6-degree curve - High Rail - 100 MGT
Lateral Rail Displacement (in)
Rail Rotation (deg)
0.5
0.4
0.3
0.2
0.1
0
5
4
3
2
1
0
7" x 9" x 8'-6"
Hemlock Fir
So. Yellow Pine
Red Maple
Wood Species
Railhead
Rail Base
Rail Rotation

Track geometry car (EM80) data:



SUMMARY @ 260 MGT

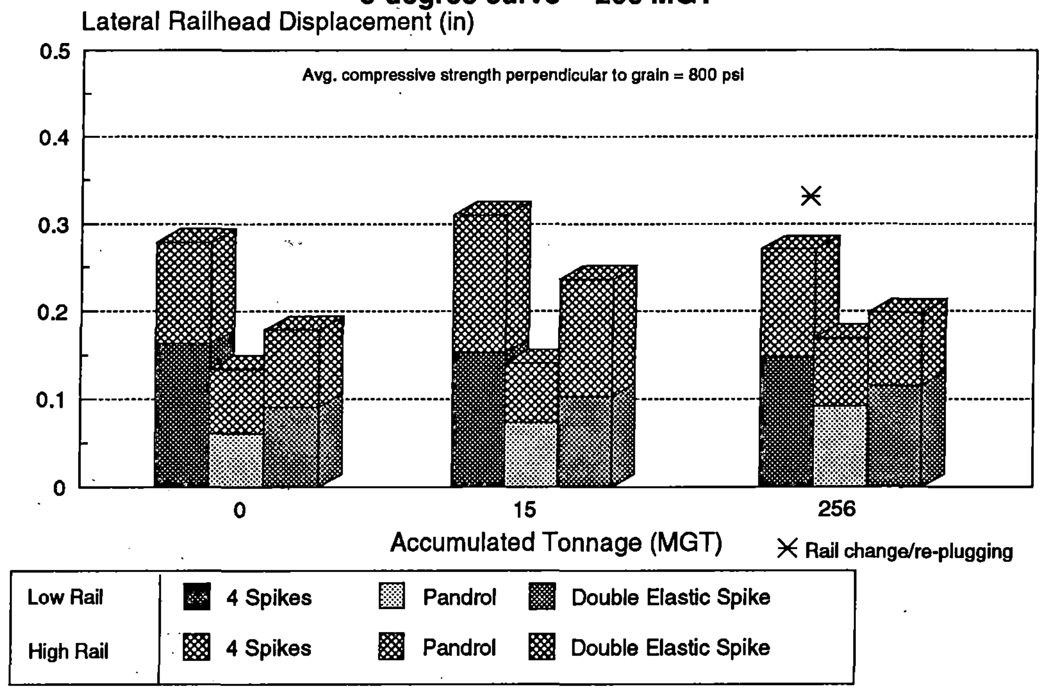
- Under static vertical and lateral forces equivalent to a L/V ratio of 0.5, the cut spikes allow more lateral railhead displacement and rail rotation, than any of the elastic fasteners in test.
- Under L/V ratios of less than 0.25, there is no measurable difference in the lateral restraint capabilities of any of the fasteners in test.
- There is no significant difference in the measured and observed performance of the four and five spike systems in test.
- There appears to be very little difference in lateral railhead displacement with an L/V ratio of 0.5 between the new wood species which were installed after 160 MGT of HAL traffic.
- Under a L/V ratio of 0.5, the combined high and low lateral railhead displacement, for any of the fasteners in test, does not exceed 0.5 inches.

- Lateral railhead displacement measured on Azobe ties with cut and elastic spikes is consistently less than that measured on the domestic hardwood ties in test.
- Gage degradation is evident is Section 25 in some of the softwood test zones. Section 25 was surfaced after 260 MGT of traffic due to other test requirements.
- There appears to be very little tie plate cutting in all of the wood tie test zones.

DATA NOT INCLUDED IN THE PRESENTATION

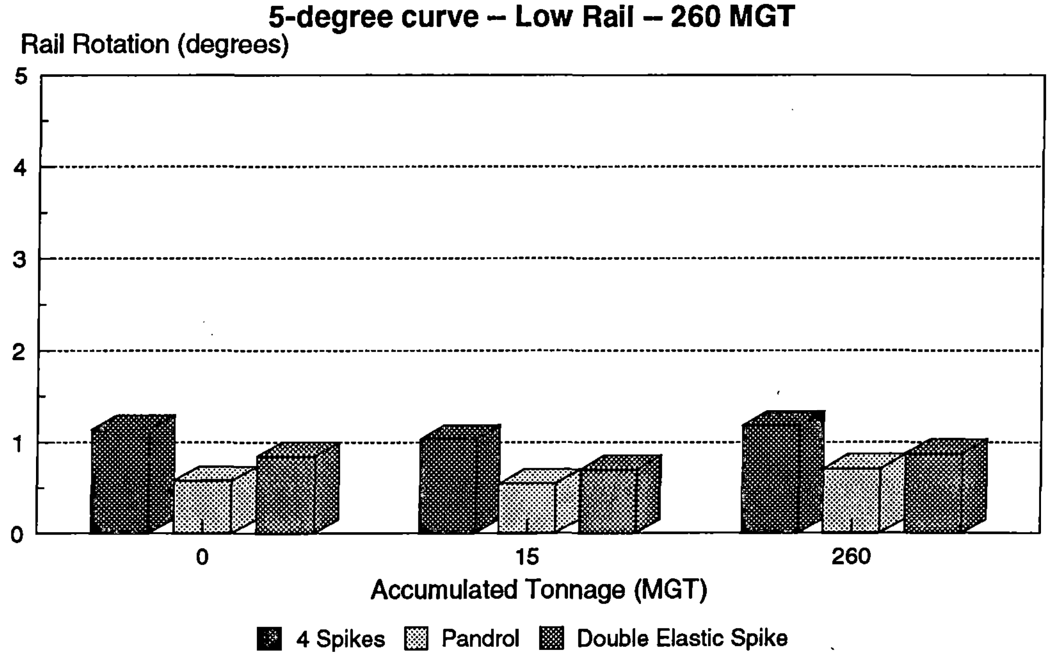
SECTION 07 – SOFTWOODS

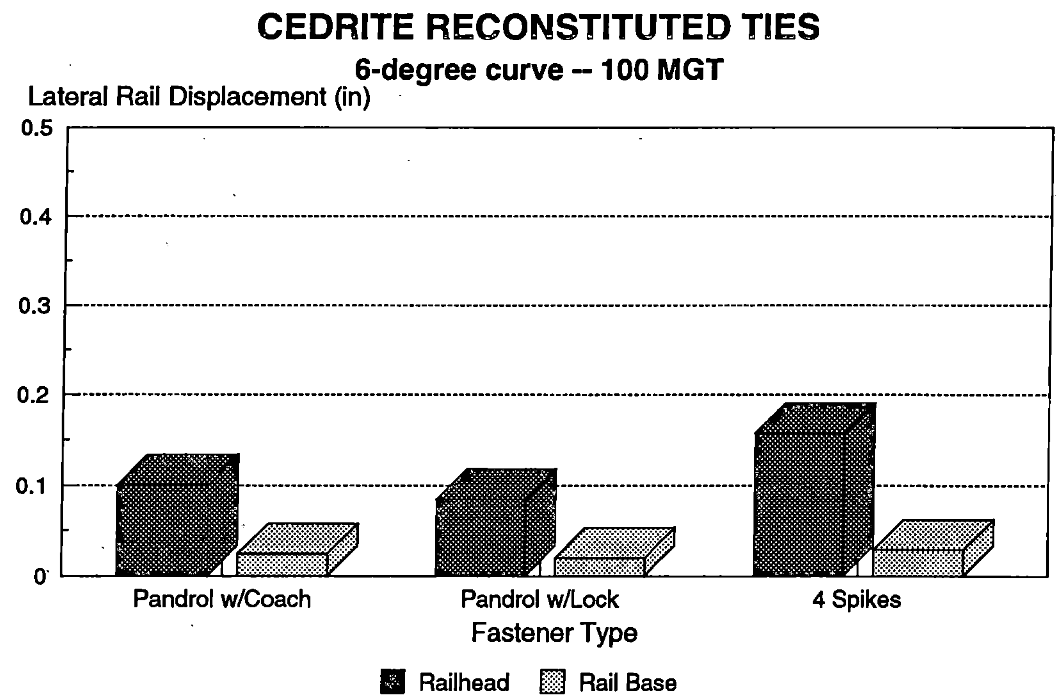
5-degree curve -- 260 MGT

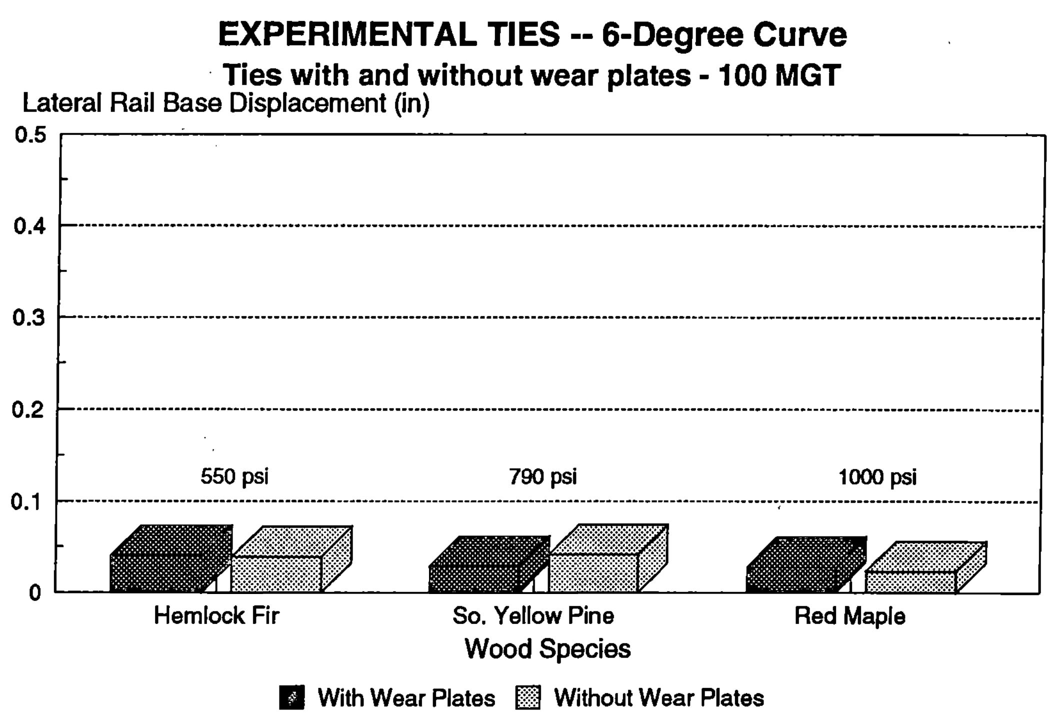


SECTION 07 -- SOFTWOODS

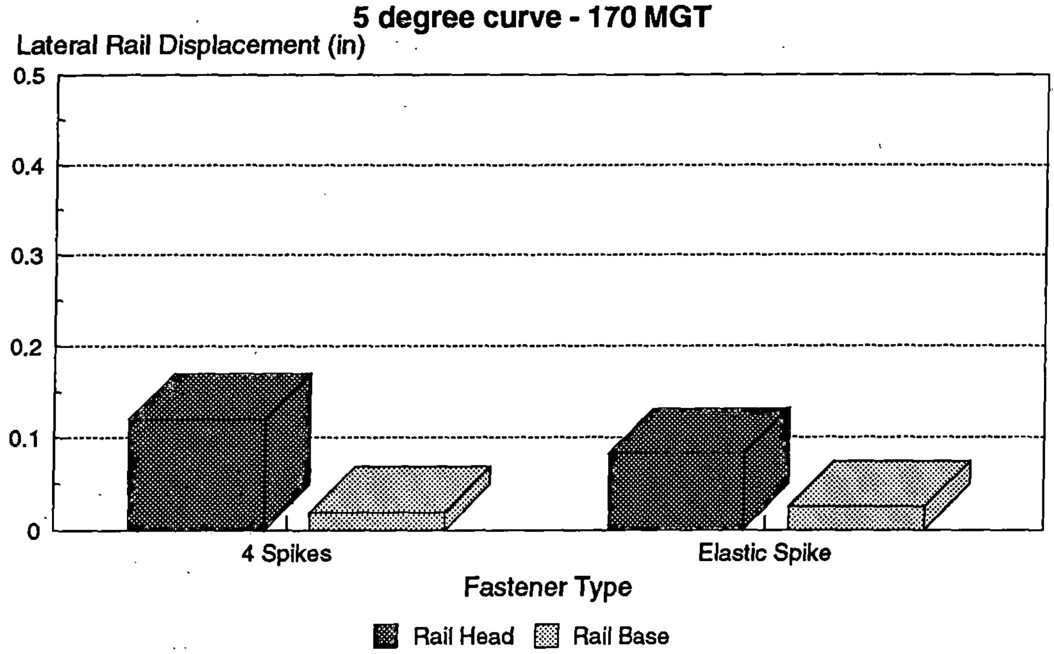
5-degree curve – Low Rail – 260 MGT




CEDRITE RECONSTITUTED TIES
6-degree curve -- 100 MGT
Lateral Rail Displacement (in)
0.5
0.4
0.3
0.2
0.1
0
Pandrol w/Coach
Pandrol w/Lock
4 Spikes
Fastener Type
Railhead
Rail Base


EXPERIMENTAL TIES -- 6-Degree Curve
Ties with and without wear plates - 100 MGT
Lateral Rail Base Displacement (in)
0.5
0.4
0.3
0.2
0.1
0
550 psi
790 psi
1000 psi
Hemlock Fir
So. Yellow Pine
Red Maple
Wood Species
With Wear Plates
Without Wear Plates

AZOBE TIES



5 degree curve - 170 MGT
Lateral Rail Displacement (in)
0.5
0.4
0.3
0.2
0.1
0
4 Spikes
Elastic Spike
Fastener Type
Rail Head
Rail Base

FAST
HAL

CONCRETE TIE RAIL SEAT ABRASION EXPERIMENT

By Scott E. Gage
Experiment Manager

**TRANSPORTATION TEST CENTER
PUEBLO, COLORADO**

CONCRETE TIE RAIL SEAT ABRASION EXPERIMENT

Introduction:

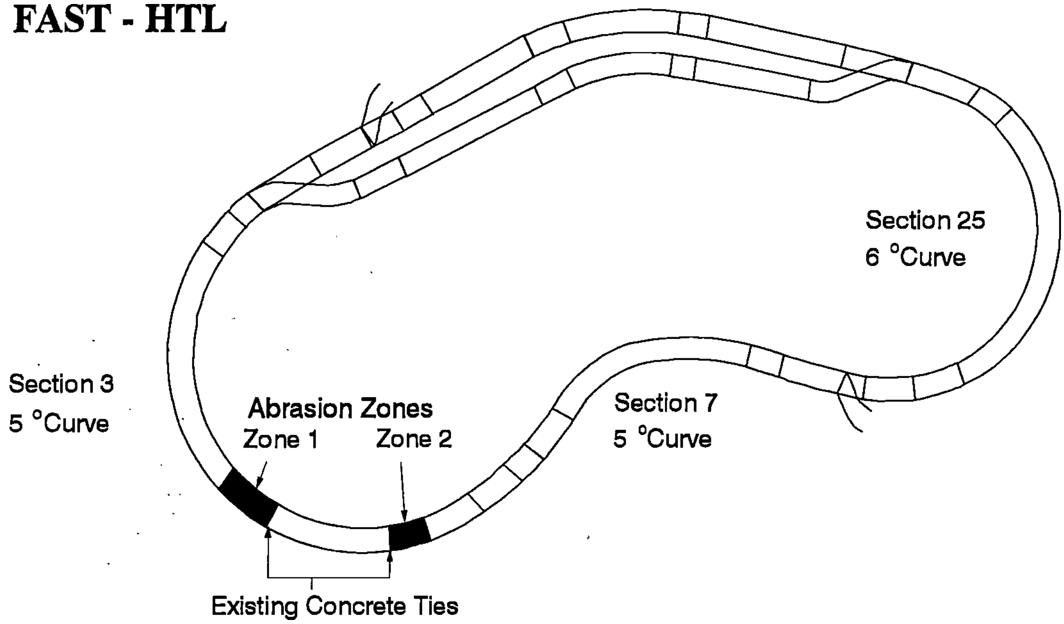
- Growing concern for railroad industry
- Abrasion of 2mm or more/year on many railroads
- Can lead to loss of toe load with elastic fasteners
- Contributing factors
  - Water
  - Sand
  - Grinding residue
- Over 300 concrete ties donated to develop & test possible solutions

Objective:

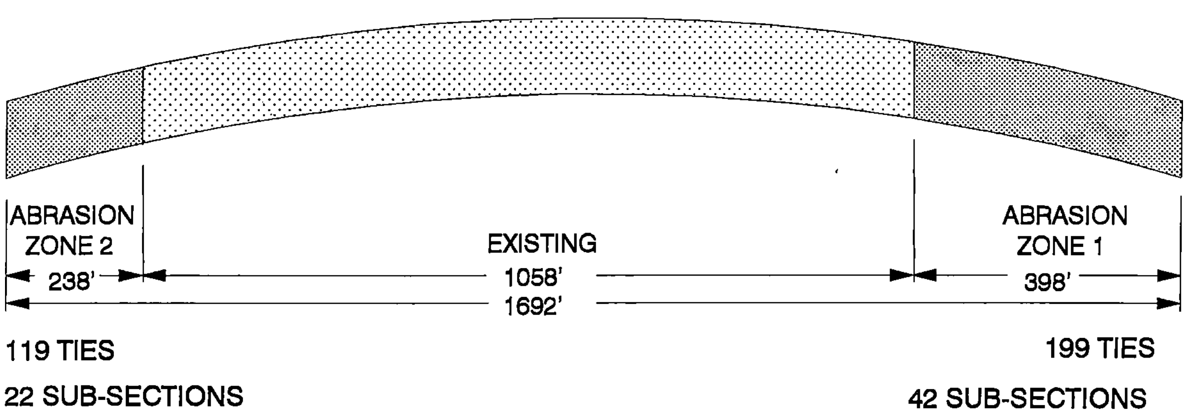
- Determine methods and material combinations, for in-field repairs and manufacturing processes, that are effective in preventing, reducing, or stopping rail seat abrasion

CONCRETE TIE RAIL SEAT ABRASION EXPERIMENT
Location:

FAST - HTL



SECTION 03 - CONCRETE TIE AND ABRASION ZONES



CONCRETE TIE RAIL SEAT ABRASION EXPERIMENT

Implementation:

- Installed during Phase II rebuild - 12/90
- 0 to 32 MGT - Ties watered every 2nd day of train Ops
- 32 to 100 MGT - Ties watered daily during train Ops
  - 0.1" per day
  - 21" per year
  - 21" simulated + 11" natural = 32" per year
- HAL Grinding Experiment located over Abrasion Zones

Materials:

- Dual Rate tie pads
- Bonded tie pads
- Seal rings on tie pads
- Steel plates
- Tie pads cast in tie
- Structural repair materials

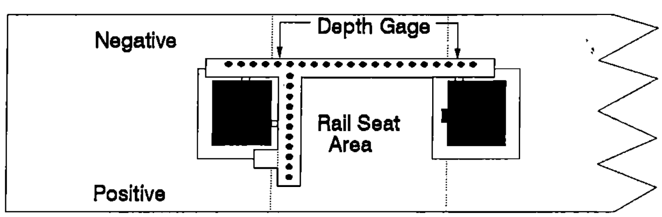
CONCRETE TIE RAIL SEAT ABRASION EXPERIMENT

Measurements:

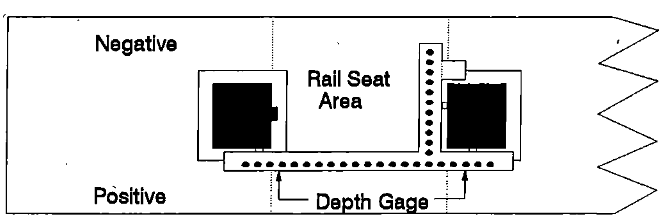
- Measurement Cycle
  - 0 MGT - High & low rail/every tie
  - 50 MGT - High rail only/selected ties
  - 100 MGT - High & low rail/every tie

- CXT Rail Seat Depth Gage
  - 64 measurements per rail seat
  - 1/2" spacing
  - Reference 3 non-wearing points

CXT Rail Seat Depth Gage



Negative - Field side measurments

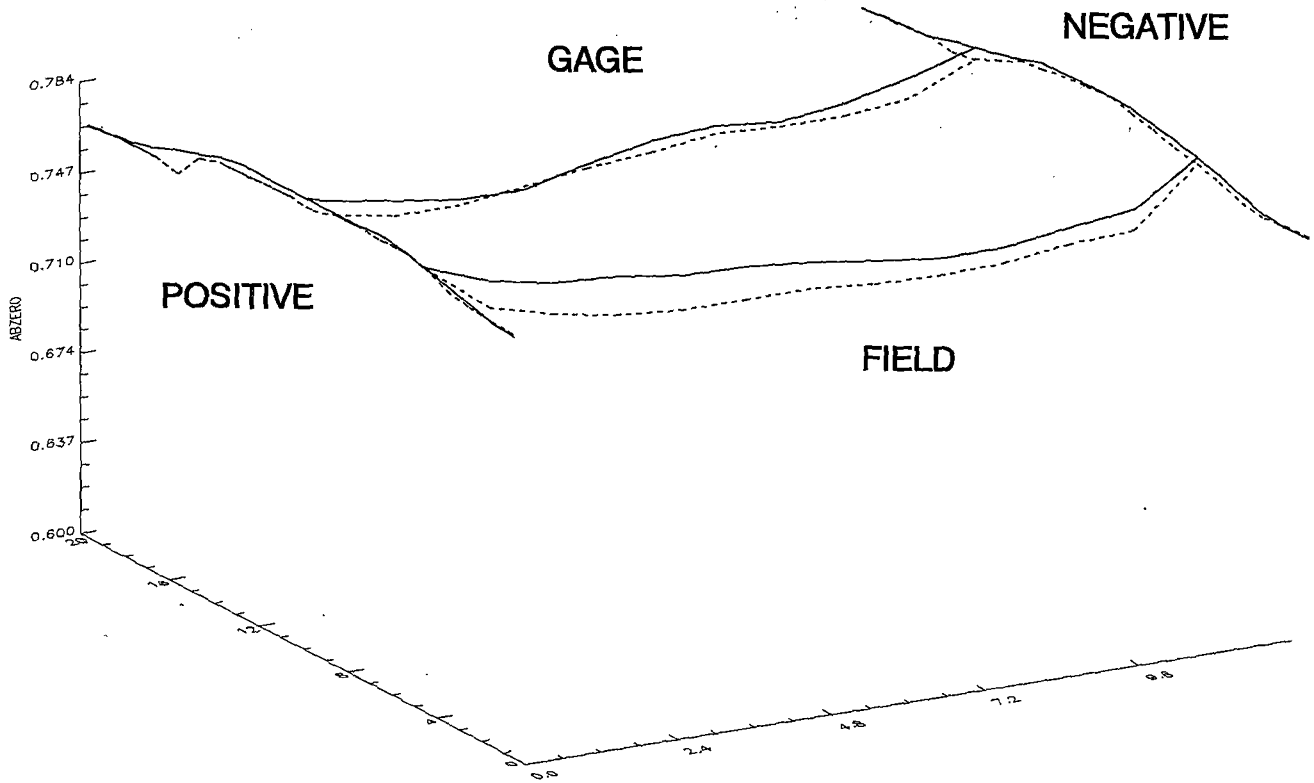


Positive - Gage side measurments

1AA - AVERAGE DEPTH PROFILE

0 MGT

100 MGT

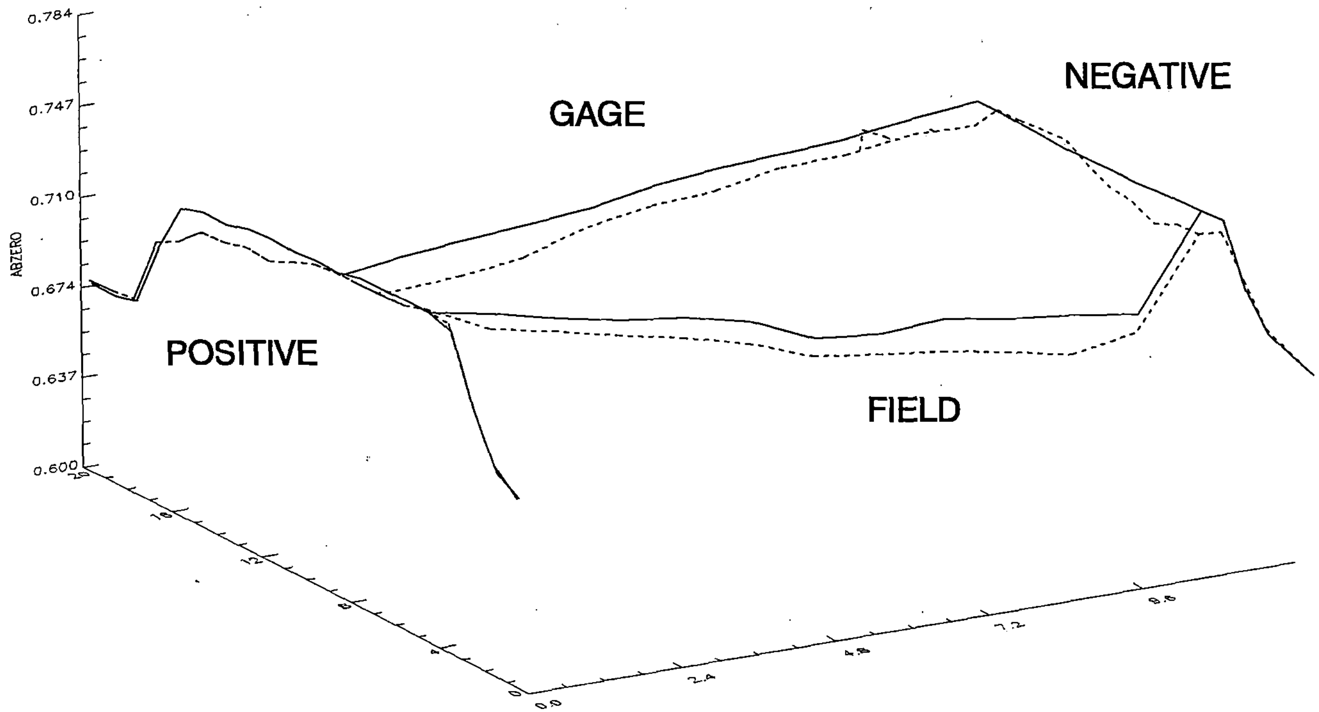


CP CT3 - STANDARD AS CAST
PANDROL
MOBANE

1BA - AVERAGE DEPTH PROFILE

——— 0 MGT

------------ 100 MGT

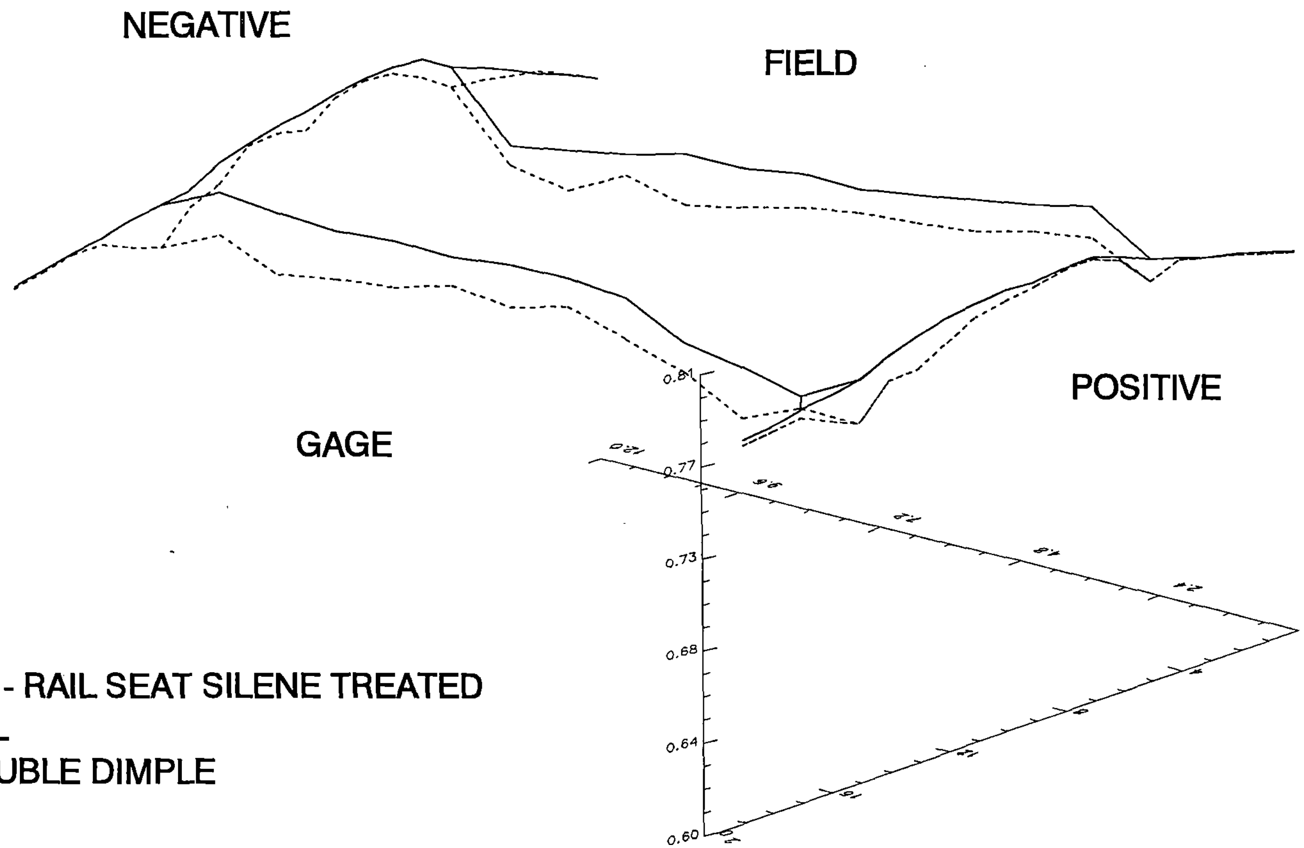


CP CT3 - BLASTED + 1/4" JEFFAMINE
PANDROL
MOBANE

1YA - AVERAGE DEPTH PROFILE

0 MGT

100 MGT

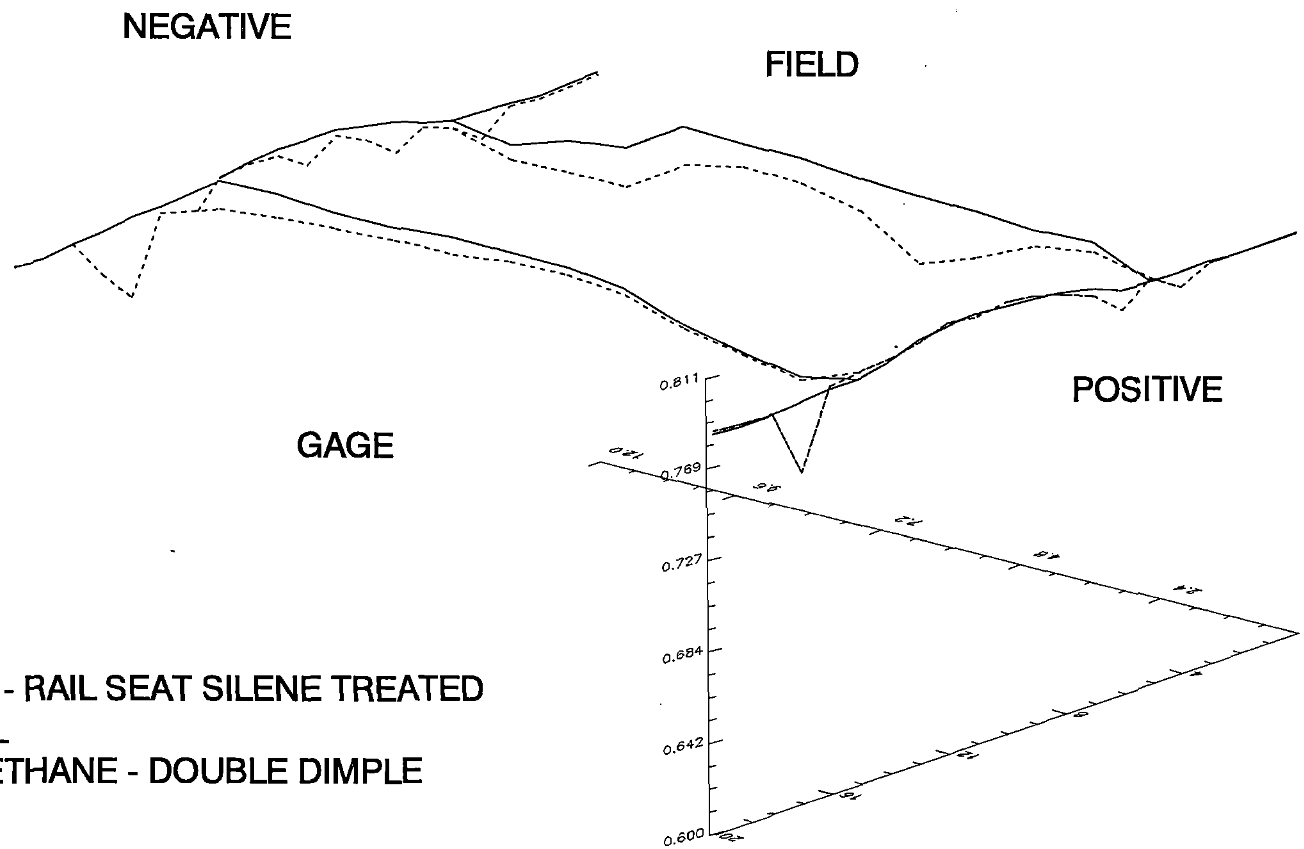


K11 1011 - RAIL SEAT SILENE TREATED
PANDROL
EVA - DOUBLE DIMPLE

1YB - AVERAGE DEPTH PROFILE

0 MGT

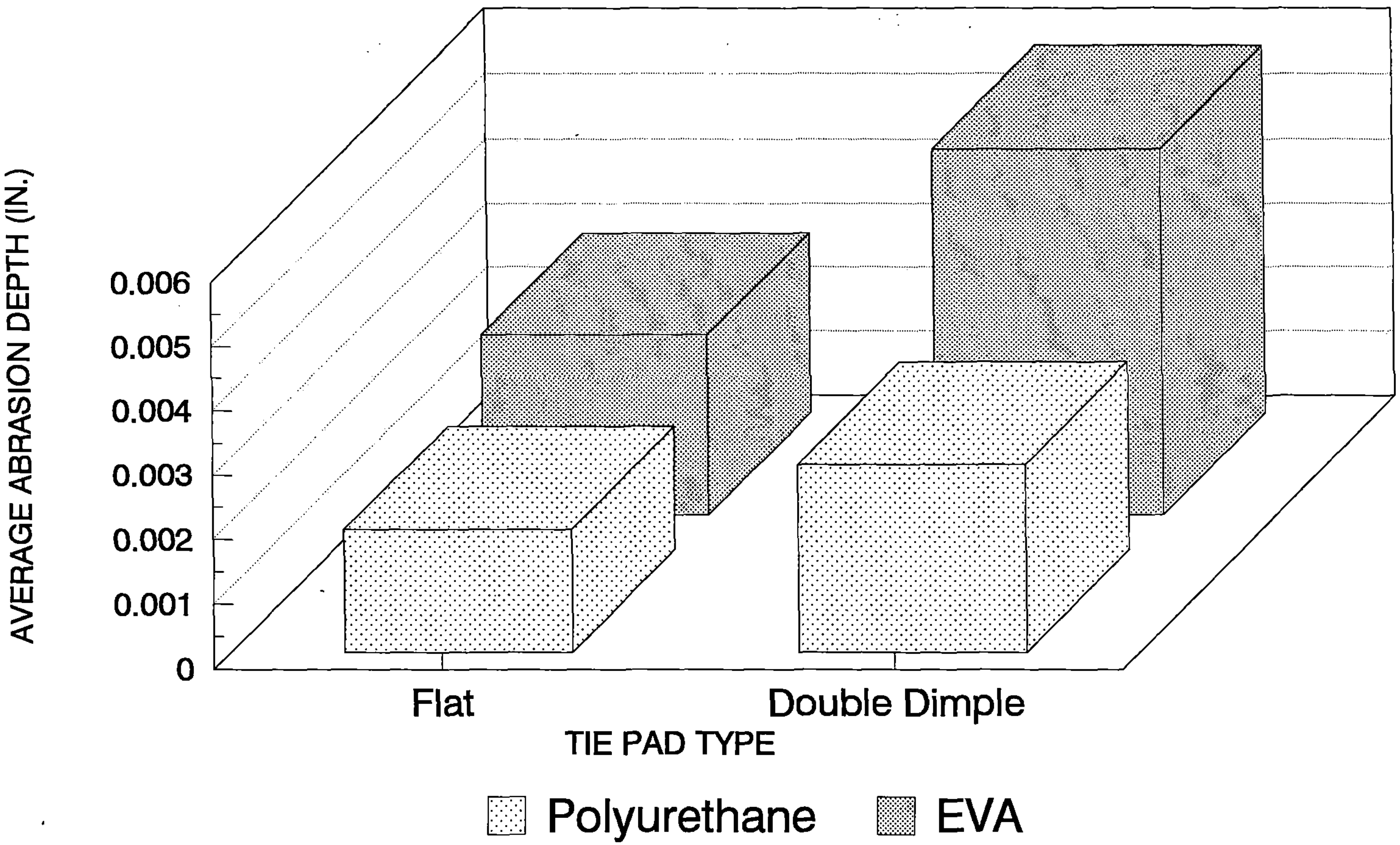
100 MGT



K11 1011 - RAIL SEAT SILENE TREATED
PANDROL
POLYURETHANE - DOUBLE DIMPLE

COMPARISON OF FLAT AND DOUBLE DIMPLE TIE PADS

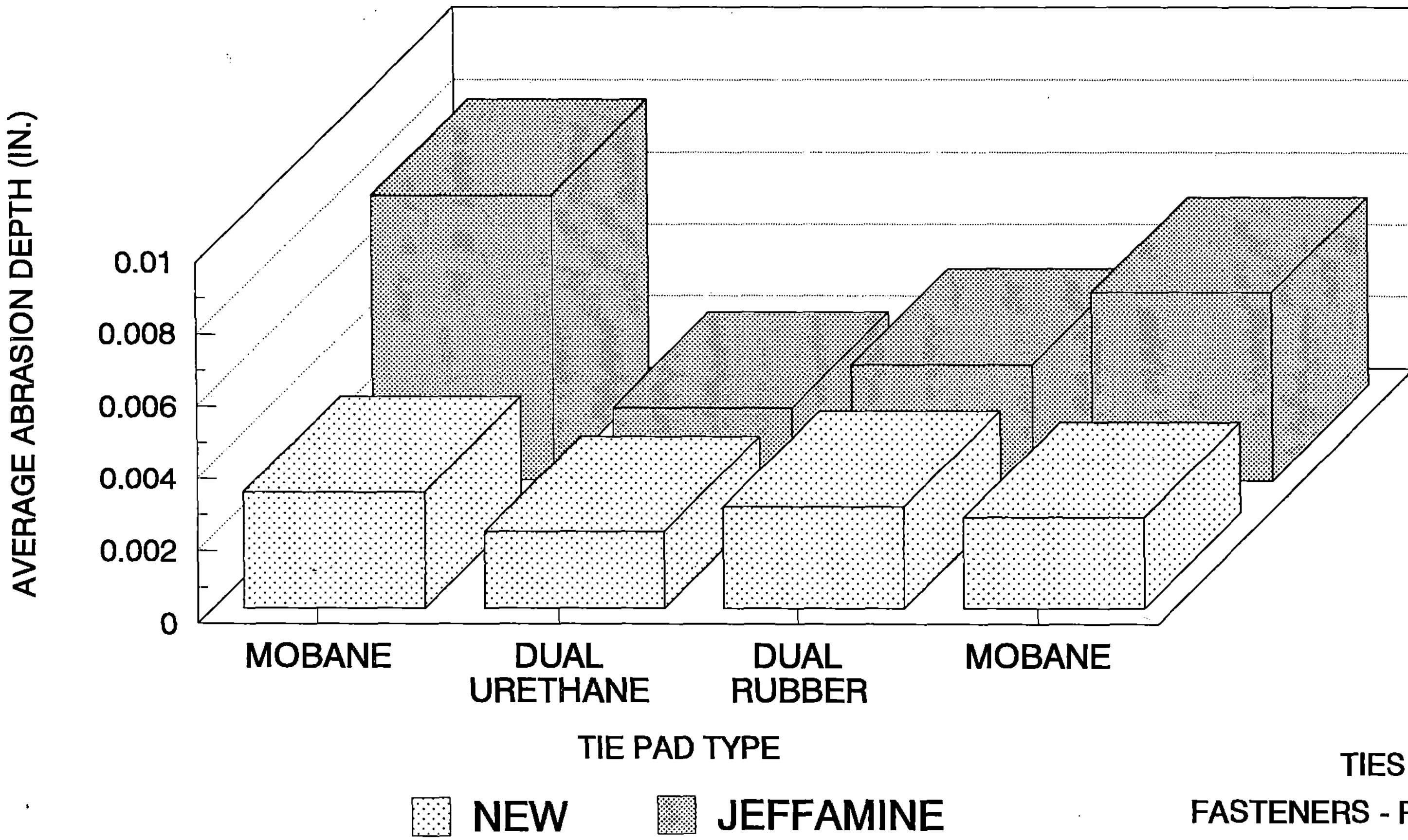
AFTER 100 MGT



COMPARISON OF STRUCTURAL REPAIR MATERIALS

FOR REPAIR OF ABRAIDED TIES

AFTER 100 MGT



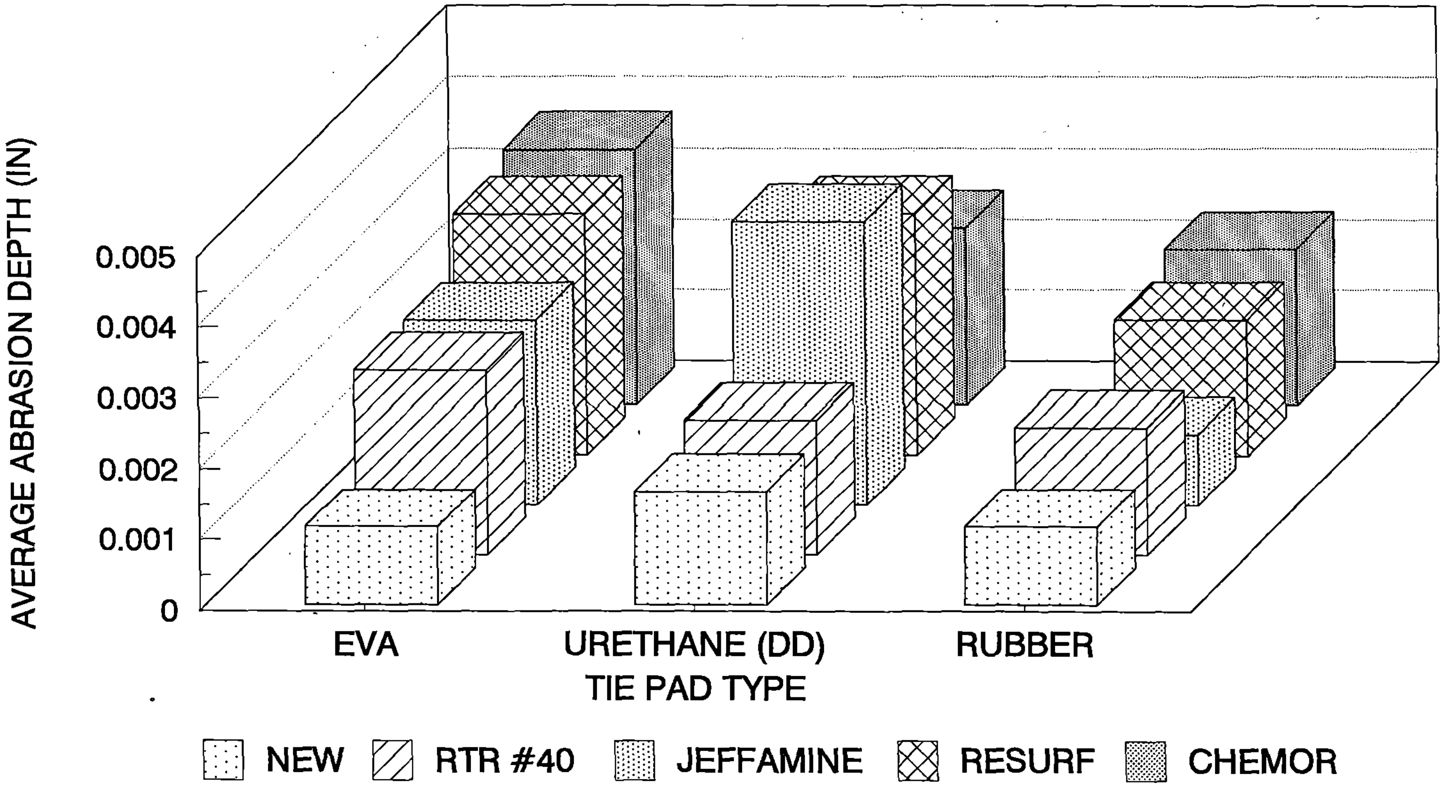
TIES - CP CT3

FASTENERS - PANDROL

COMPARISON OF STRUCTURAL REPAIR MATERIALS

FOR REPAIR OF ABRAIDED TIES

AFTER 100 MGT

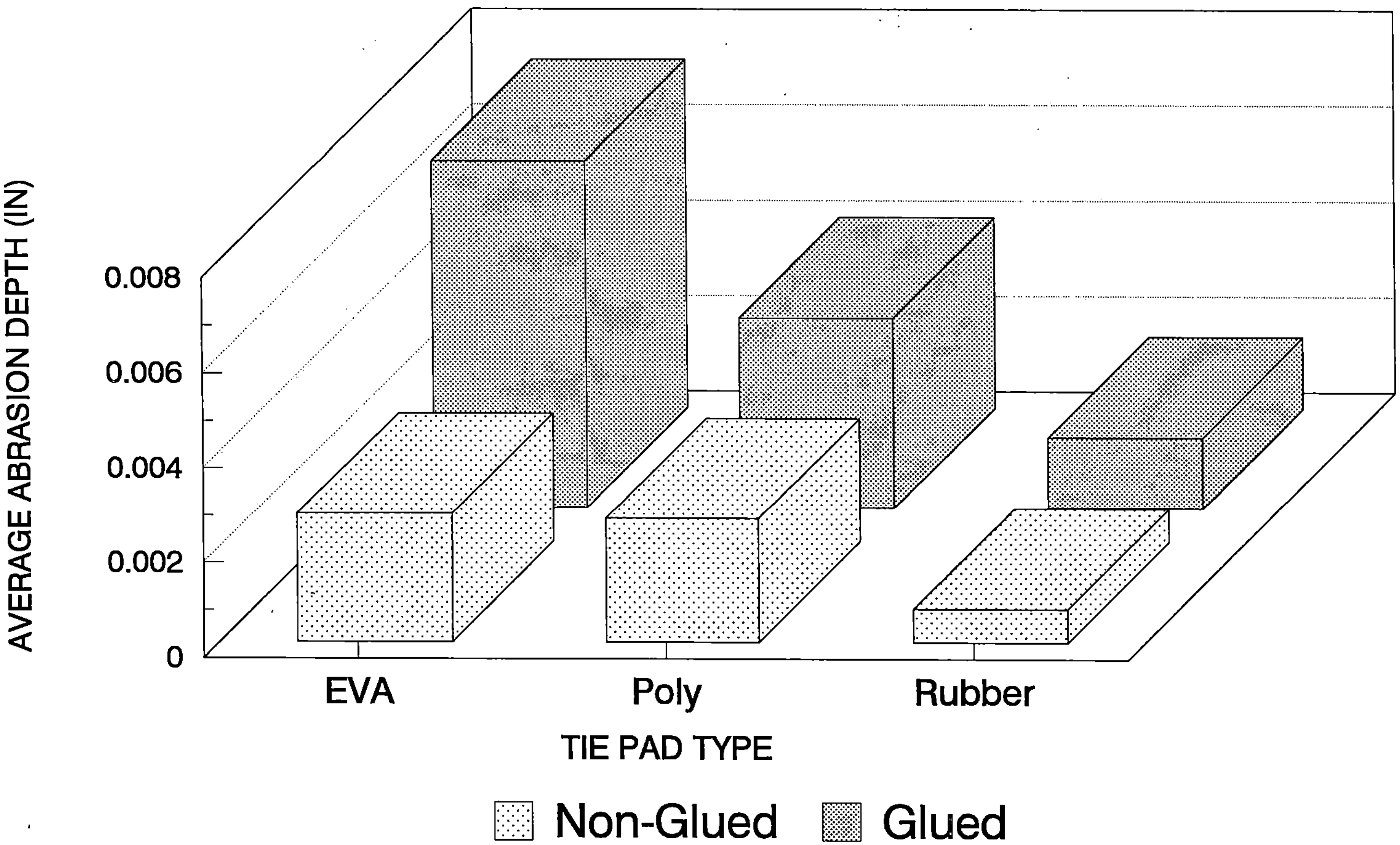


Ties - CN 60C

Fasteners - Pandrol

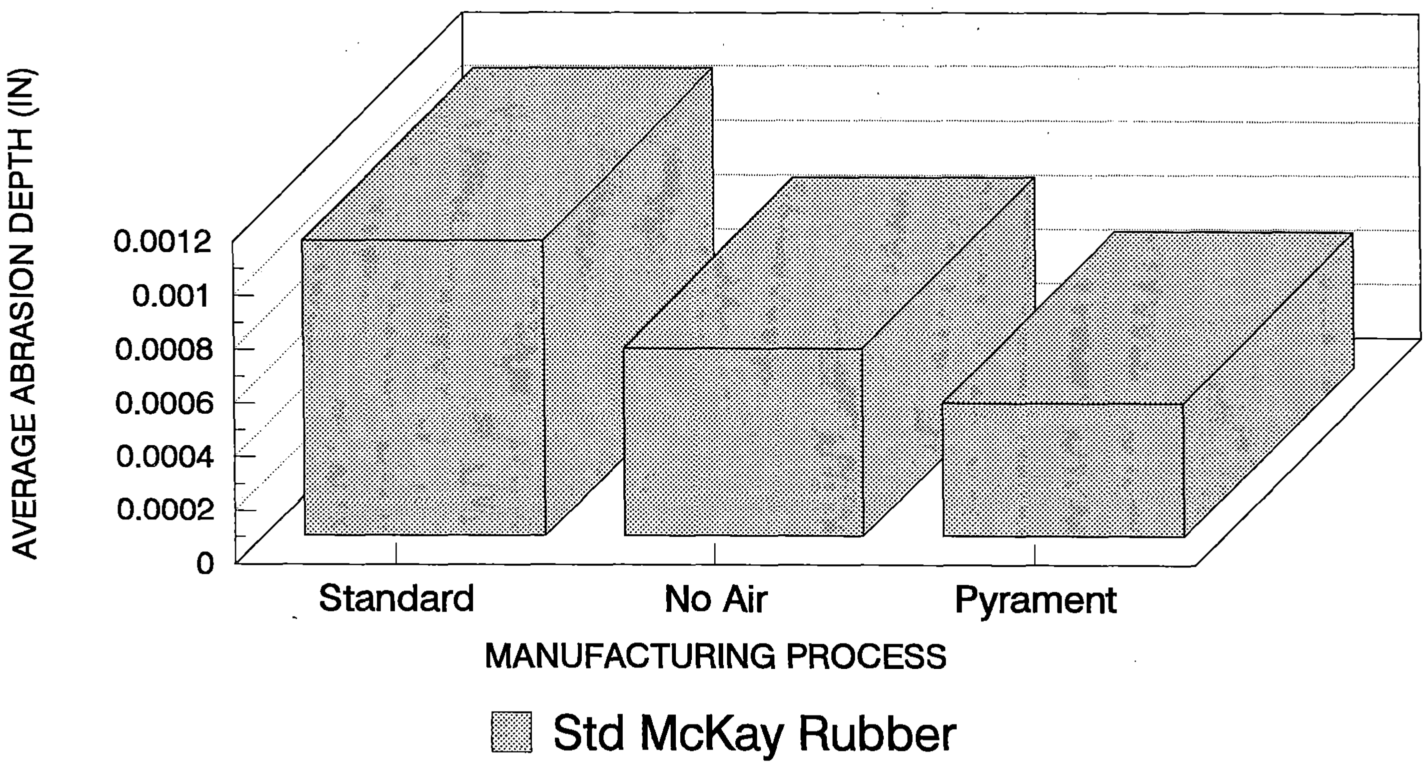
COMPARISON OF GLUED AND NON-GLUED TIE PADS

AFTER 100 MGT



MANUFACTURING PROCESSES FOR NEW TIES

AFTER 100 MGT



TIES - BN 100

FASTENERS - McKAY

CONCRETE TIE RAIL SEAT ABRASION EXPERIMENT

Results:

- In some cases, Flat pads are showing less abrasion than Double Dimple pads of same composition
- Some structural repair materials showing greater evidence of abrasion than standard ties
- Rubber pads effective in slowing abrasion but deforming & deteriorating rapidly
- Ties with glued pads are abraiding more rapidly than non-glued pads
- Steel plate & polyurethane pad show no measureable evidence of abrasion to date

Future:

- Tie pad cast to rail seat
- Convex rail seat
- Steel plate cast in tie
- Materials to bond tie pad to rail seat

DATA NOT INCLUDED IN THE PRESENTATION

MATERIALS

Materials List - Zone 1 (197 ties)

Zone	Tie	No.	Source	Fastener/Pad	Air/Treatment
1A(A)	CP CT3	5	CXT/ CP	Pandrol CDA/ Mobane	3 1/2% min./ Standard as cast
1A(B)	CP CT3	5	CXT/ CP	Pandrol CDA/ Dual Hardness Urethane	3 1/2% min./ Standard as cast
1A(C)	CP CT3	5	CXT/ CP	Pandrol CDA/ Dual hardness Rubber	3 1/2% min./ Standard as cast
1A(D)	CP CT3	5	CXT/ CP	Pandrol CDA/ Mobane	3 1/2% min./ Standard as cast
1B(A)	CP CT3	5	CXT/ CXT	Pandrol CDA/ Mobane	3 1/2% min./ Blasted + 1/4" Jeffamine
1B(B)	CP CT3	5	CXT/ CXT	Pandrol CDA/ Dual Hardness Urethane	3 1/2% min./ Blasted + 1/4" Jeffamine
1B(C)	CP CT3	2	CXT/ CXT	Pandrol CDA/ Dual Hardness Rubber	3 1/2% min./ Blasted + 1/4" Jeffamine
1B(D)	CP CT3	3	CXT/ CXT	Pandrol CDA/ Glued CRP Rubber	3 1/2% min./ Blasted + 1/4" Jeffamine
1B(E)	CP CT3	5	CXT/ CXT	Pandrol CDA/ Mobane	3 1/2% min./ Blasted + 1/4" Jeffamine
1F	UP 497	14	CXT/ UP	Pandrol Inc./ 6 1/2 mm Poly	3 1/2% min./ Standard as cast
1G	UP 497	6	CXT/ CXT	Pandrol Inc./ Poly	3 1/2% min./ Jeffamine
1H	UP 497	7	CXT/ CXT	Pandrol Inc./ Dual Poly	3 1/2% min./ Jeffamine
1I	UP 497	7	CXT/ CXT	Pandrol Inc./ Dual Rubber	3 1/2% min./ Jeffamine
1J	UP 497	6	CXT/ UP	Pandrol Inc./ Poly with glue	3 1/2% min./ Standard as cast
1K(A)	UP 497	2	CXT/ UP	Pandrol Inc./ Dual Durometer Poly	3 1/2% min./ Standard as cast
1K(B)	UP 497	3	CXT/ UP	Pandrol Inc./ Poly w/seal ring	3 1/2% min./ Standard as cast
1L(A)	UP 497	2	CXT/ UP	Pandrol Inc./ Neoprene below Poly	3 1/2% min./ Standard as cast
1L(B)	UP 497	3	CXT/ UP	Pandrol Inc./ BUNA below Poly	3 1/2% min./ Standard as cast
1W(A)	K11 1011	2	Koppers/ Koppers	Pandrol Inc./ Acme EVA (Double Dimple)	4% min./ Standard as cast
1W(B)	K11 1011	2	Koppers/ Koppers	Pandrol Inc./ Polyurethane (Double Dimple)	4% min./ Standard as cast
1X(A)	K11 1011	3	Koppers/ Koppers	Pandrol Inc./ Rubber w/seal ring	4% min./ Standard as cast
1X(B)	K11 1011	2	Koppers/ Koppers	Pandrol Inc./ Dual Durometer Rubber	4% min./ Standard as cast
1X(C)	K11 1011	1	Koppers/ Koppers	Pandrol Inc./ Glued Rubber (No seal ring)	4% min./ Standard as cast

Materials List--cont'd

Zone	Tie	No.	Source	Fastener/Pad	Air/Treatment
1Y(A)	K11 1011	2	Koppers/ Koppers	Pandrol Inc./ Acme EVA (Double Dimple)	4% min./ Rail seat Silene treated
1Y(B)	K11 1011	2	Koppers/ Koppers	Pandrol Inc./ Polyurethane (Double Dimple)	4% min./ Rail seat Silene treated
1Y(C)	K11 1011	2	Koppers/ Koppers	Pandrol Inc./ Rubber w/seal ring	4% min./ Rail seat Silene treated
1Y(D)	K11 1011	2	Koppers/ Koppers	Pandrol Inc./ Dual Durometer Rubber	4% min./ Rail seat Silene treated
1Z(A)	K11 1011	1	Koppers/ Koppers	Pandrol Inc./ Acme EVA (Double Dimple)	4% min./ Whole tie Silene treated
1Z(B)	K11 1011	1	Koppers/ Koppers	Pandrol Inc./ Polyurethane (Double Dimple)	4% min./ Whole tie Silene treated
1O	BN 100	10	LSM/ LSM	McKay/ Std McKay rubber-control	3 1/2% min./ Standard as cast
1P	BN 100	10	CXT/ CXT	McKay/ Gasket/Steel Plate & Polyurethane	3 1/2% min./ Standard as cast
1Q	BN 100	12	LSM/ LSM	McKay/ Std McKay rubber-8 mm	No air/ Standard as cast
1R	BN 100	6	LSM/ LSM	McKay/ Std McKay rubber-8 mm	Pyrament/ Standard as cast
1S	BN 100	10	CXT/ CXT	McKay/ McKay EVA-8 mm	Silica fume + air/ Standard as cast
1T(A)	BN 100	2	CXT/ CXT	McKay/ Neoprene below Poly	3 1/2% min./ Standard as cast
1T(B)	BN 100	3	CXT/ CXT	McKay/ BUNA below Poly	3 1/2% min./ Standard as cast
1T(C)	BN 100	5	CXT/ CXT	McKay/ Masti Cord	3 1/2% min./ Standard as cast
1U	BN 100	10	CXT/ CXT	McKay/ CRP glue + McKay Polyurethane	3 1/2% min./ Standard as cast
1V	BN 100	10	CXT/ CXT	McKay/ McKay Polyurethane-8 mm	Silica fume + air/ Standard as cast
2Y(A)	BN 100	5	CXT/ BN	McKay/ Sika-flex & CRP Rubber	Air entrained/ Sika-flex
2Y(B)	BN 100	4	CXT/ BN	McKay/ Epoxy/Steel plate & Polyurethane	Air entrained/ Epoxy

Materials List - Zone 2 (119 ties)

Zone	Tie	No.	Source	Fastener/Pad	Air/Treatment
2A(A)	CN 60C	8	CN	Pandrol CDA/ EVA	Air entrained/ New tie
2A(B)	CN 60C	2	CN	Pandrol CDA/ Glued EVA	Air entrained/ New tie
2B	CN 60C	5	CN	Pandrol CDA/ Urethane	Air entrained/ New tie
2C	CN 60C	5	CN	Pandrol CDA/ Rubber	Air entrained/ New tie
2D	CN 60B	6	CN	Pandrol CDA/ EVA	Air entrained/ Jeffamine-1984 tie
2E	CN 60B	6	CN	Pandrol CDA/ Urethane	Air entrained/ Jeffamine-1984 tie
2F	CN 60B	6	CN	Pandrol CDA/ Rubber	Air entrained/ Jeffamine-1984 tie
2G	CN 60B	5	CN	Pandrol CDA/ EVA	Air entrained/ Chemor-1984 tie
2H	CN 60B	6	CN	Pandrol CDA/ Urethane	Air entrained/ Chemor-1984 tie
2I	CN 60B	6	CN	Pandrol CDA/ Rubber	Air entrained/ Chemor-1984 tie
2J	CN 60B	5	CN	Pandrol CDA/ EVA	Air entrained/ Resurf 241
2K	CN 60B	5	CN	Pandrol CDA/ Urethane	Air entrained/ Resurf 241
2L	CN 60B	5	CN	Pandrol CDA/ Rubber	Air entrained/ Resurf 241
2M	CN 60B	4	CN	Pandrol CDA/ EVA	Air entrained/ RTR #40
2N	CN 60B	3	CN	Pandrol CDA/ Urethane	Air entrained/ RTR #40
2O	CN 60B	3	CN	Pandrol CDA/ Rubber	Air entrained/ RTR #40
2V	BN 100	9	BN/ LSM	McKay/ Rubber	Air entrained/ Less than 2mm abrasion
2W	BN 100	10	BN/ CXT	McKay/ Rubber	Air entrained/ Epoxy
2X(A) **	BN 100	5	BN/ LSM	McKay/ Sika-flex/Steel Plate & Polyurethane	Air entrained/ More than 1.5mm abrasion
2X(B)	BN 100	5	BN/ LSM	McKay/ Epoxy/Steel plate & Polyurethane	Air entrained/ More than 1.5mm abrasion
2Z	BN 100	10	BN	McKay/ Rubber - control	Air entrained/ New tie

FAST HAL

BALLAST EXPERIMENT

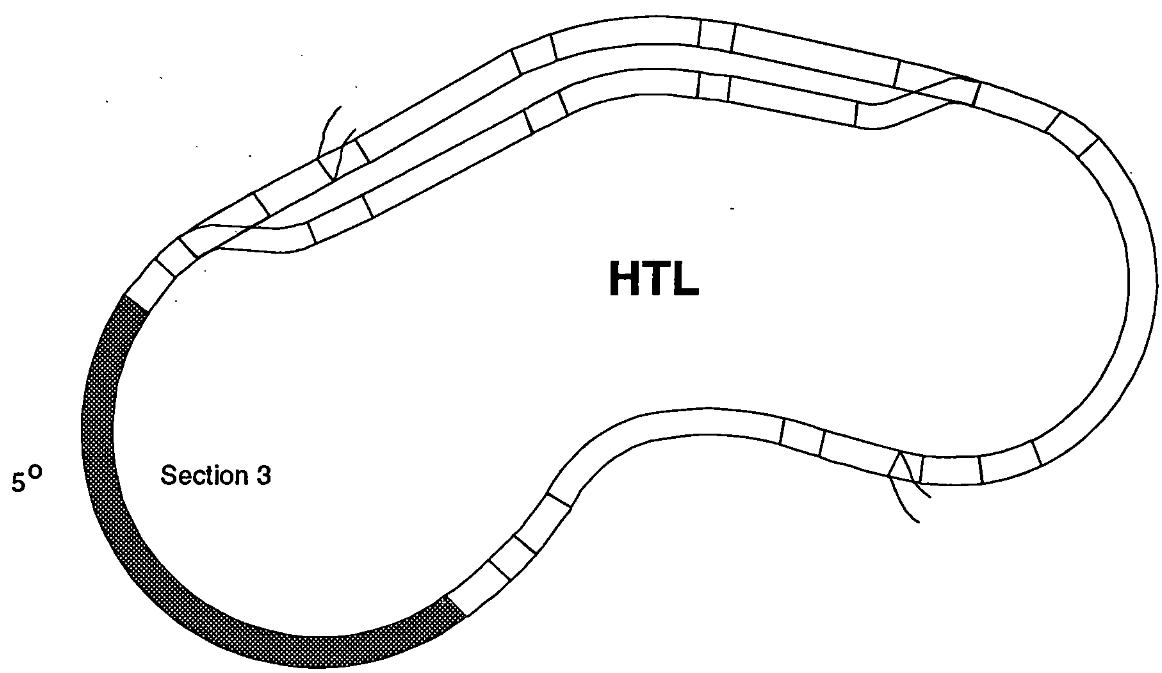
By M. Carmen Trevizo
Experiment Manager

TRANSPORTATION TEST CENTER
PUEBLO, COLORADO

INTRODUCTION AND OBJECTIVE

Ballast materials, with their varied mineral characteristics, may prove to be impractical or incapable of supporting traffic for a suitable length of time in a heavy axle load environment. During the Ballast Experiment at FAST, data on four different ballast materials are being collected to evaluate their deterioration rate and profile under 39-ton axle load traffic.

TEST LOCATION



MEASUREMENTS

- Loaded and unloaded profile elevations
- Vertical track modulus
- Ballast density
- Geometry car
- Gradation analysis

SUMMARY AFTER 160 MGT OF HAL TRAFFIC

- All four ballast materials have been able to withstand the heavy axle load environment during the first 160 MGT of HAL traffic.
- At this tonnage, the degradation of similar granite ballast, does not appear to be sensitive to axle load increase.
- Dolomite ballast required more frequent spot maintenance in areas where rail joints were present.

UPDATE

- Out-of-face surfacing:

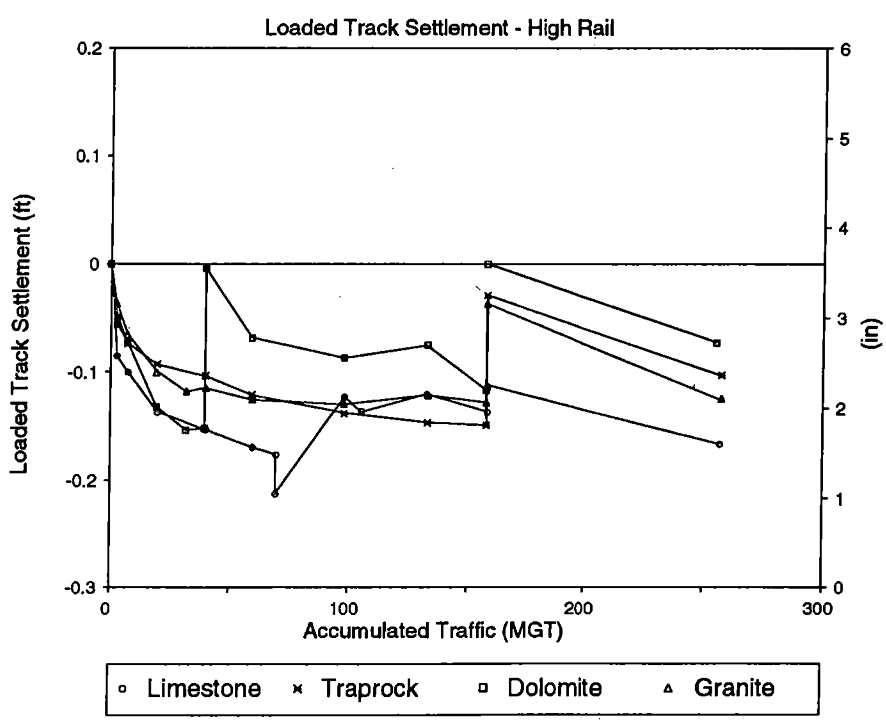
  40 MGT -- Dolomite

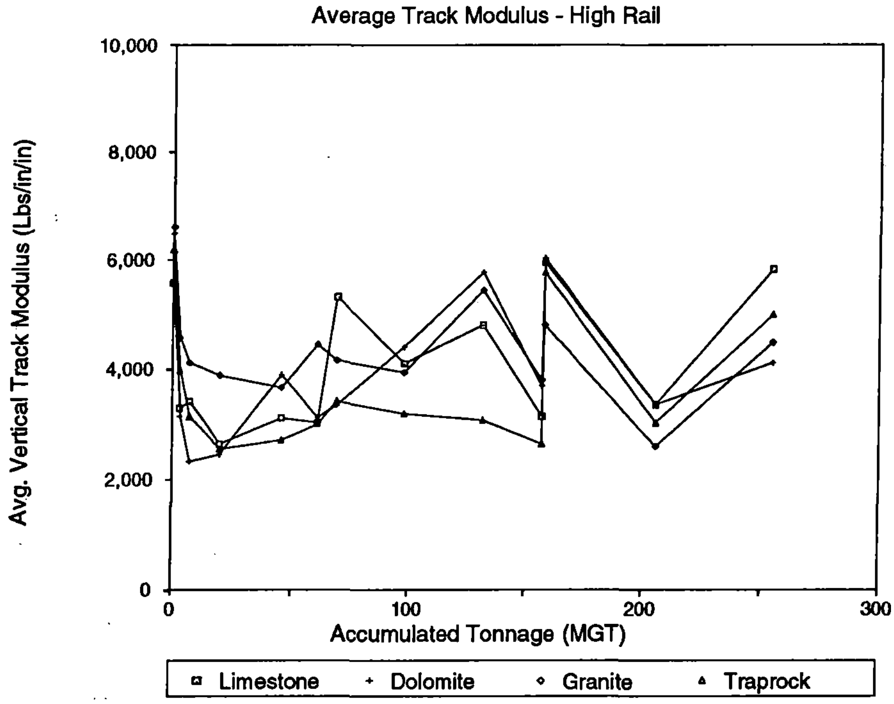
  70 MGT -- Limestone

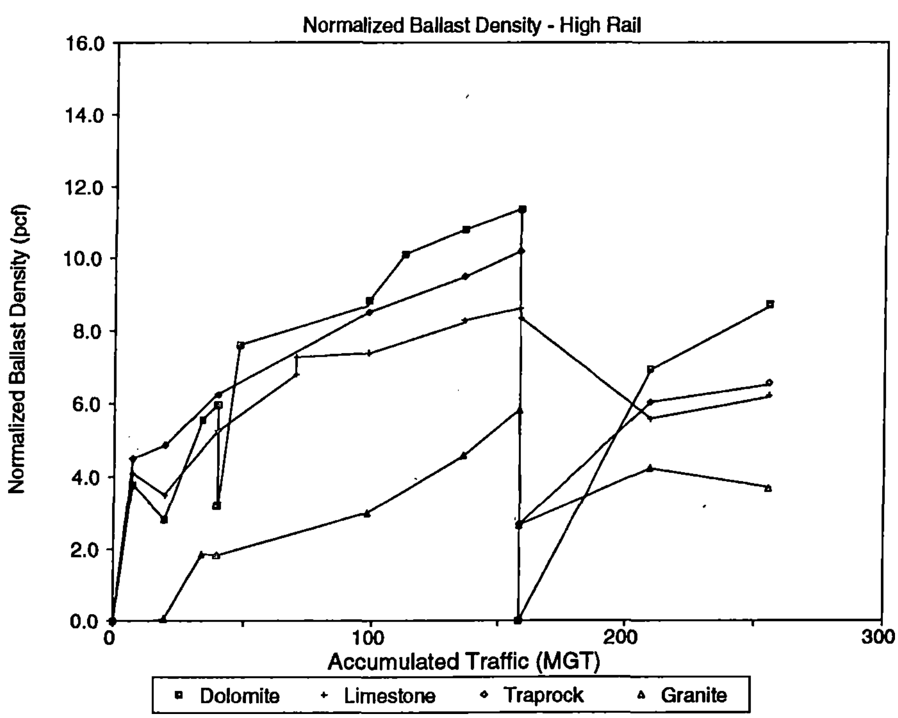
  160 MGT -- Traprock, Granite, Dolomite, Limestone

  260 MGT -- Limestone (track buckle)

DATA




Average Track Modulus - High Rail
Avg. Vertical Track Modulus (Lbs/in/in)
10,000
8,000
6,000
4,000
2,000
0
0
100
200
300
Accumulated Tonnage (MGT)
Limestone
Dolomite
Granite
Traprock


Normalized Ballast Density - High Rail
Normalized Ballast Density (pcf)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
100
200
300
Accumulated Traffic (MGT)
Dolomite
Limestone
Traprock
Granite

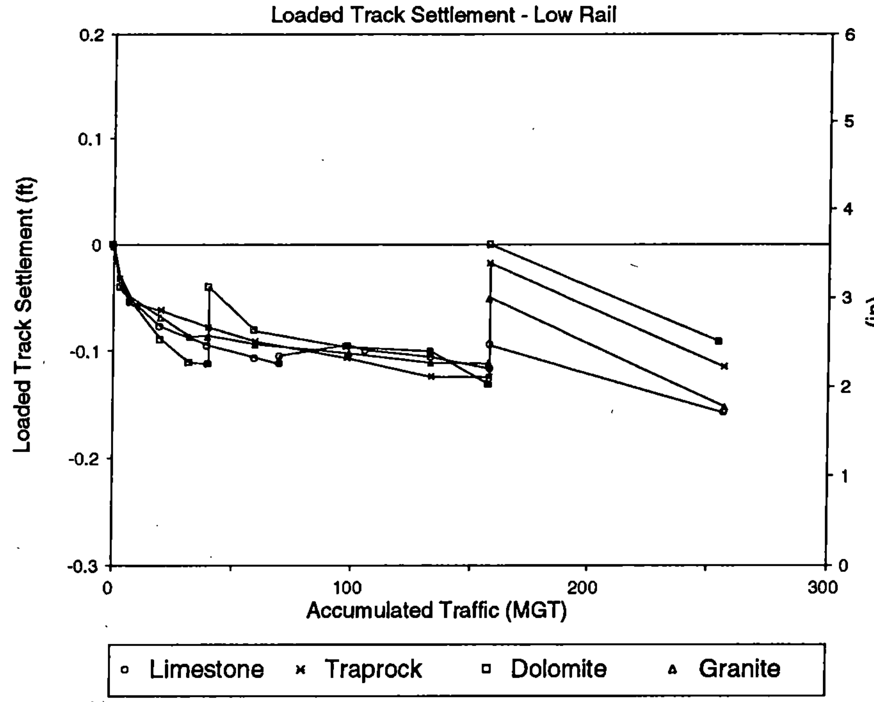
RESULTS

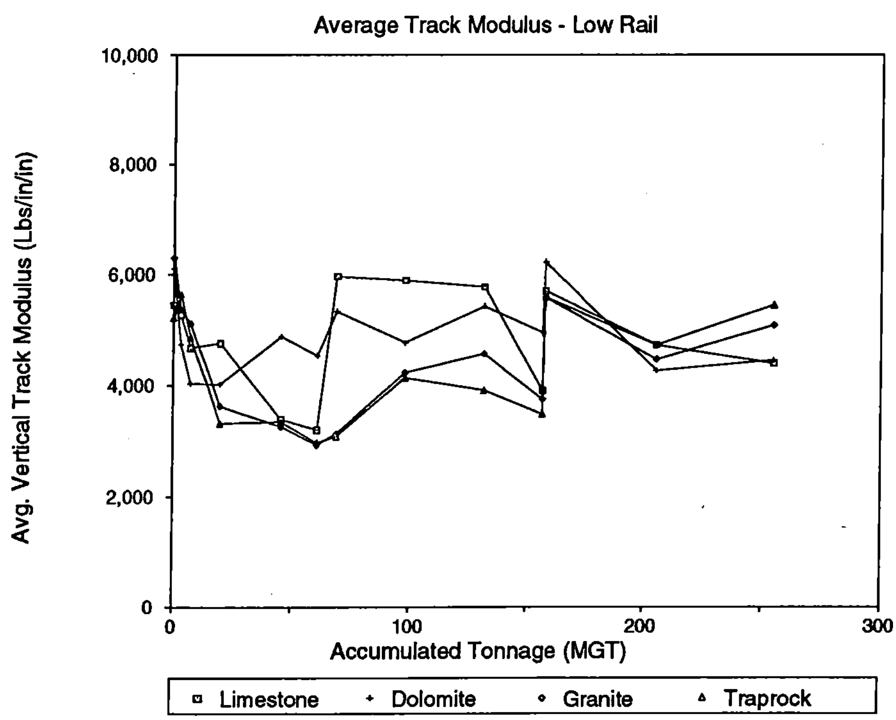
For the first 260 MGT of HAL traffic, all four ballast materials have been able to withstand the heavy axle load environment.

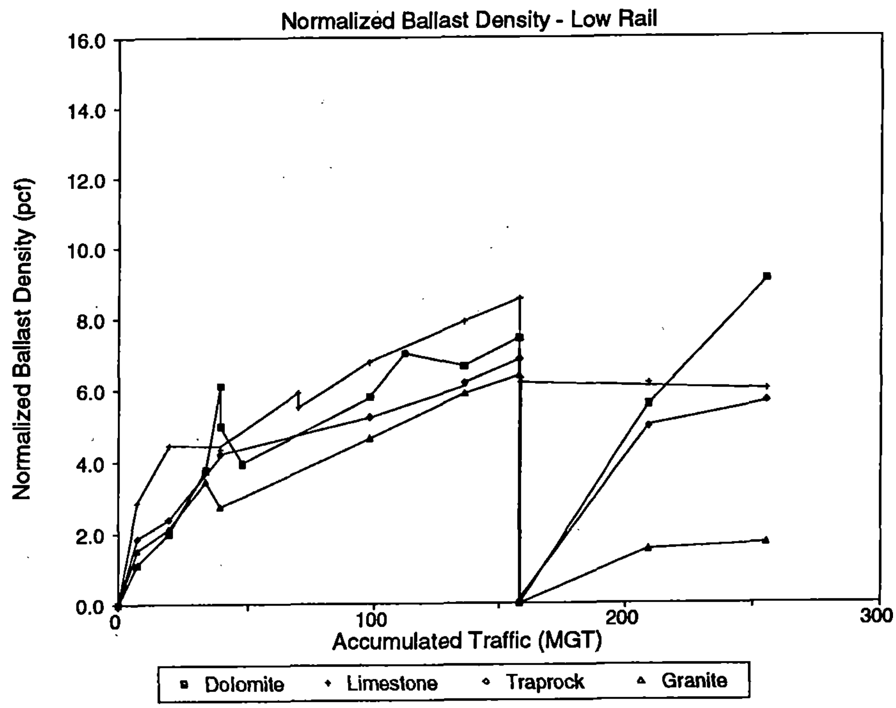
FUTURE

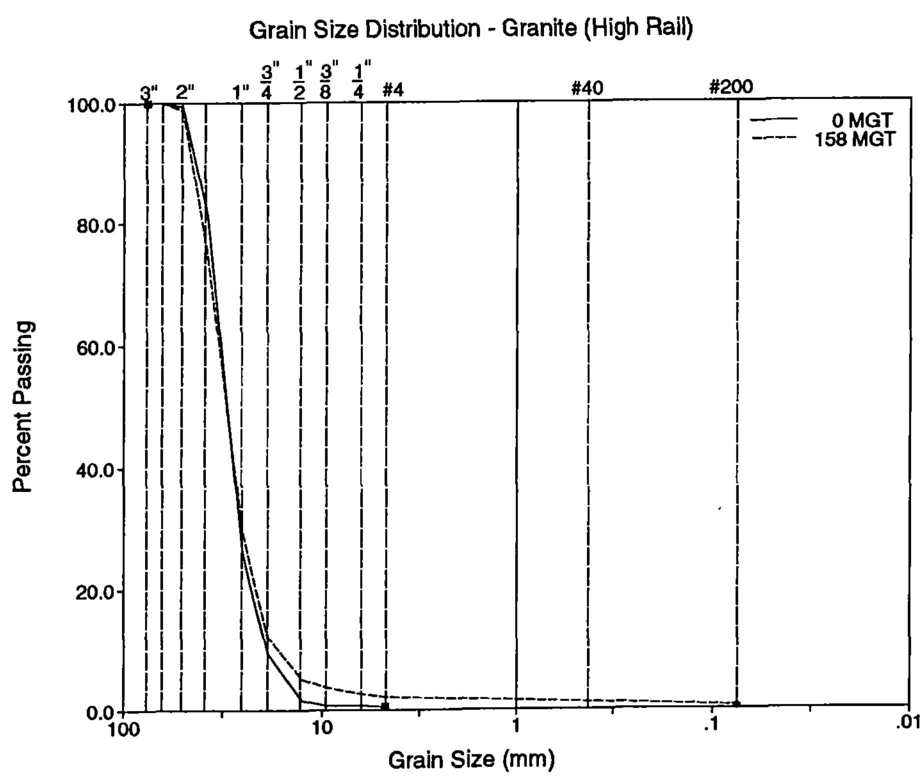
- Geometry Retention Measurements: Measurements will continue at the predetermined measurement cycles.
- Ballast Samples: Samples will be taken only at the end of the ballast life and during out-of-face surfacing, due to lack of sampling locations.

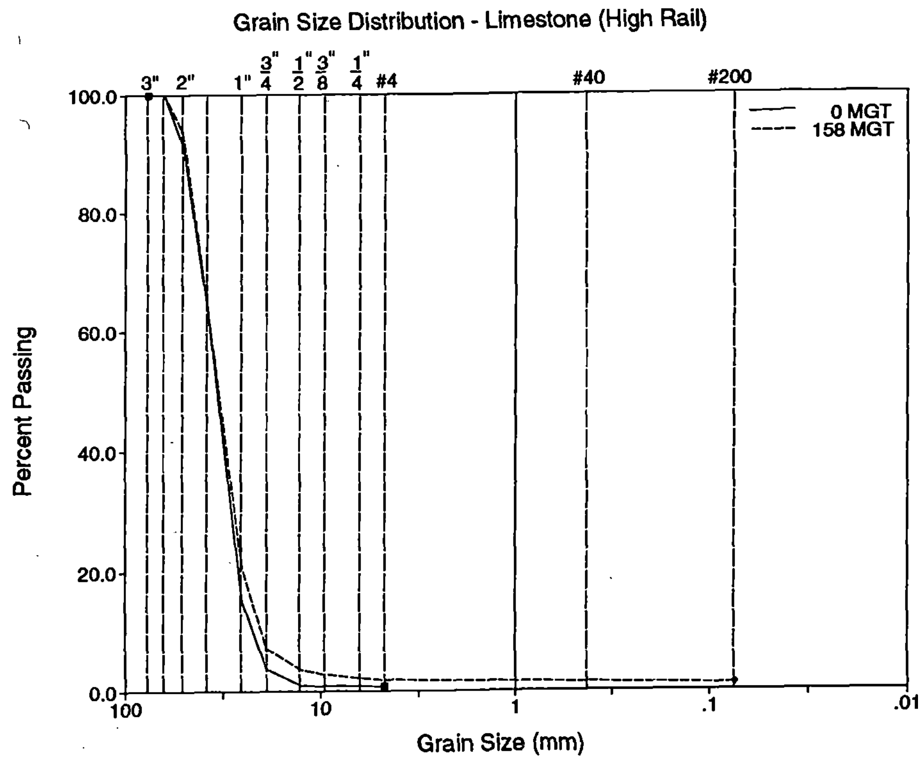
DATA NOT INCLUDED IN THE PRESENTATION

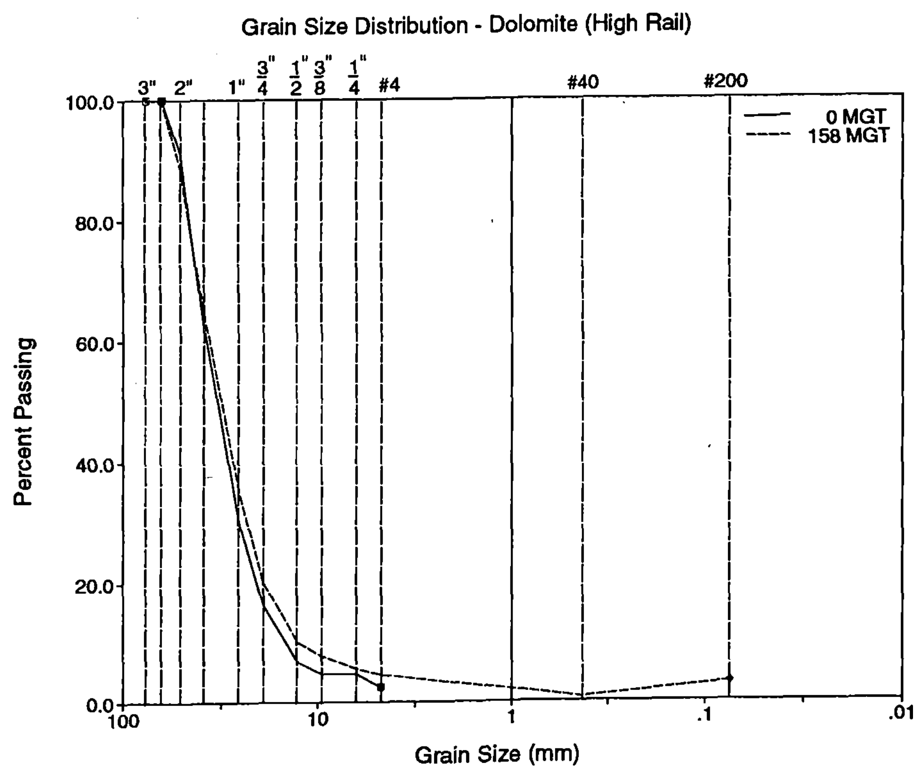

Loaded Track Settlement - Low Rail
0.2
0.1
0
-0.1
-0.2
-0.3
Loaded Track Settlement (ft)
6
5
4
3
2
1
0
(in)
0
100
200
300
Accumulated Traffic (MGT)
Limestone
Traprock
Dolomite
Granite


Average Track Modulus - Low Rail
10,000
8,000
6,000
4,000
2,000
0
Avg. Vertical Track Modulus (Lbs/in/in)
0
100
200
300
Accumulated Tonnage (MGT)
Limestone
Dolomite
Granite
Traprock

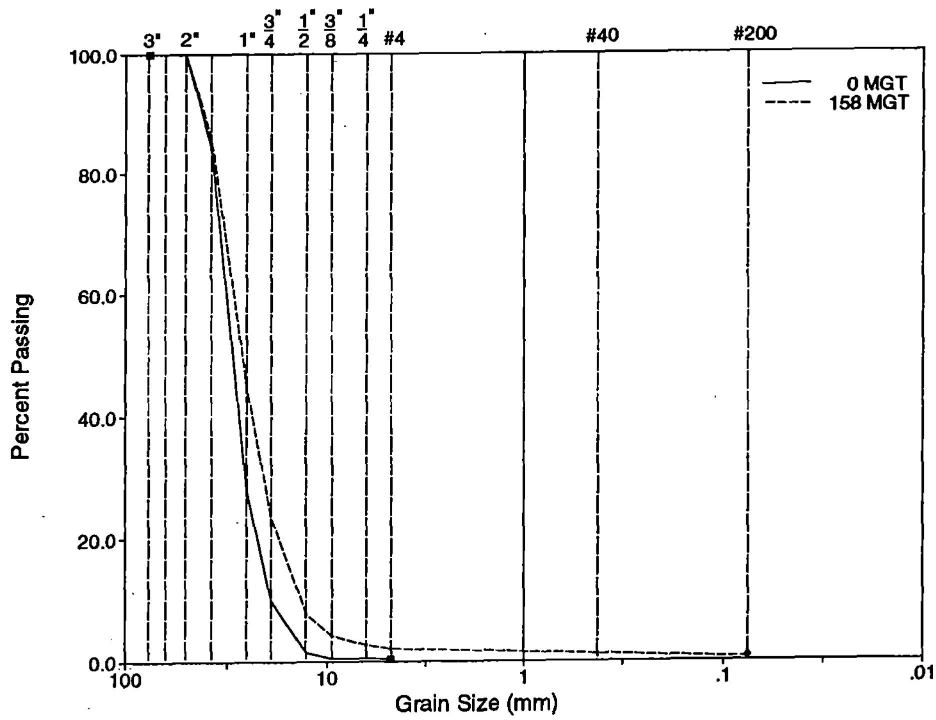

Normalized Ballast Density - Low Rail
Normalized Ballast Density (pcf)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
100
200
300
Accumulated Traffic (MGT)
Dolomite
Limestone
Traprock
Granite


Grain Size Distribution - Granite (High Rail)
3"
2"
1"
3/4"
1/2"
3/8"
1/4"
#4
#40
#200
0 MGT
158 MGT
Percent Passing
100.0
80.0
60.0
40.0
20.0
0.0
100
10
1
.1
.01
Grain Size (mm)


Grain Size Distribution - Limestone (High Rail)
3" 2" 1" 3/4" 1/2" 3/8" 1/4" #4 #40 #200
0 MGT
158 MGT
Percent Passing
100.0
80.0
60.0
40.0
20.0
0.0
100 10 1 .1 .01
Grain Size (mm)


Grain Size Distribution - Dolomite (High Rail)
3" 2" 1" 3/4" 1/2" 3/8" 1/4" #4 #40 #200
0 MGT
158 MGT
Percent Passing
100.0
80.0
60.0
40.0
20.0
0.0
100 10 1 .1 .01
Grain Size (mm)

Grain Size Distribution - Traprock (High Rail)



FAST
HAL

LOW TRACK MODULUS EXPERIMENT

By David M. Read
Experiment Manager

TRANSPORTATION TEST CENTER
PUEBLO, COLORADO

LOW TRACK MODULUS EXPERIMENT INTRODUCTION

- *Silty-Sand Soil And Semi-Arid Climate At FAST Creates Generally High Quality Subgrade Conditions*
- *HAL Traffic At FAST Indicated Little Problem With Track Constructed On "Above Average" Support Conditions*
- *What Would Happen To Track Built On "Low End" Of What Is Considered Main Line Support Conditions*
- *Average FAST Wood Tie Track Modulus Is 4500 lb/in/in*
- *Field Survey Of "Typical" Main Line Track Indicated Range Of Track Modulus To Be 2000 lb/in/in To 6000 lb/in/in*

LOW TRACK MODULUS EXPERIMENT OBJECTIVES

Short Term Objectives:

- ***Determine Track Geometry Degradation Under 39-Ton Axle Loads For Two Different Track Modulus Conditions***
- ***Provide Data For Validation Of Track Response Models To Allow Prediction Of Maintenance Under Other Support Conditions***

Long Term Objective:

- ***Determine Service Life Of Components On Low Modulus Track***

LOW TRACK MODULUS EXPERIMENT TEST DESIGN

- *Construct Two Segments Of Tangent Track With Identical Superstructures*
  - *one zone on standard FAST subgrade (control zone)*
  - *one zone on modified "soft" subgrade (LTM test zone)*
- *Monitor Performance Under 39-Ton Axle Loads*
- *Maintain When Approaching FRA Class 4 Safety Limits*

LOW TRACK MODULUS EXPERIMENT

LOW MODULUS TEST ZONE DESIGN

Objective:

- *Create Test Zone With Nominal Track Modulus of 2000 lb/in/in*

Approach:

- *Excavate Trench Under Exisitng Track*
- *Replace Native Granular Subgrade Material With Lower Strength Cohesive Soil From Off Site*
- *Buckshot Clay Chosen As Backfill Material*
  - *low resilient modulus*
  - *not highly sensitive to changes in moisture content*
  - *prior use by Army Corp of Engineers*
- *Design Of Trench Determined Analytically*
- *100-Foot-Long Pilot Test Pit Constructed To Verify Initial Design And Construction Specifications*

LOW TRACK MODULUS EXPERIMENT

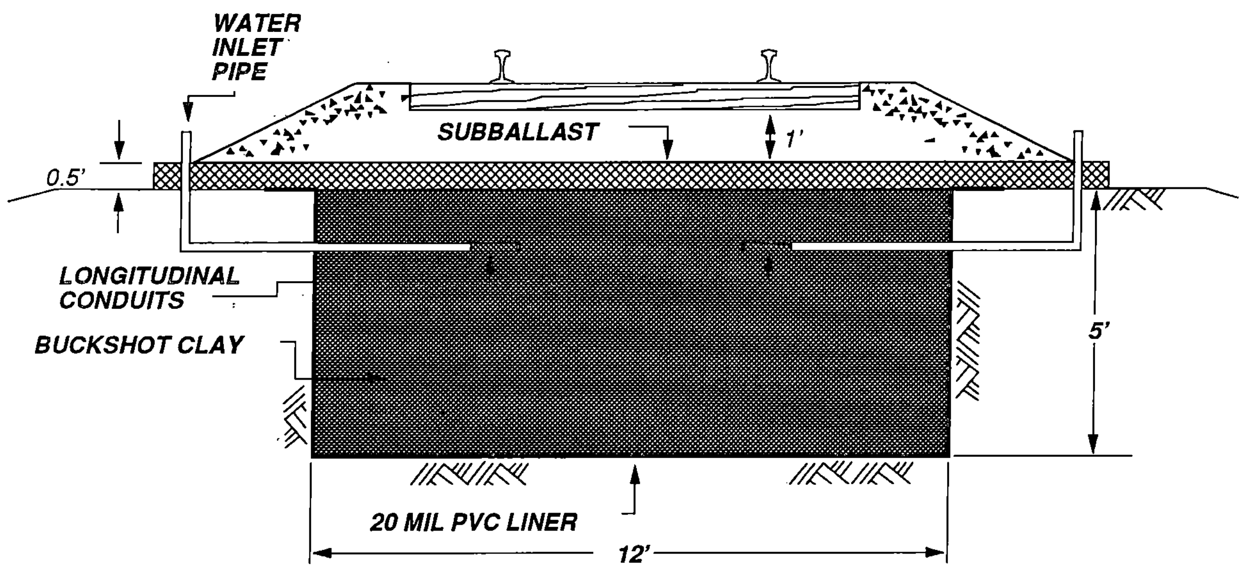
LOW MODULUS (LTM) TEST ZONE CONSTRUCTION SPECIFICATIONS

- ***Trench Specifications:***
  - *depth - 5 feet*
  - *width - 12 feet*

- ***Clay Installation Specifications:***
  - *moisture content: 30-35 percent of dry weight*
  - *8 inch to 12 inch lifts*

- ***Clay Moisture Control Specifications:***
  - *water input conduit placed longitudinally under both rails at 1.5 foot depth*
  - *moisture sensors installed every 150 feet*
  - *sides and bottom of trench lined with 20 mil PVC*
  - *6-inch subballast layer on top*

FIGURE 1. LOW TRACK MODULUS TEST ZONE CROSS SECTION

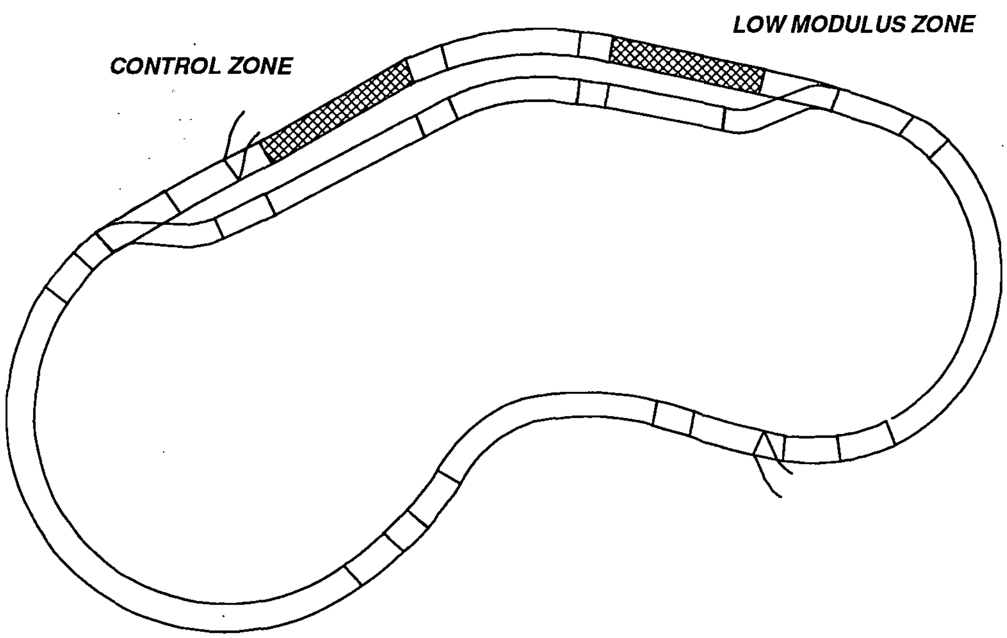


LOW TRACK MODULUS EXPERIMENT

TRACK COMPONENTS REPLICATED IN LTM AND CONTROL ZONES

- *Mix Of New And Used Ties*
- *Granite Ballast (AREA #4) 12-Inch Depth Under Ties*
- *CWR 136# Standard Rail*
- *Cut Spikes, AREA Tie Plates, And Rail Anchors*
- *6-Inch Prepared Subballast Section*
- *One Pair Bonded Insulated Joints*

FIGURE 2. LOCATION OF LOW TRACK MODULUS TEST ZONES ON FAST HIGH TONNAGE LOOP



LOW TRACK MODULUS EXPERIMENT
KEY PERFORMANCE PARAMETERS

- *Track Geometry (Plasser EM80)*
- *Dynamic Wheel/Rail Forces (Instrumented Wheel Sets)*
- *Maintenance Demand*
- *Vertical Track Modulus*
- *Loaded And Unloaded Top-Of-Rail Profile*

FIGURE 3. TRACK PROFILE DEGRADATION COMPARISON

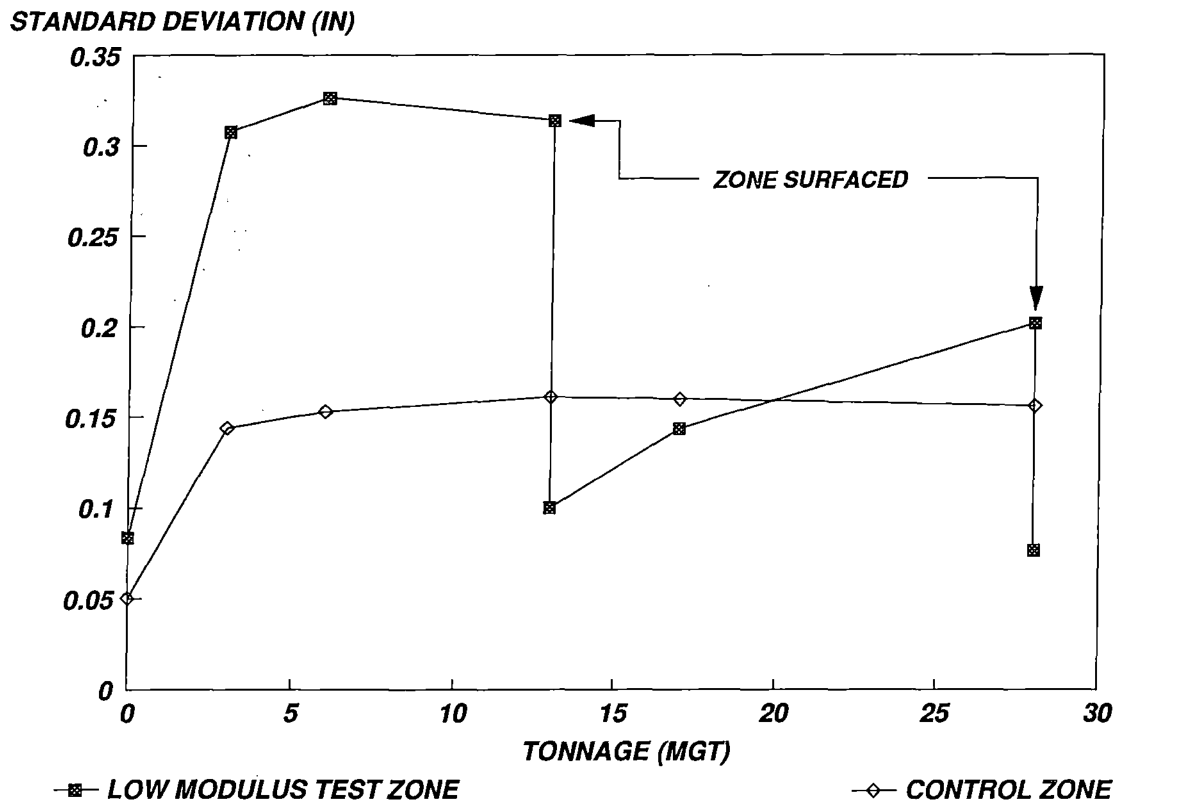


FIGURE 4. CROSS LEVEL DEGRADATION COMPARISON

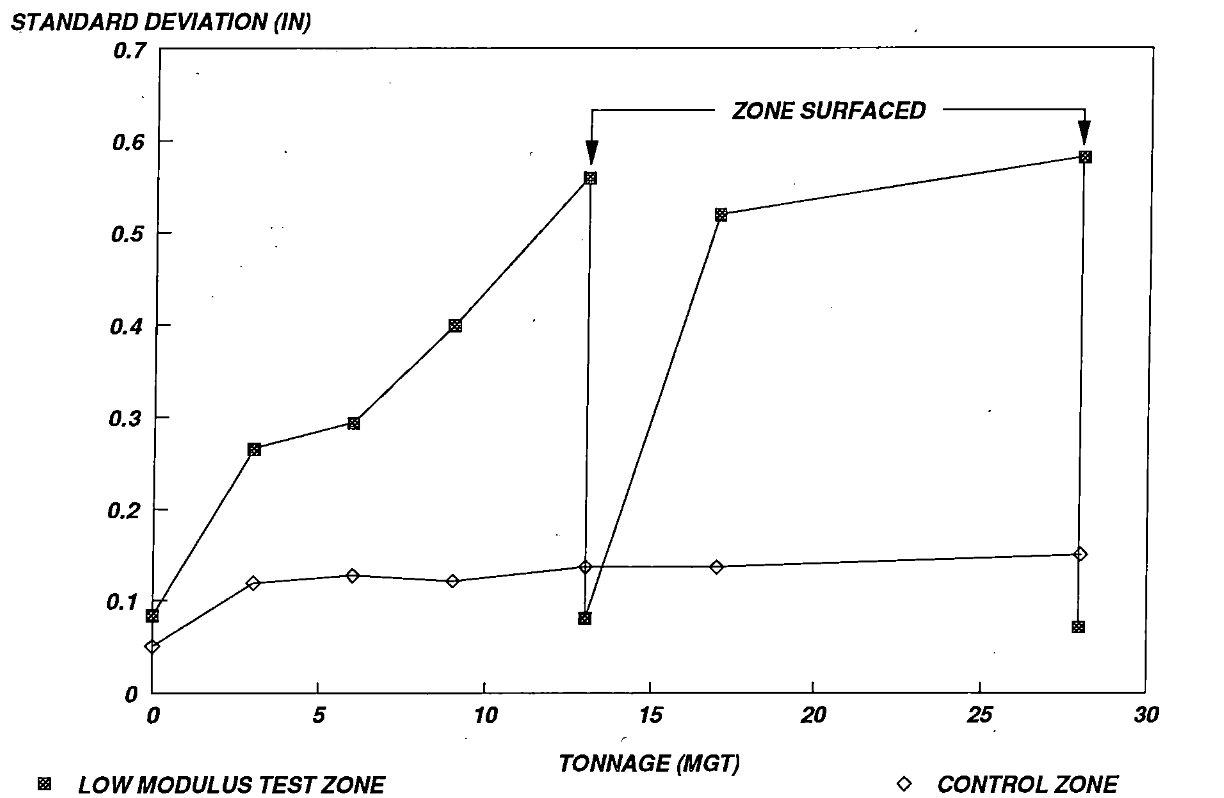


FIGURE 5. CROSS LEVEL AND TRACK MODULUS MEASURED IN LTM TEST ZONE 15 MGT AFTER SURFACING

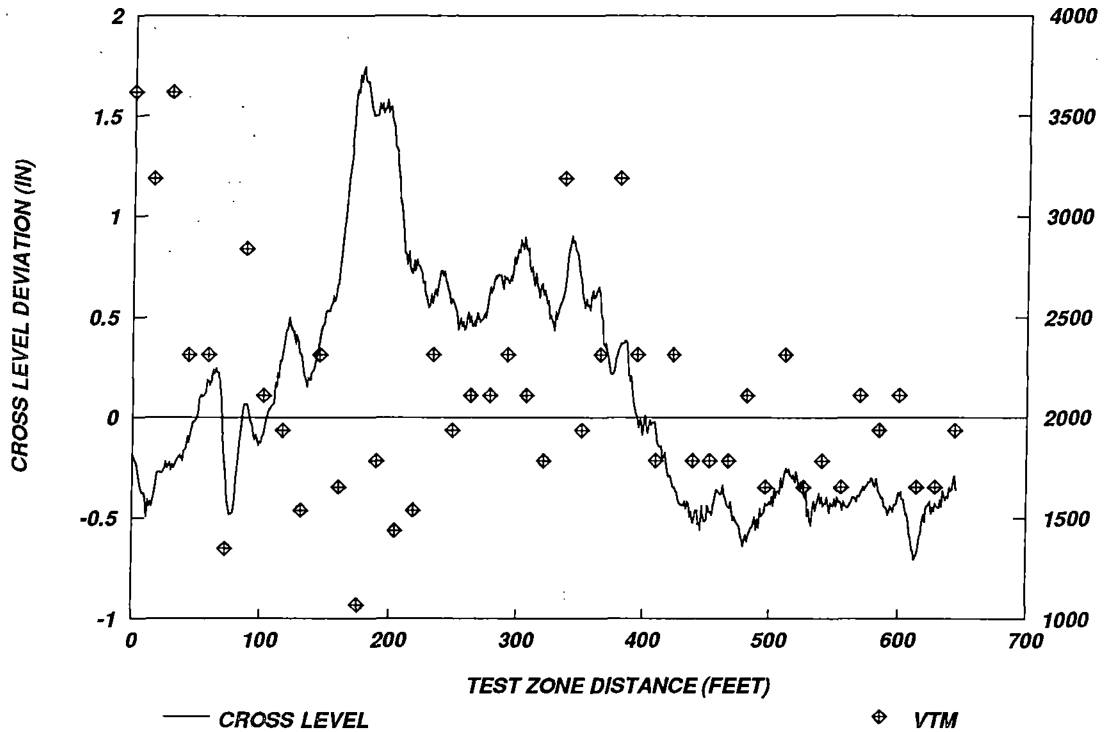


FIGURE 6. RELATIONSHIP OF CROSS LEVEL DEVIATIONS TO TRACK MODULUS 15 MGT AFTER SURFACING OF LTM ZONE

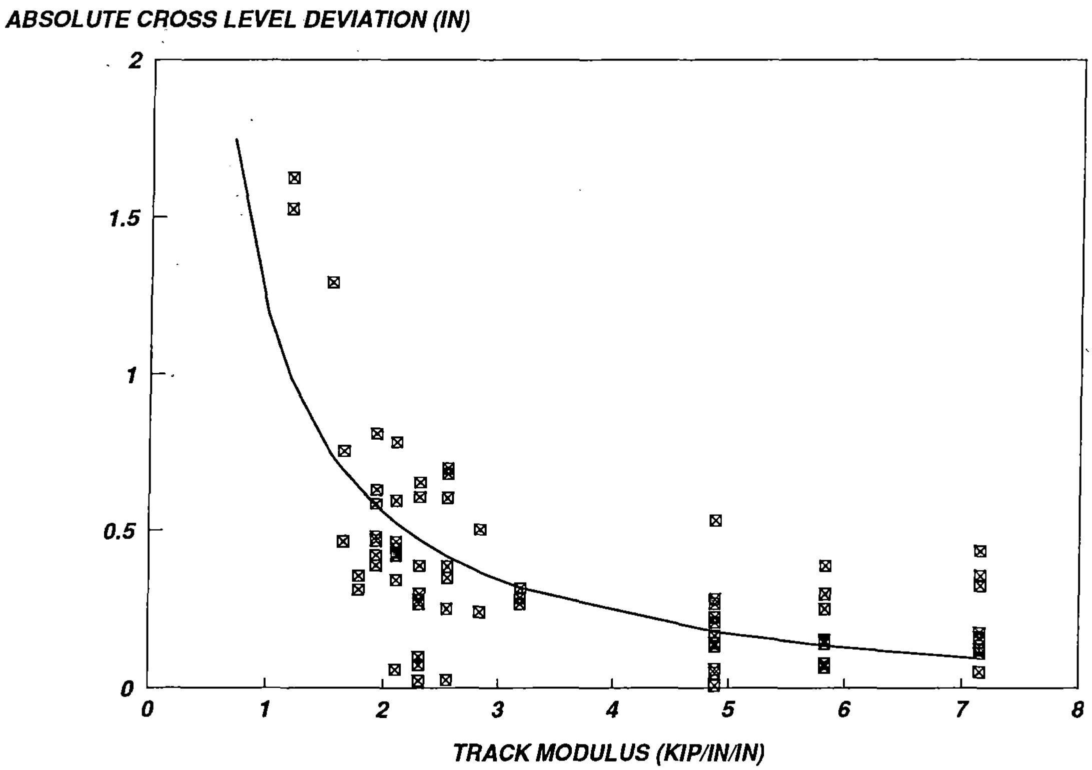


FIGURE 7. VERTICAL WHEEL FORCE IN LOW MODULUS ZONE 0 MGT DATA

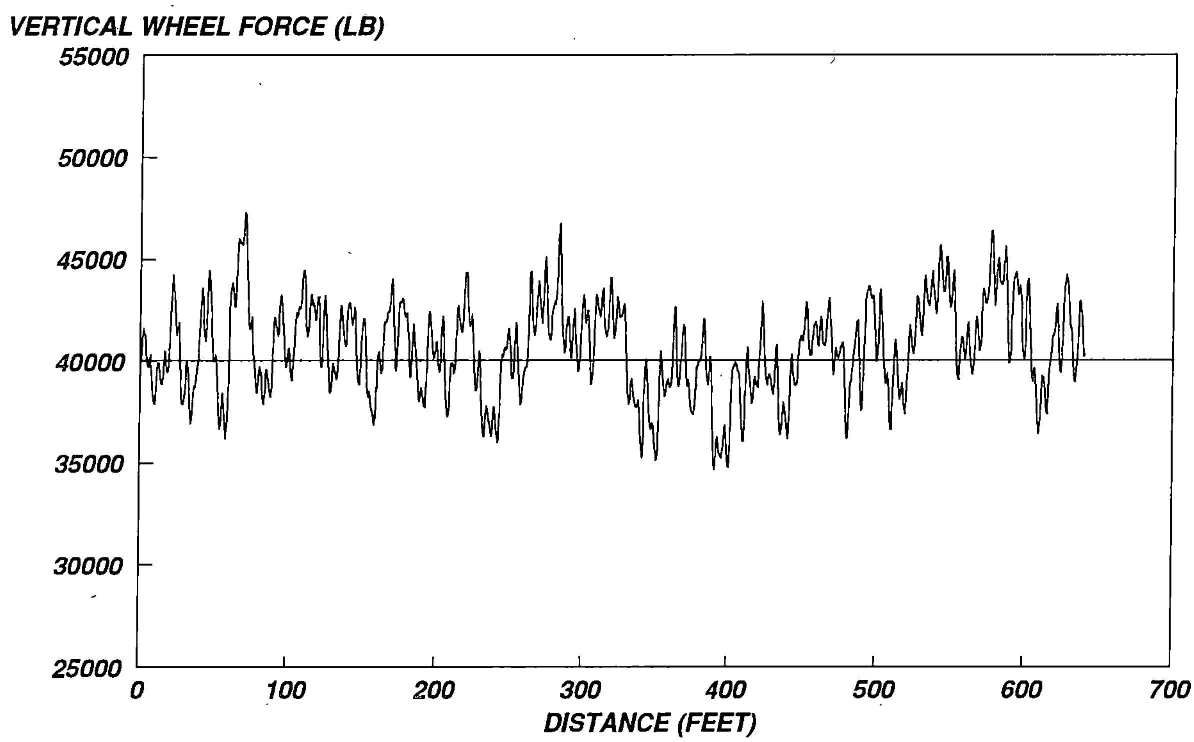


FIGURE 8. VERTICAL WHEEL FORCE IN LOW MODULUS ZONE 13 MGT DATA

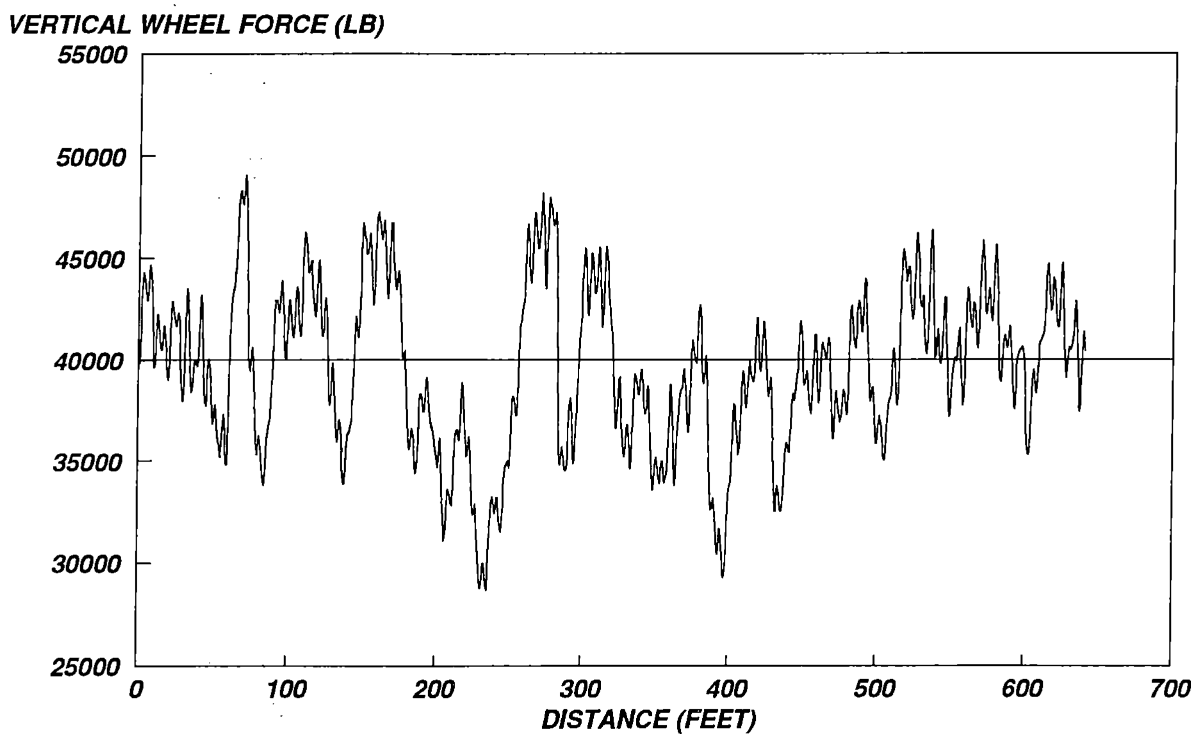
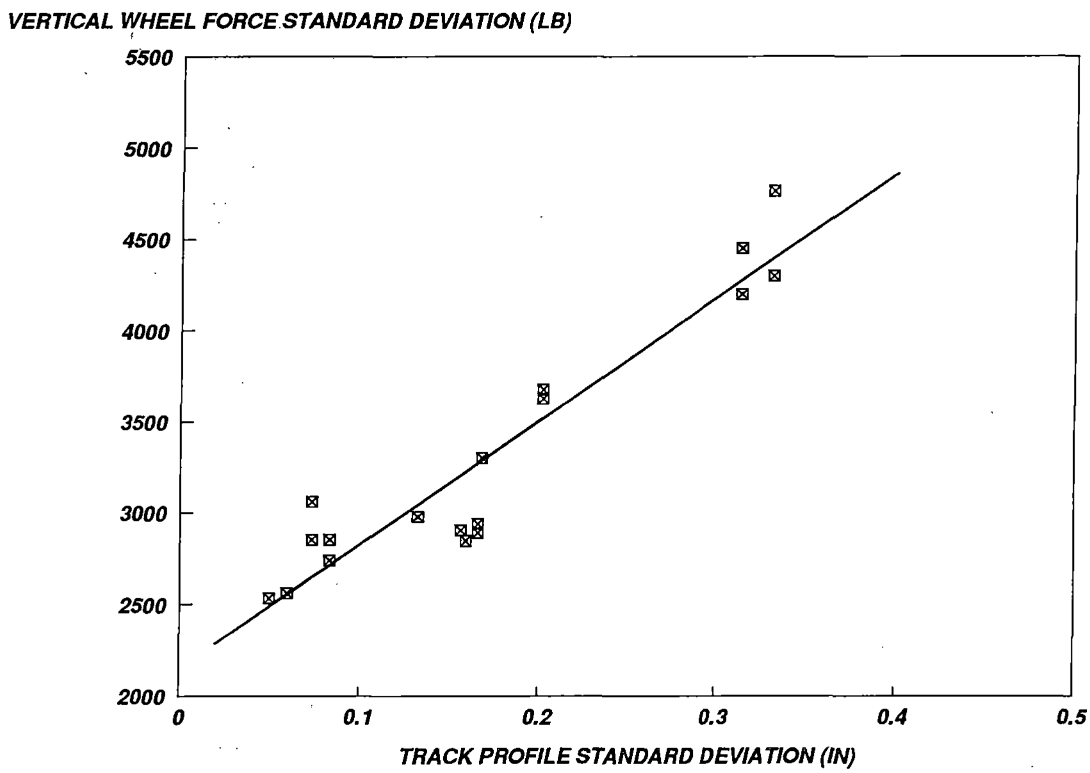


FIGURE 9. RELATIONSHIP OF VERTICAL FORCE TO TRACK PROFILE ROUGHNESS



LOW TRACK MODULUS EXPERIMENT SUMMARY OF RESULTS AFTER 28 MGT

- *Capable Of Constructing Track With A Target Modulus*
- *Cross Level Has Been Primary Mode Of Track Degradation*
  - *LTM zone surfaced at 13 and 28 MGT due to cross level deviations*
- *Dynamic Vertical Forces Appear To Increase Linearly With Track Profile Degradation*
- *Data Indicates a Correlation Exists Between Track Modulus Values And Cross Level Deviation Severity*

FAST HAL

LOAD PATH EVALUATION EXPERIMENT

By M. Carmen Trevizo
Experiment Manager

TRANSPORTATION TEST CENTER
PUEBLO, COLORADO

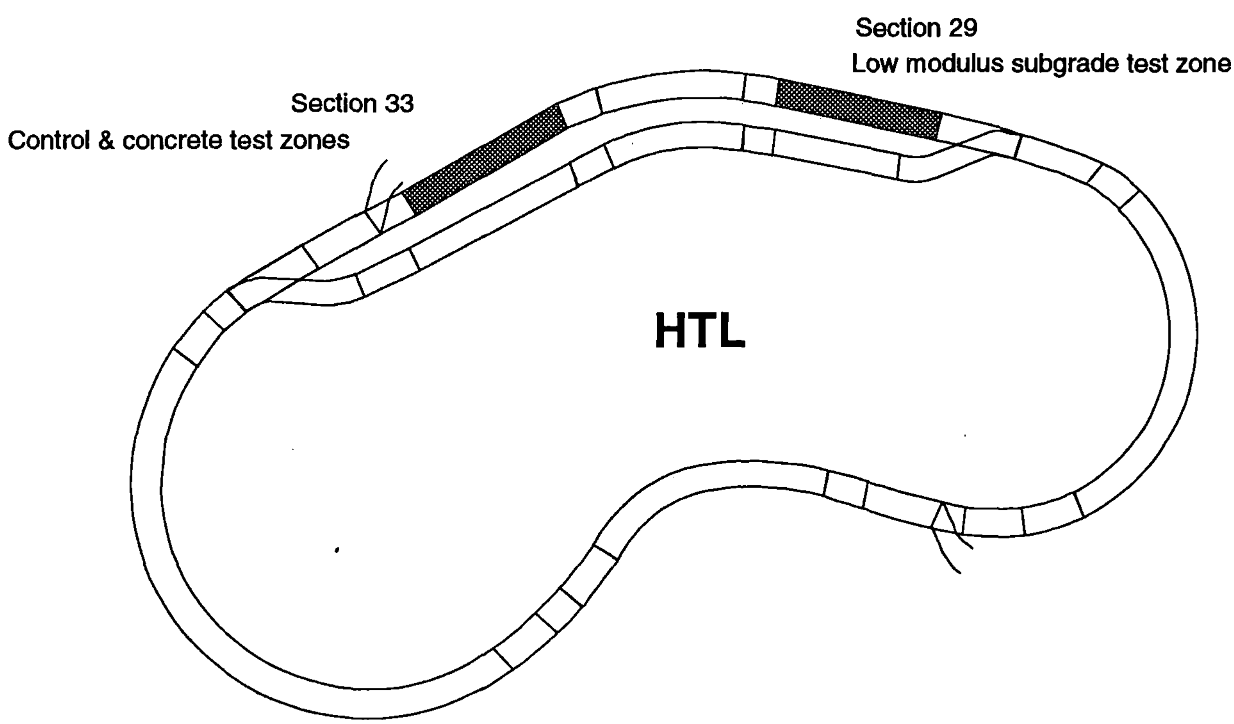
INTRODUCTION

To provide a better understanding of the vertical force distribution of the track, the Load Path Evaluation Experiment was started at FAST. The experiment will provide vertical force distribution on tracks with different subgrade support conditions but with similar construction and track components. This data will used as a tool in analytical and laboratory models to evaluate track degradation under varying support conditions.

OBJECTIVE

The objective of the Load Path Evaluation Experiment is to provide vertical track force data to be used as input in evaluating track degradation by the use of analytical and laboratory methods.

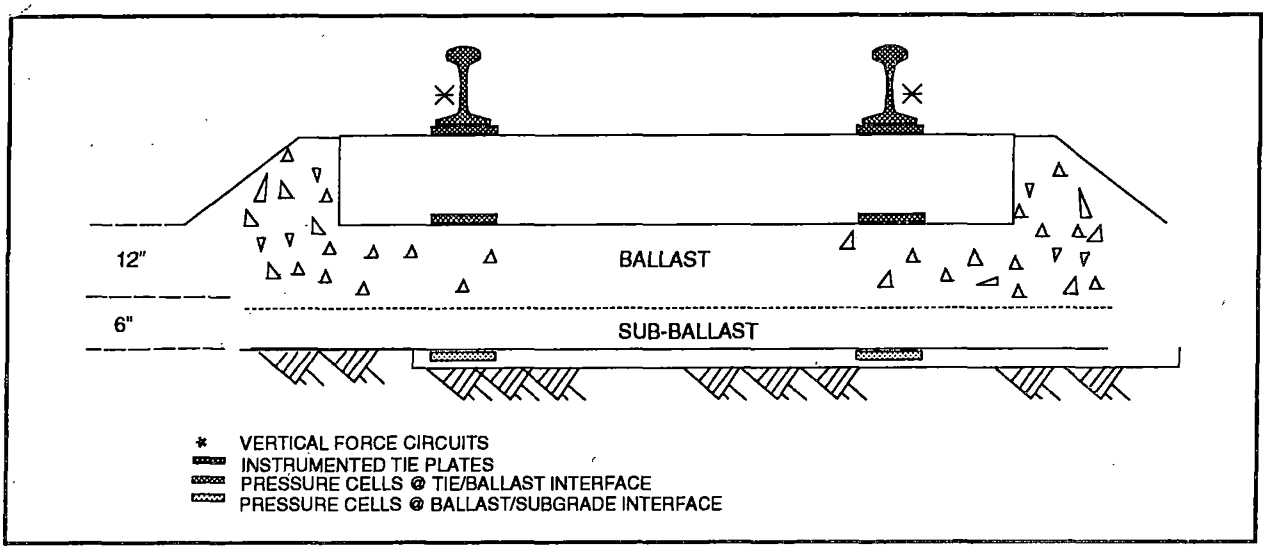
TEST LOCATION

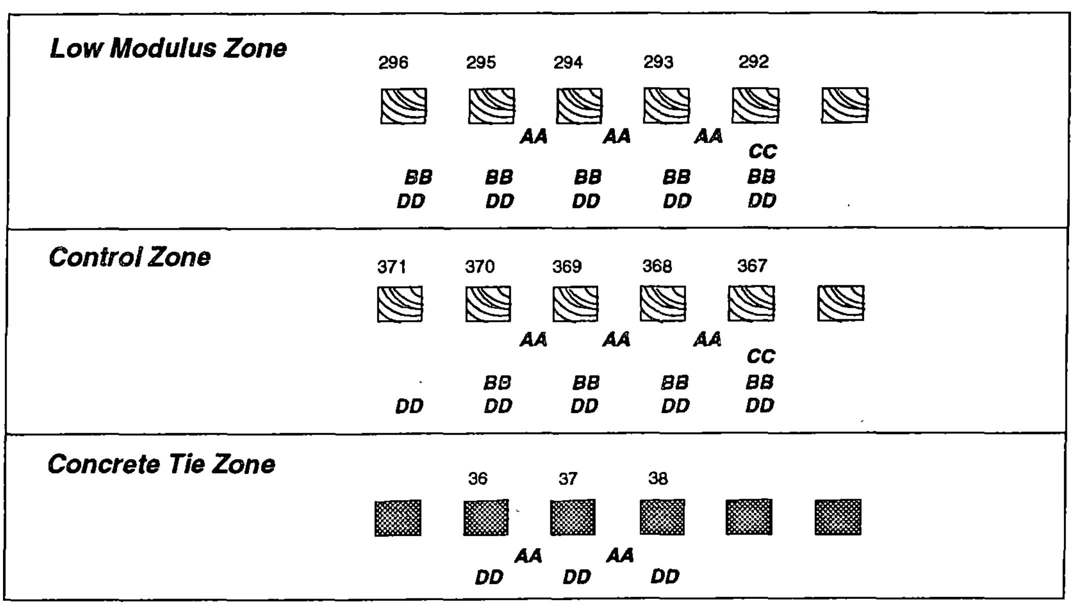


MEASUREMENTS

- Track geometry
- Rail vertical forces
- Rail seat loads
- Pressures at the sub-ballast/subgrade interface

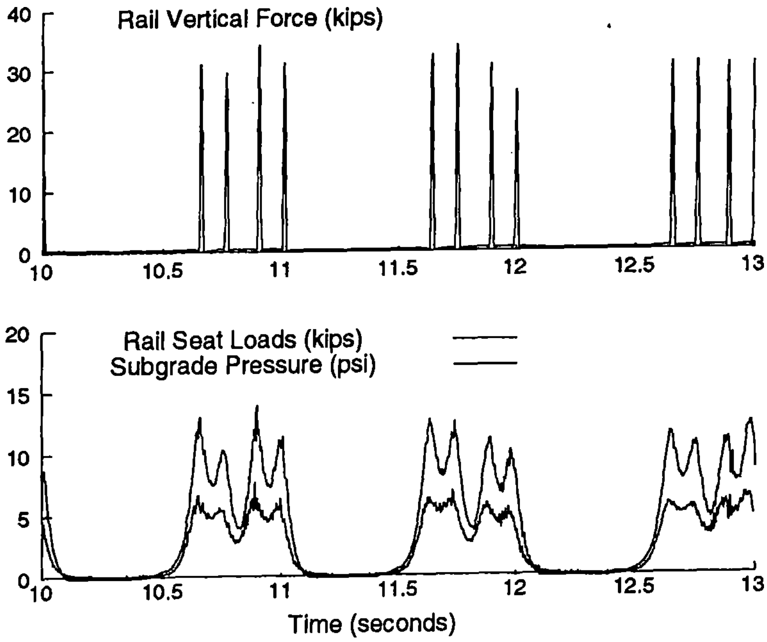
DATA





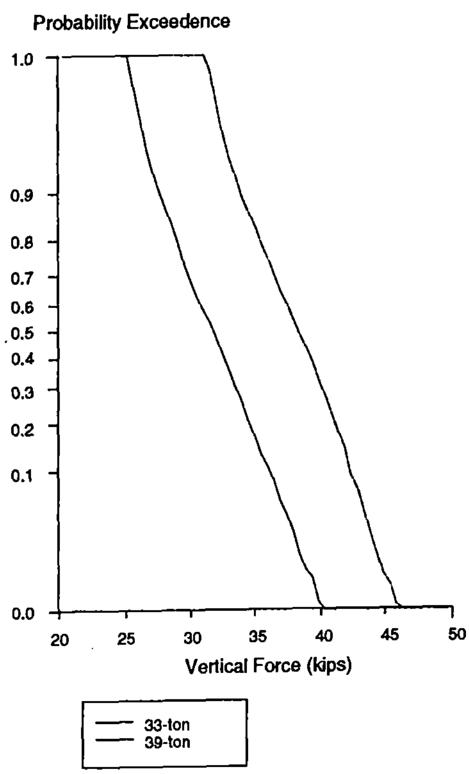
AA - L/V Circuit
BB - Instrumented Tie Plates
CC - Pressure cells @ tie/ballast interface
DD - Pressure cells @ sub-ballast/subgrade interface

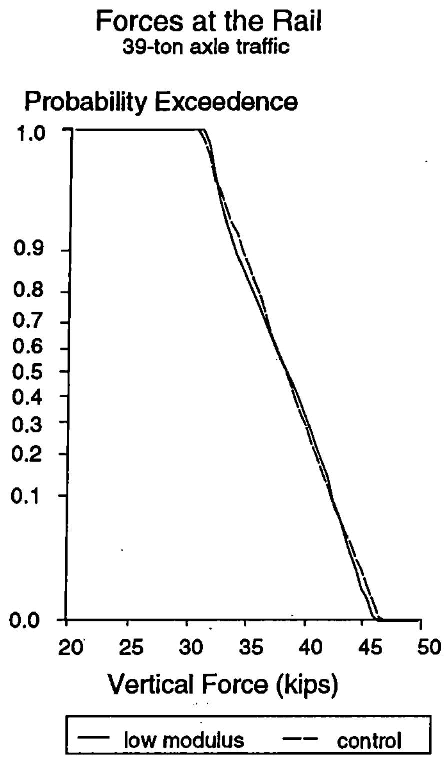
Real Time Data



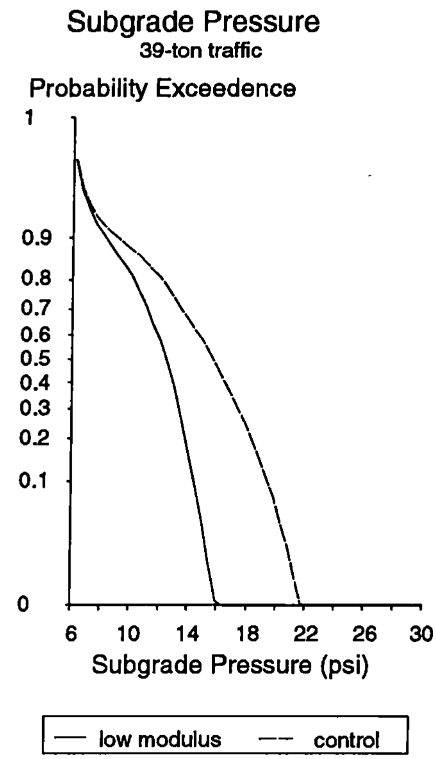
Section 29 - Low Modulus Section

Rail Loads (40 mph)

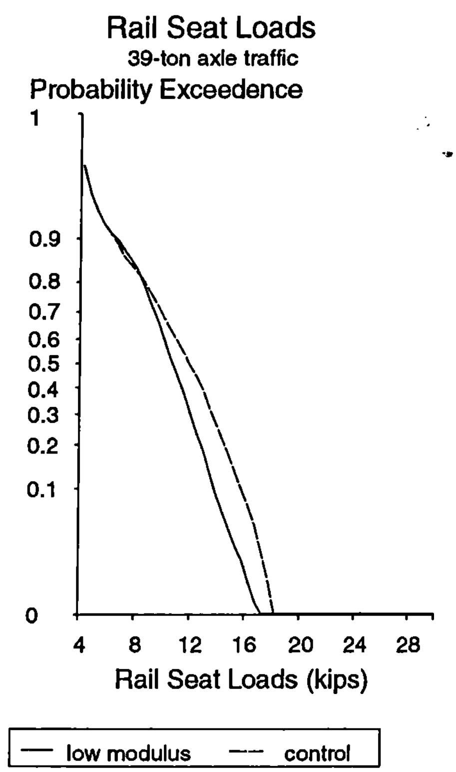




Forces at the Rail
39-ton axle traffic
Probability Exceedence
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
20
25
30
35
40
45
50
Vertical Force (kips)
low modulus
control

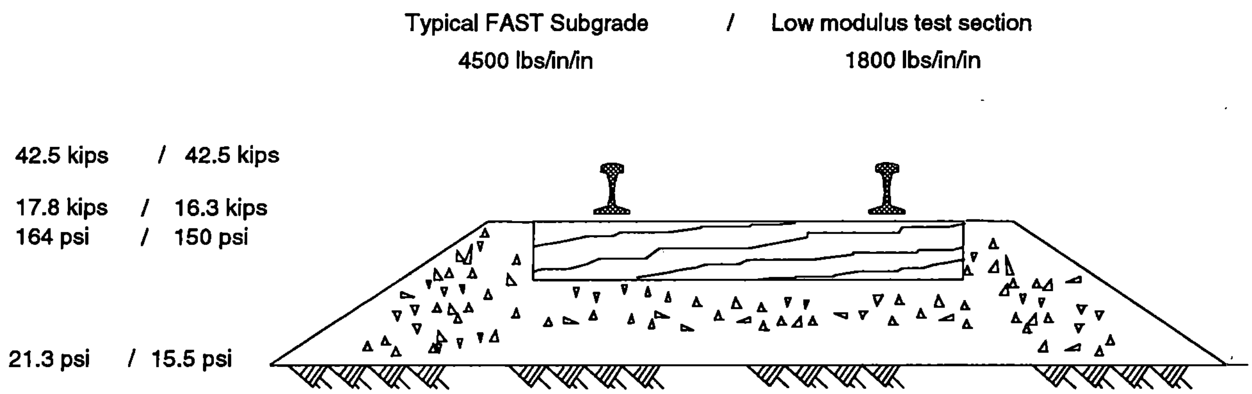


Subgrade Pressure
39-ton traffic
Probability Exceedence
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
6
10
14
18
22
26
30
Subgrade Pressure (psi)
low modulus
control



Rail Seat Loads
39-ton axle traffic
Probability Exceedence
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
4
8
12
16
20
24
28
Rail Seat Loads (kips)
low modulus
control

39-ton axle loads - 98%



RESULTS

Axle load increase from 33-ton to 39-ton traffic was evident on the forces measured at the rail and rail seat; likewise on the pressures measured at the sub-ballast/subgrade interface. The increase in forces and pressures was apparent in both the control and low modulus subgrade test zones.

- **FORCES MEASURED AT THE RAIL**

  There is no difference in magnitude of the forces measured on the rail in both test zones for either the 33-ton or 39-ton axle load cars.

- **FORCES MEASURED ON THE RAIL SEAT AREA**

  There appears to be a difference in magnitude, in both the 33-ton and 39-ton axle load cars, for the forces measured in the control and low modulus subgrade test zones.

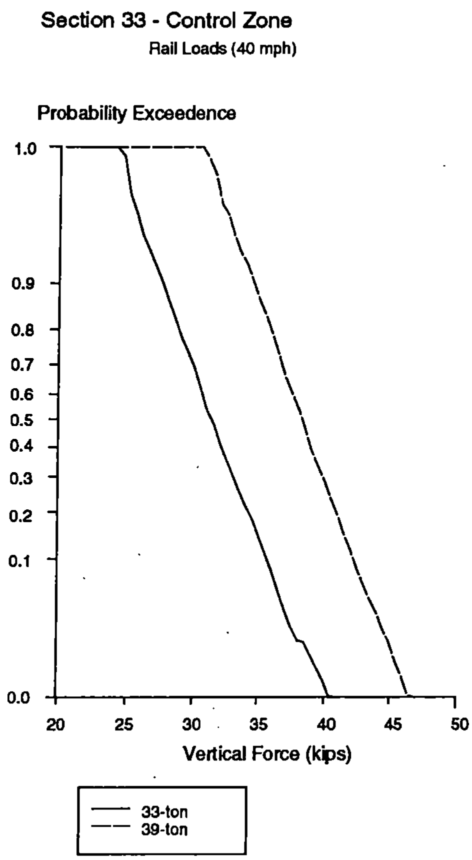
- **PRESSURES MEASURED AT THE SUB-BALLAST/SUBGRADE INTERFACE**

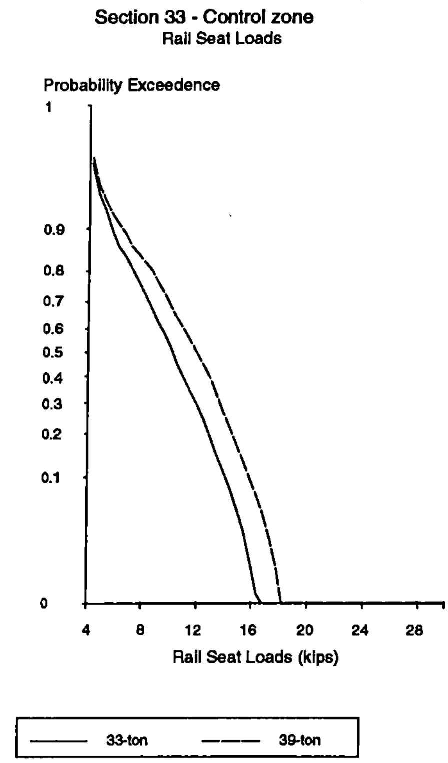
  The difference in magnitude appears to be more distinct between the two test zones.

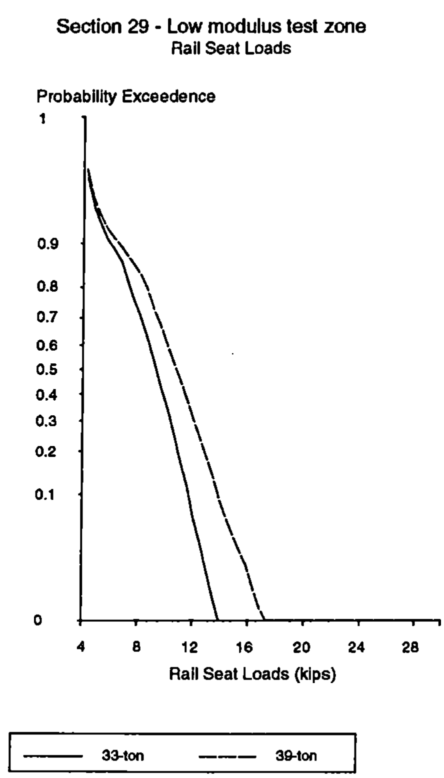
FUTURE

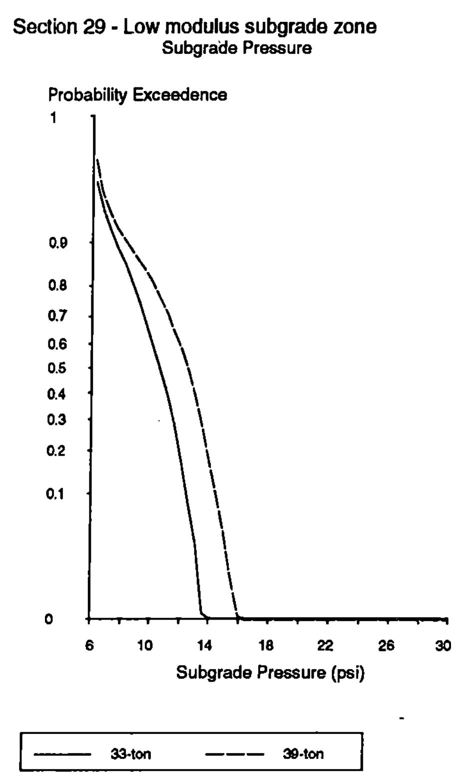
- Measurements will continue at predetermined MGT cycles
- Pressures at the tie/ballast interface will be measured during the next measurement cycle using the same type of instrumentation currently used at the ballast/subgrade interface.
- Instrumentation in both test sections will be used to measure forces under new improved suspension systems.

DATA NOT INCLUDED IN THE PRESENTATION

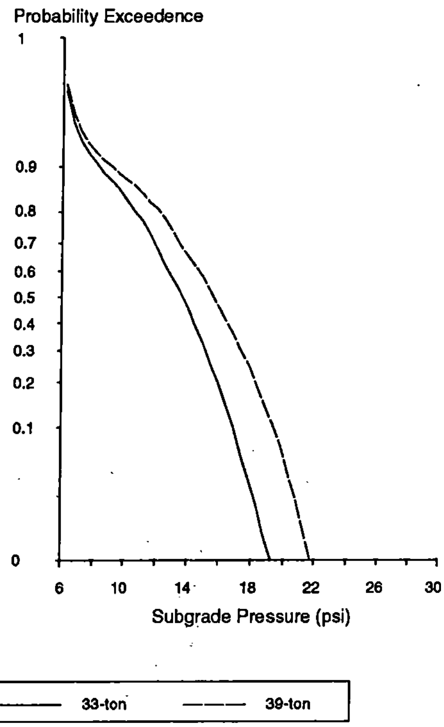

Section 33 - Control Zone
Rail Loads (40 mph)
Probability Exceedence
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
20
25
30
35
40
45
50
Vertical Force (kips)
33-ton
39-ton


Section 33 - Control zone
Rail Seat Loads
Probability Exceedence
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
4
8
12
16
20
24
28
Rail Seat Loads (kips)
33-ton
39-ton


Section 29 - Low modulus test zone
Rail Seat Loads
Probability Exceedence
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
4
8
12
16
20
24
28
Rail Seat Loads (kips)
33-ton
39-ton


Section 29 - Low modulus subgrade zone
Subgrade Pressure
Probability Exceedence
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
6
10
14
18
22
26
30
Subgrade Pressure (psi)
33-ton
39-ton

Section 33 - Control zone
Subgrade Pressure



FAST HAL

TURNOUT PERFORMANCE EXPERIMENT

By Jon S. Hannafious
Experiment Manager

TRANSPORTATION TEST CENTER
PUEBLO, COLORADO

FAST/HAL TURNOUT PERFORMANCE EXPERIMENT

OBJECTIVE: To document and compare the performance of turnouts on the FAST HTL under Heavy Axle Loads

- No. 20 Standard Component AREA Geometry (S.P.)
- No. 20 Premium Component AREA Geometry (Bethlehem)
- No. $18\frac{1}{2}$ Advanced Design Tangential Geometry (BWG/ATS)

Performance Criteria include:

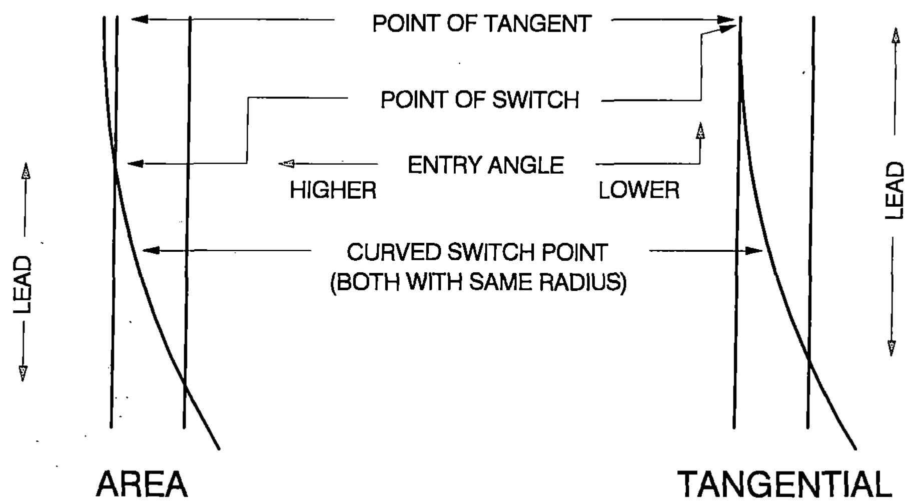
- Component wear and failure
- Maintenance demand
- Wheel loading (Instrumented wheel sets)

TURNOUT COMPONENTS

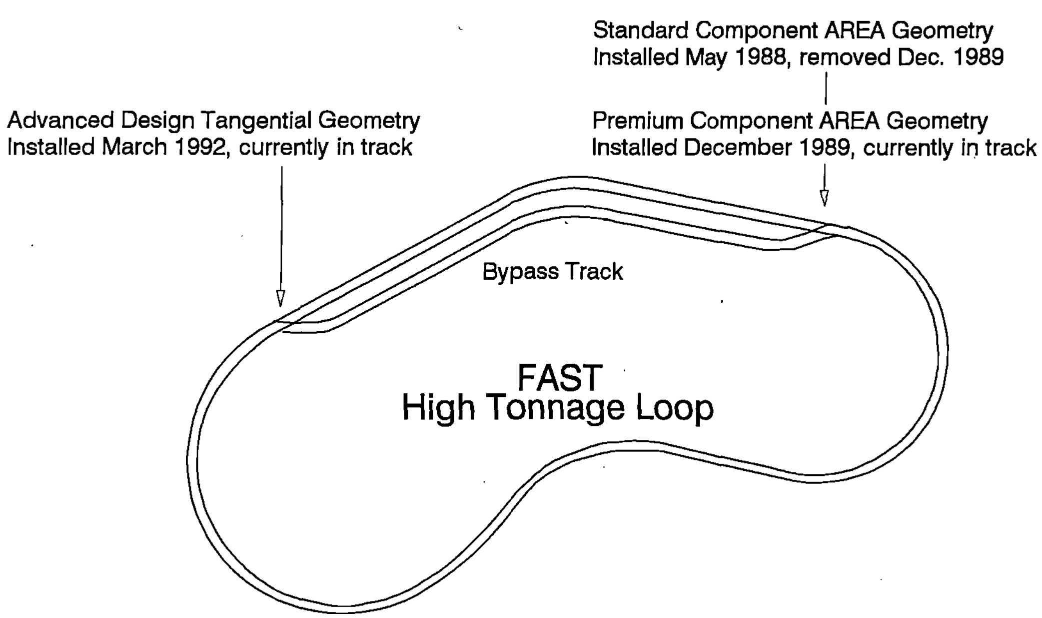
NUMBER 20 STANDARD COMPONONT AREA GEOMETRY	NUMBER 20 PREMIUM COMPONENT AREA GEOMETRY	NUMBER 181/2 ADVANCED DESIGN TANGENTIAL GEOMETRY
AREA No. 20 assembled at TTC	Pre-assembled AREA No. 20	No. 18 1/2, assembled at TTC
Switch Radius = 3605.7 ft. (1°35') Lead radius (CL) = 3329.9 ft. (1°43')	Switch Radius = 3605.7 ft.(1°35') Lead radius (CL) = 3329.9 ft. (1°43')	3937 ft. radius (1°27') tangent one tie ahead of p.s. and at heel of frog
156 ft. 1/2 in. lead	156 ft. 1/2 in. lead	185 ft. lead
Hardwood ties	Hardwood ties	Sherman Abetong concrete ties
CF&I standard (285 Bhn) stock, closure, wing, and heel rails	Bethlehem fully heat treated stock, closure, wing, and heel rails	Thyssen standard stock, closure, wing, and heel rails - heat treated in key areas by BWG
Bolted rail joints throughout turnout area	Continuously thermite welded, except insulated joints	Continuously thermite welded, except beveled insulated joints
Cut spikes throughout turnout Box anchored	Pandrol "e" clips throughout turnout with Pandrol lock spikes	Pandrol "e" clips throughout turnout on plates bolted to the ties
Undercut "samson" switch point •Curved 39 ft. •4 3/4 in. throw •Slide plates/Graduated risers •No rollers or helpers •Bolted rail braces •Hook twin plates behind heel of switch points •3 Gage plates •Rigid bolted heel blocks	Undercut thick web switch point •50 ft. 11 in. (Curved 39 ft.) •4 3/4 in. throw •Slide plates/Uniform risers •Rollers, no helpers •Bolted rail braces with screw spikes & boltless Pandrol rail braces with lock spikes •Screw spikes •3 Gage plates •Floating heel blocks	Undercut full web switch point •76 ft. 7 in. (Tangential) •4 3/4 in. throw •Graduated risers •Three helper rods •Schwihag fastening system •Double Pandrol "e" clips •Floating heel blocks
Manual throw	Manual throw	GRS model 5A switch motors
Thin wall manganese steel frog casting, Plates riveted to wing rails	High integrity manganese steel frog casting Gage plates (point and heel)	Movable point frog •One helper •Locking mechanism built in (Clamp lock system) •Double lock (clamp & motor)
15 ft. bolted "T" guard rail with single shoulder canted tie plates	23 ft. hook flange guard rail	No guard rail

COMPARISON (EXAGERATED): AREA 39 FT. CURVED SWITCH POINTS VS. TANGENTIAL GEOMETRY SWITCH POINTS

GAGE OPTIMIZATION



TEST TURNOUT LOCATIONS



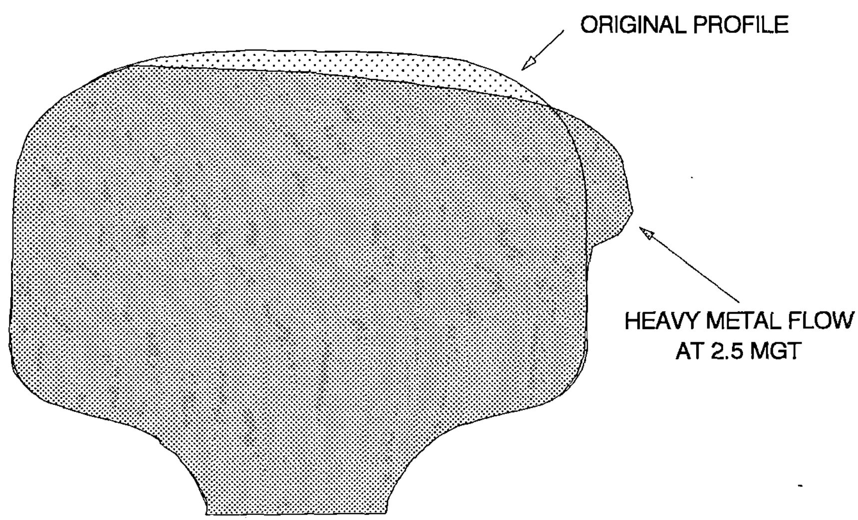
HIGHLIGHTS OF TURNOUT PERFORMANCE

Turnout	Service MGT	Highlights of Performance
Standard Component AREA Geometry	106.4 Removed	Switch point cracked - repair welded (31 MGT) Several weld build-ups of frog heel and heel rail Frog removed and repaired (73 MGT) Corrugation in frog and sw. area rails (106 MGT)
Premium Component AREA Geometry	150.2	Broken gage plates at heel of frog (140.2) Heel rail broke (bolt hole) - replaced (150 MGT)
Advanced Design Tangential Geometry	29.8	Difficult fit of components during cnstruction Different design of throw at movable frog Batter and metal flow required grinding (2.5 MGT) Rail batter corrugations (5.5 MGT) 18 weld repair welds of batter Entire turnout ground at 19 and 30 MGT

BWG/ATS TURNOUT - RAIL PROFILES AT 0 AND 2.5 MGT

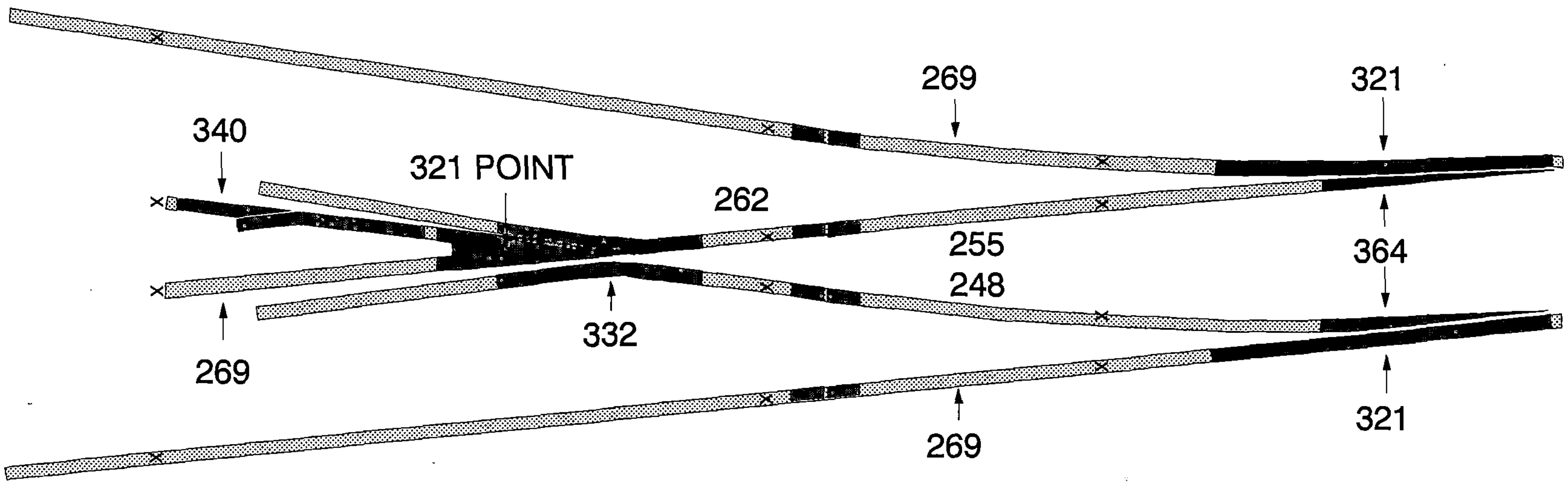
HEAT AFFECTED ZONE

ADJACENT TO RAIL END HARDENING FOR INSULATED JOINTS



HARDNESS OF TANGENTIAL GEOMETRY TURNOUT

DARK SHADING DENOTES HEAT TREATED AREAS

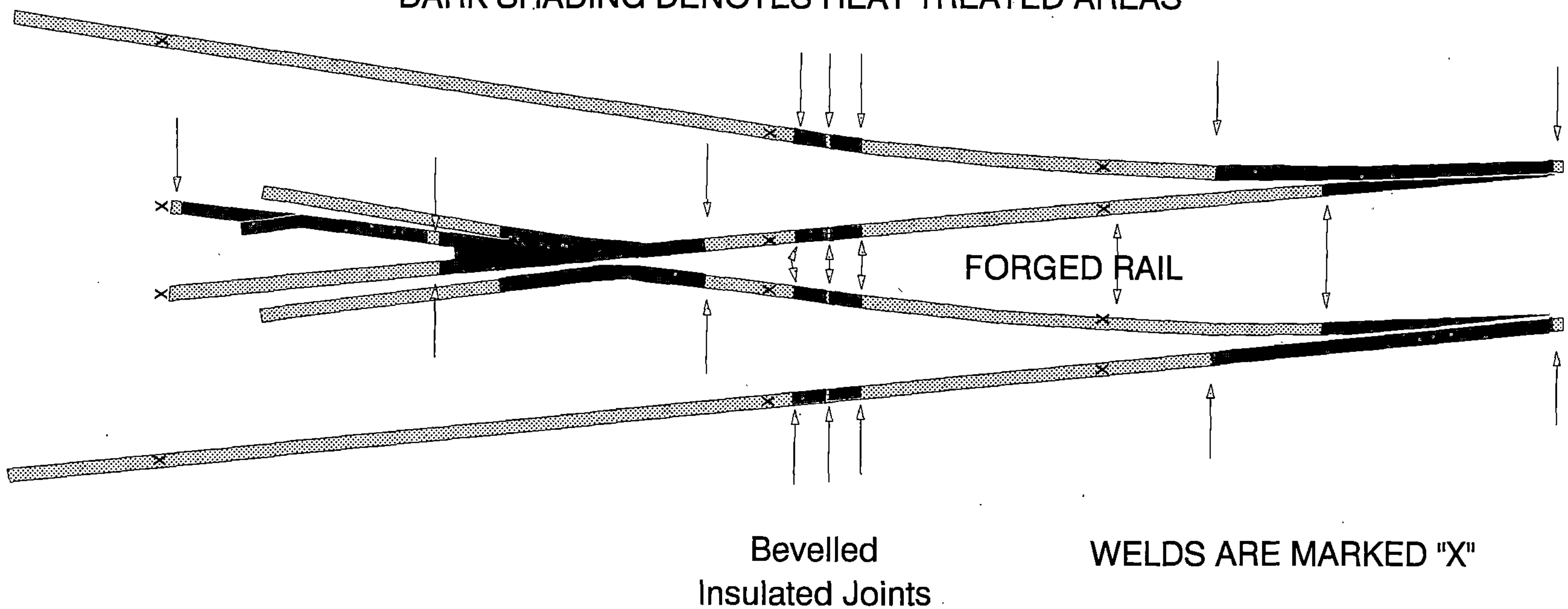


WELDS ARE MARKED "X"

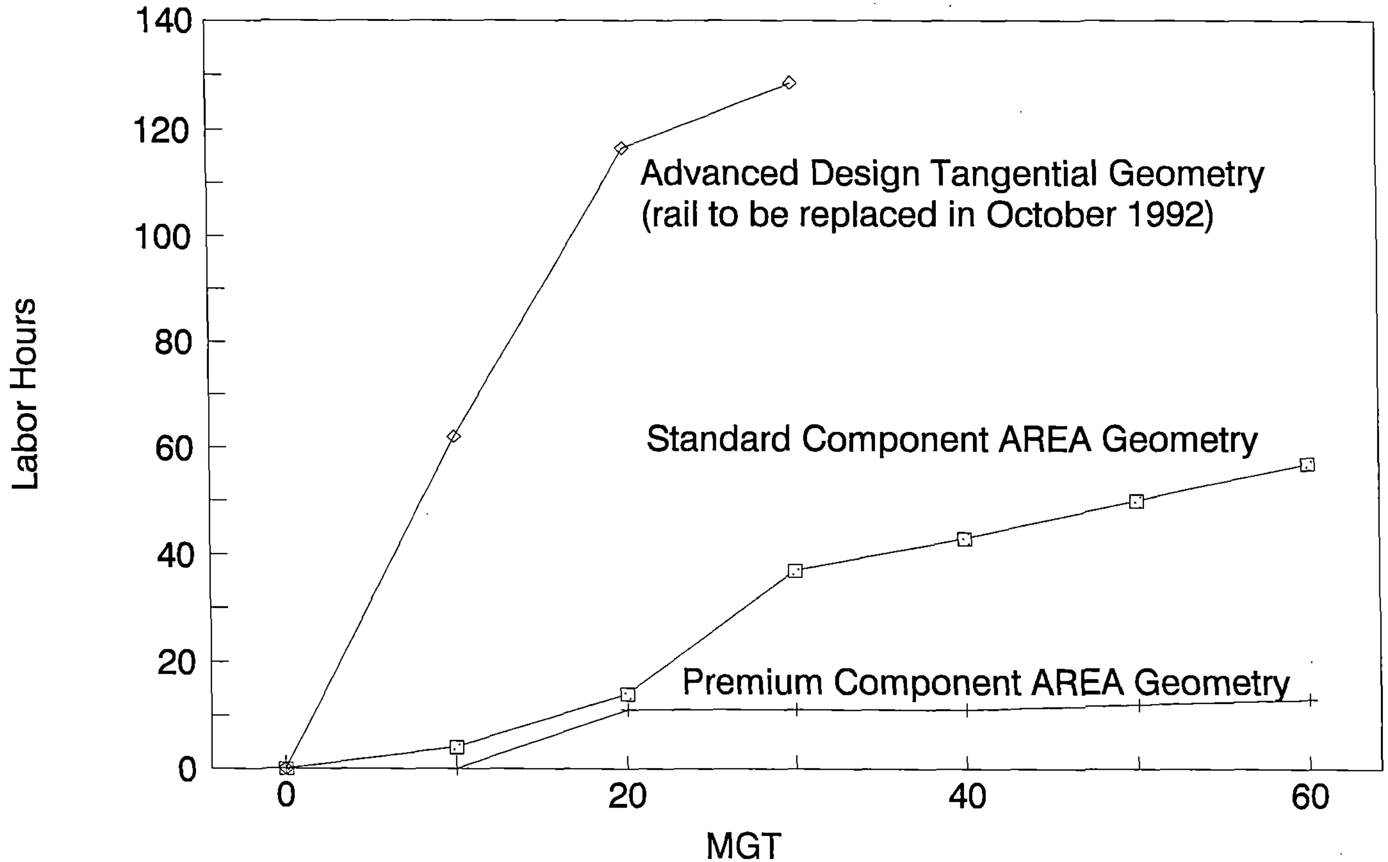
BATTER LOCATIONS ON TANGENTIAL GEOMETRY TURNOUT

ARROWS DENOTE BATTER LOCATIONS
MOST OF WHICH HAVE REQUIRED WELD BUILD-UPS

DARK SHADING DENOTES HEAT TREATED AREAS

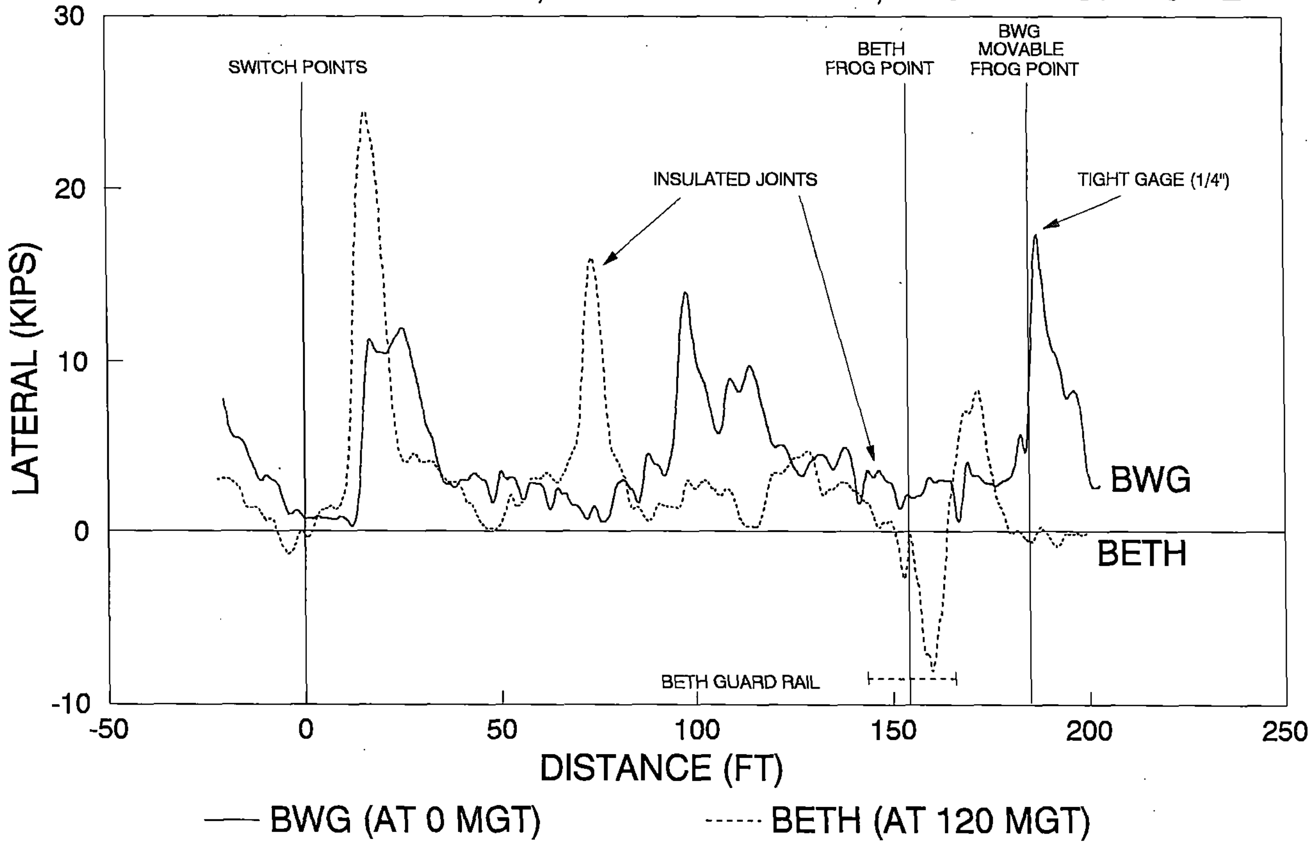


LABOR HOURS VS. MGT FOR TEST TURNOUTS



LATERAL INSTRUMENTED WHEEL SET FORCES

BWG & BETH TURNOUT, DIVERGING ROUTE, CLOSED POINT SIDE



CONCLUSIONS

- Tangential geometry reduces lateral forces at switch points
- QC is critical in manufacturing concrete tie turnout components
- Material selection is critical to turnout performance
  - Harder rail has resisted fatigue, wear, batter, & corrugation
  - High integrity frog has resisted fatigue better

FAST
HAL

FROG PERFORMANCE EXPERIMENT

By Jon S. Hannafious
Experiment Manager

TRANSPORTATION TEST CENTER
PUEBLO, COLORADO

FAST/HAL FROG PERFORMANCE EXPERIMENT

OBJECTIVE: To monitor the performance of a variety of frogs under 39-ton axle loads.

Performance criteria include:

- Casting or insert wear.
- Development of fatigue defects.
- Maintenance demand of each frog.

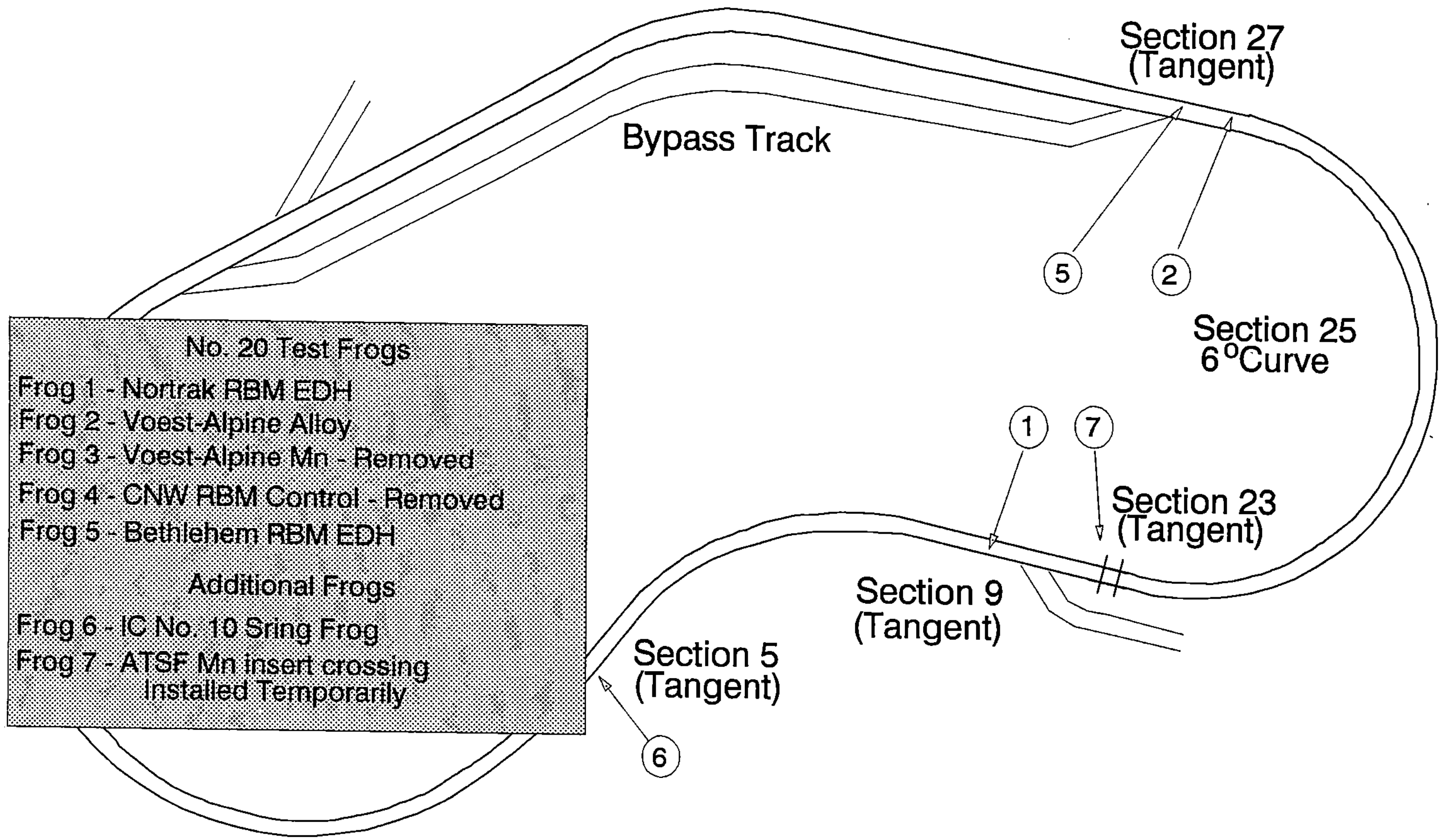
TEST FROG COMPONENTS

Frog Number and Donor	Frog Type All No. 20 Unless Noted	Wingrail & Heel-rail Rail Type	Frog Plates, Spikes & Fasteners	Guard Rail, Plates Spikes & Fasteners	Tie Center
Frog 1 Nortrak 345 Bhn	AREA Railbound Manganese (EDH)	132 RE Fully Heat Treated	Manufacturer's Frog Plates with Pandrol Lock Spikes & Pandrol Rail Clips	14'6" Bolted Tee-rail with Hook Twin Tie Plates and Lock Spikes	19.5 in.
Frog 2 Voest-Alpine 550 Bhn	European Vee-nose, Alloy	UIC 60 Head Hardened	Manufacturer's Frog Plates with Pandrol Lock Spikes & Pandrol Rail Clips	18'8" European Design Guard Rail and Plates, Lock Spikes	2 ft.
Frog 3 Voest-Alpine 370 Bhn	European Vee-nose, Manganese (EDH)	UIC 60 Head Hardened	Manufacturer's Frog Plates with Pandrol Lock Spikes & Pandrol Rail Clips	18'8" European Design Guard Rail and Plates, Lock Spikes	2 ft.
Frog 4 CNW Control Frog 370 Bhn	AREA Railbound Manganese	136 RE Standard 300 Bhn	Hook Twin Plates & Cut Spikes	22' Bolted Tee-rail, Single Shoulder Canted Plates,Cut Spikes	19.5 in.
Frog 5 Bethlehem 370 Bhn	AREA Railbound Manganese (EDH)	132 RE Fully Heat Treated	Hook Twin Plates & Cut Spikes	Used 22' Bolted Tee-rail, Single Shoulder Canted Plates,Cut Spikes	19.5 in.
Frog 6 ICG 320 Bhn	Racor No. 10 Spring Frog	136 RE Head Hardened	Manufacturer's Frog Plates with Screw Spikes	13' Bolted Tee-rail, Manufacturer's plates, Screw & Cut Spikes	19.5 in.

CONTRAST OF AREA RBM & EUROPEAN VEE-NOSE FROGS

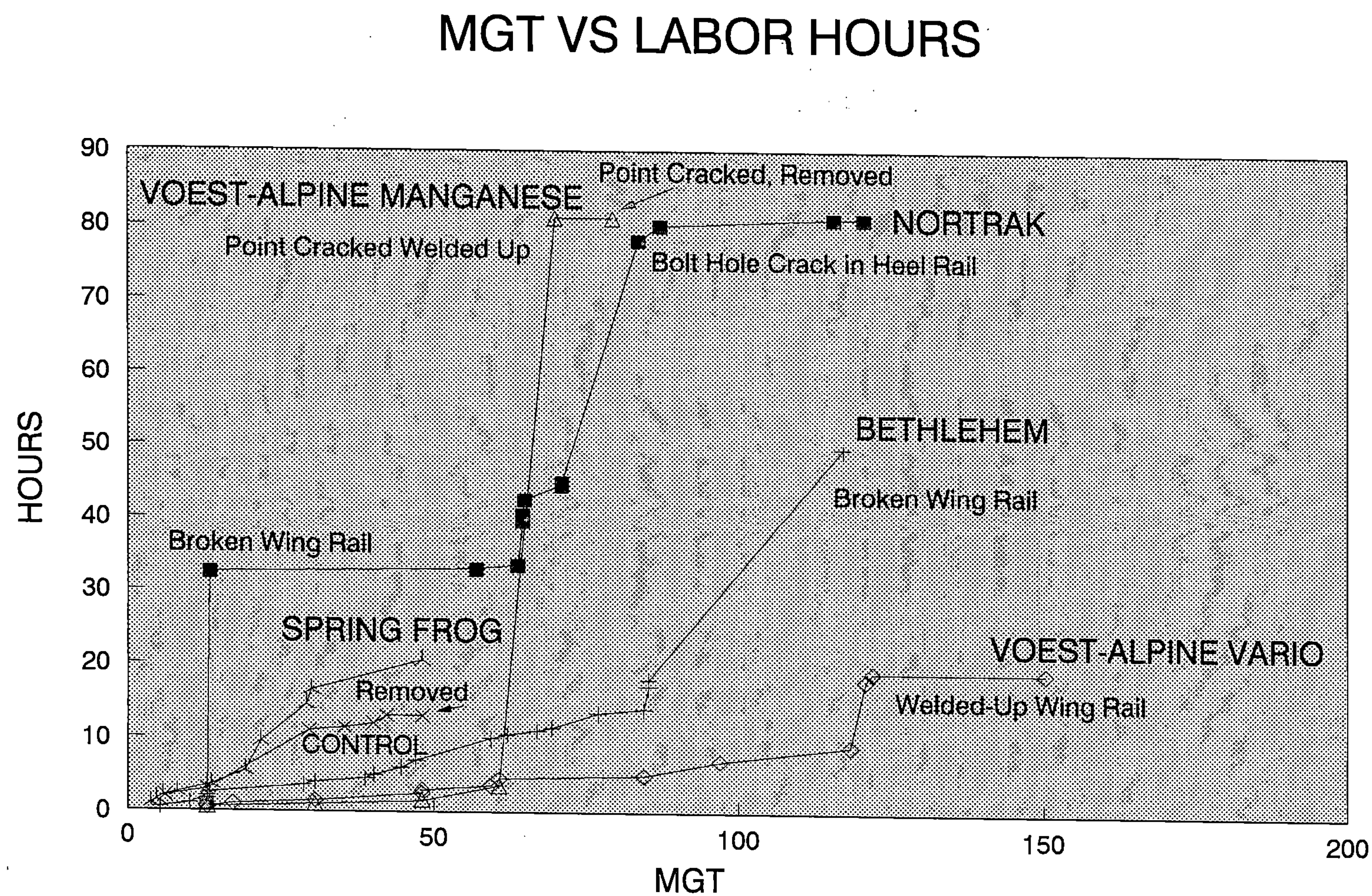
	AREA RBM FROG	EUROPEAN VEE-NOSE FROG
POINT DESIGN	Depression at actual P.F. = 3/16"	Depression at actual P.F. = 1/4"
	Tapers even to wing at 10 inches	Tapers to 1/8"at 1 ft. then even with wing at 5 ft.
FABRICATION	Heel rails bolted to insert	Heel rails welded to insert
	Wheels transfer from wingrail to wing of casting to point of frog	Wheels transfer directly from wingrail to point of frog

CURRENT LOCATION OF TEST FROGS



HIGHLIGHTS OF FROG PERFORMANCE

Frog Number and Donor	Frog Type All No. 20 Unless noted	Current MGT	Highlights of Frog Performance
Frog 1 Nortrak 345 Bhn	AREA Railbound Manganese (EDH)	120.6	Broken wingrail Five weld build-ups of heel area Broken heel rail - bolt hole crack One build-up on toe/wingrail transition
Frog 2 Voest-Alpine 550 Bhn	European Vee-nose, Alloy	150.2	Broken frog bolt Wingrail spalled, was built up Broken guard rail plates (2) Replaced
Frog 3 Voest-Alpine 370 Bhn	European Vee-nose, Manganese (EDH)	79.3 Removed	Cracked point, built up, found sand entrapment Wingrail spalled - required grinding Broken guard rail plates (5) Installed new design guard rail plates
Frog 4 CNW Control Frog 370 Bhn	AREA Railbound Manganese	48.1 Removed	Point developed shell, was built up. Removed from track due to shells and cracks on insert and corrugated wingrails
Frog 5 Bethlehem 370 Bhn	AREA Railbound Manganese (EDH)	116.9	Three build ups on toe/wingrail transition Built up point due to spalling Broken wingrail
Frog 6 ICG 320 Bhn	Racor No. 10 Spring Frog	62.4	Repeated welding and grinding.


MGT VS LABOR HOURS
HOURS
MGT
VOEST-ALPINE MANGANESE
Point Cracked, Removed
Point Cracked Welded Up
NORTRAK
Bolt Hole Crack in Heel Rail
BETHLEHEM
Broken Wing Rail
Broken Wing Rail
SPRING FROG
Removed
CONTROL
VOEST-ALPINE VARIO
Welded-Up Wing Rail
0
10
20
30
40
50
60
70
80
90
0
50
100
150
200

CONCLUSIONS

AREA Frogs have design weaknesses:

- Wheel transfer from wingrail to insert at toe of insert (Beth and Nortrak were both repaired)
- Wheel transfer from insert to heel rail (Nortrak required much welding, tamping and clip replacement)

Vee-Nose Frogs:

- More depression at point of frog
- Longer taper/wheel transfer at point of frog
- Smoother train operation.

Spring Frog so far is not a benefit (vs. # 20's) in terms of maintenance effort:

- Minor design change may increase life and decrease maintenance demand
- Does not include any traffic or maintenance on diverging route

FAST HAL

CROSSING FROG EXPERIMENT

By Duane E. Otter
Experiment Manager

TRANSPORTATION TEST CENTER
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FAST CROSSING FROG EVALUATION

OBJECTIVES:

- Monitor the performance of crossing under 39-ton axle loads.
  - Metal Flow, Wear, Fatigue, Track Geometry, Maintenance
- Investigate strain environment

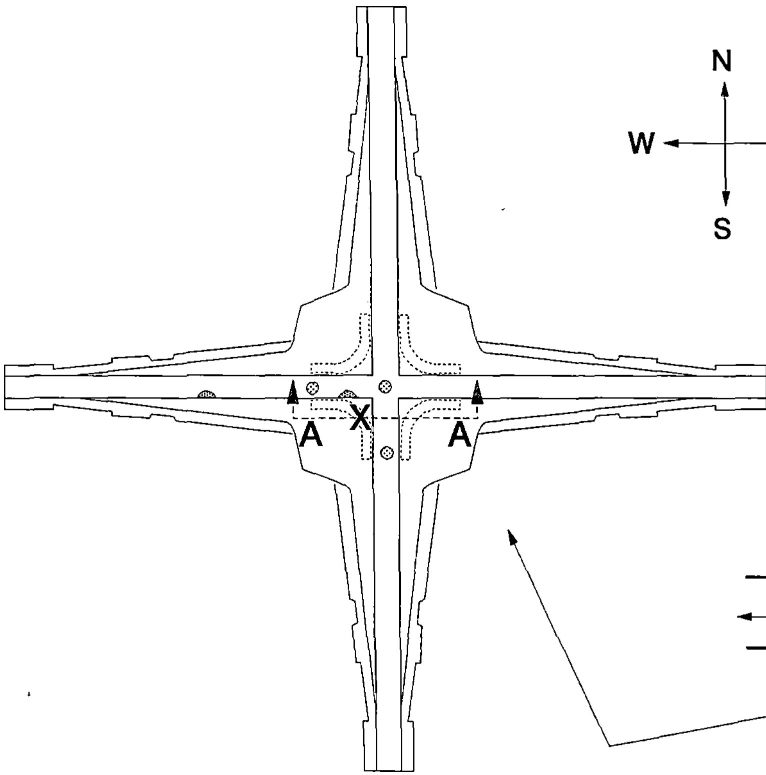
MATERIALS:

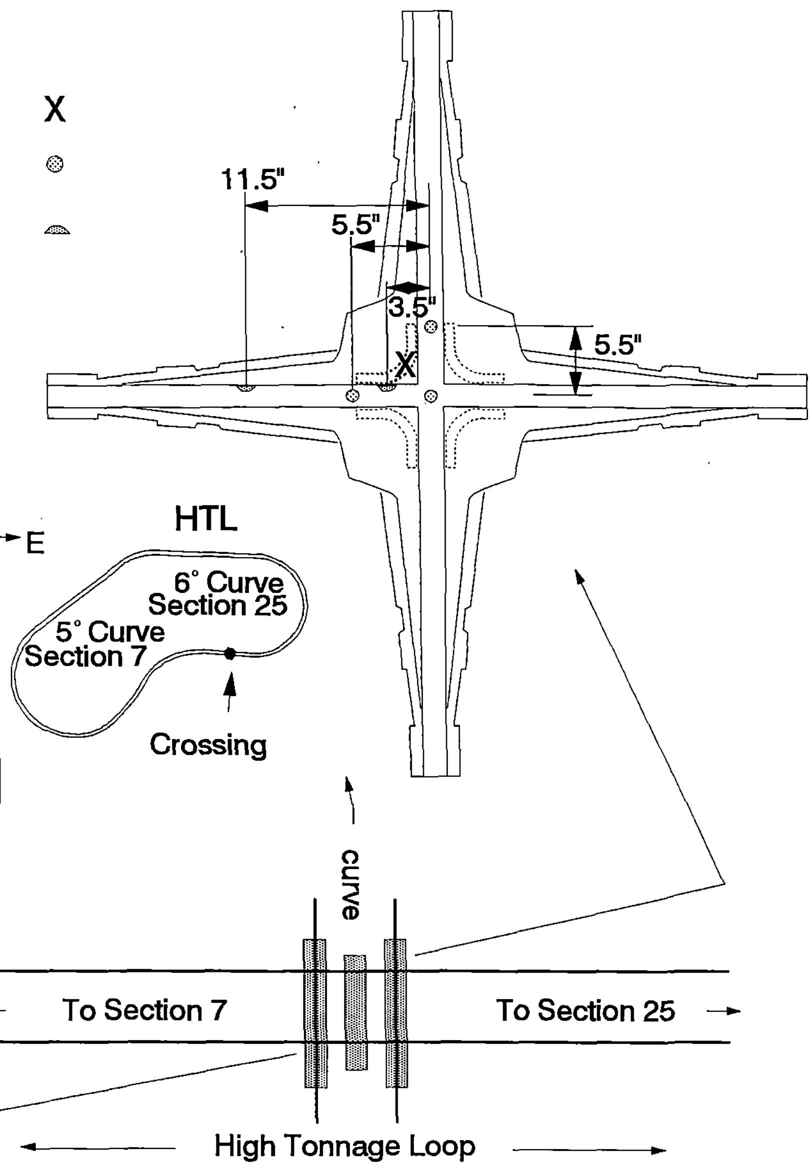
- 133 RE Manganese Steel Insert Crossing donated by ATSF
- Manufactured by Conley Frog & Switch for Installation at Bonner Springs, KS
- ATSF Tangent Crossed UP 3° Curve at 89° 20'
- Rail: 133 RE Standard < 300 BHN
- Casting: Manganese Steel ≈280 BHN
- Hardwood Ties 7" x 12" x 12' (2)
  7" x 12" x 9' (1)
- Ballast: Mixture of Granite, Traprock and Slag

Hardness Tests

Bottom of Flangeway

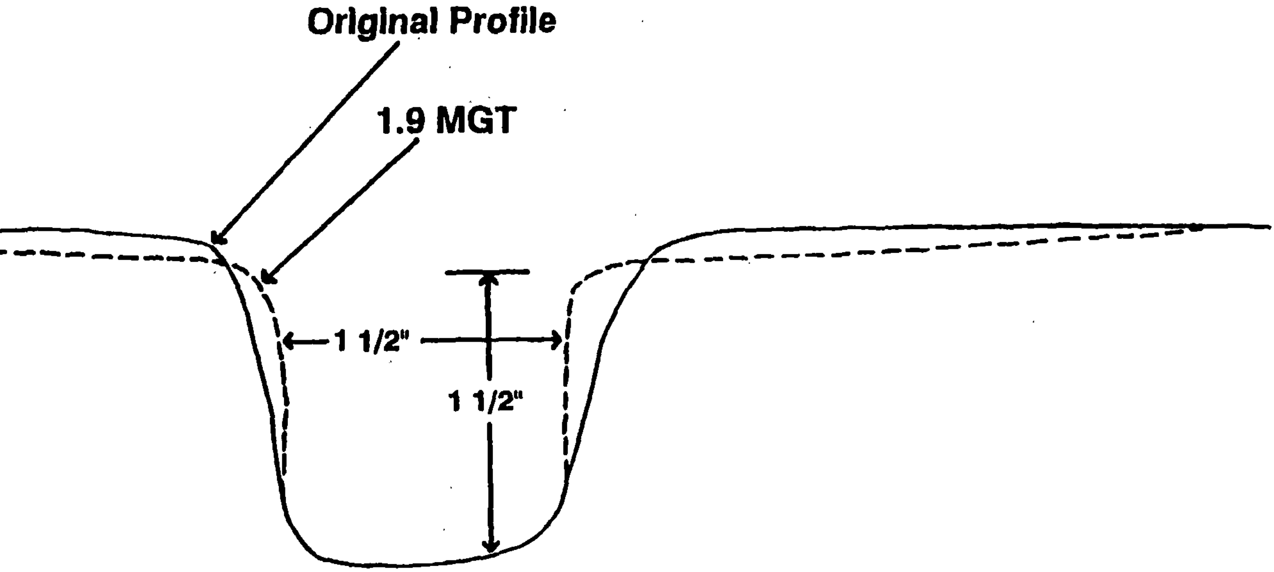
Flangeway wall 1.125 in. below top of casting





X
11.5"
5.5"
3.5"
5.5"
X
E
HTL
6° Curve
Section 25
5° Curve
Section 7
Crossing
curve
To Section 7
To Section 25
High Tonnage Loop

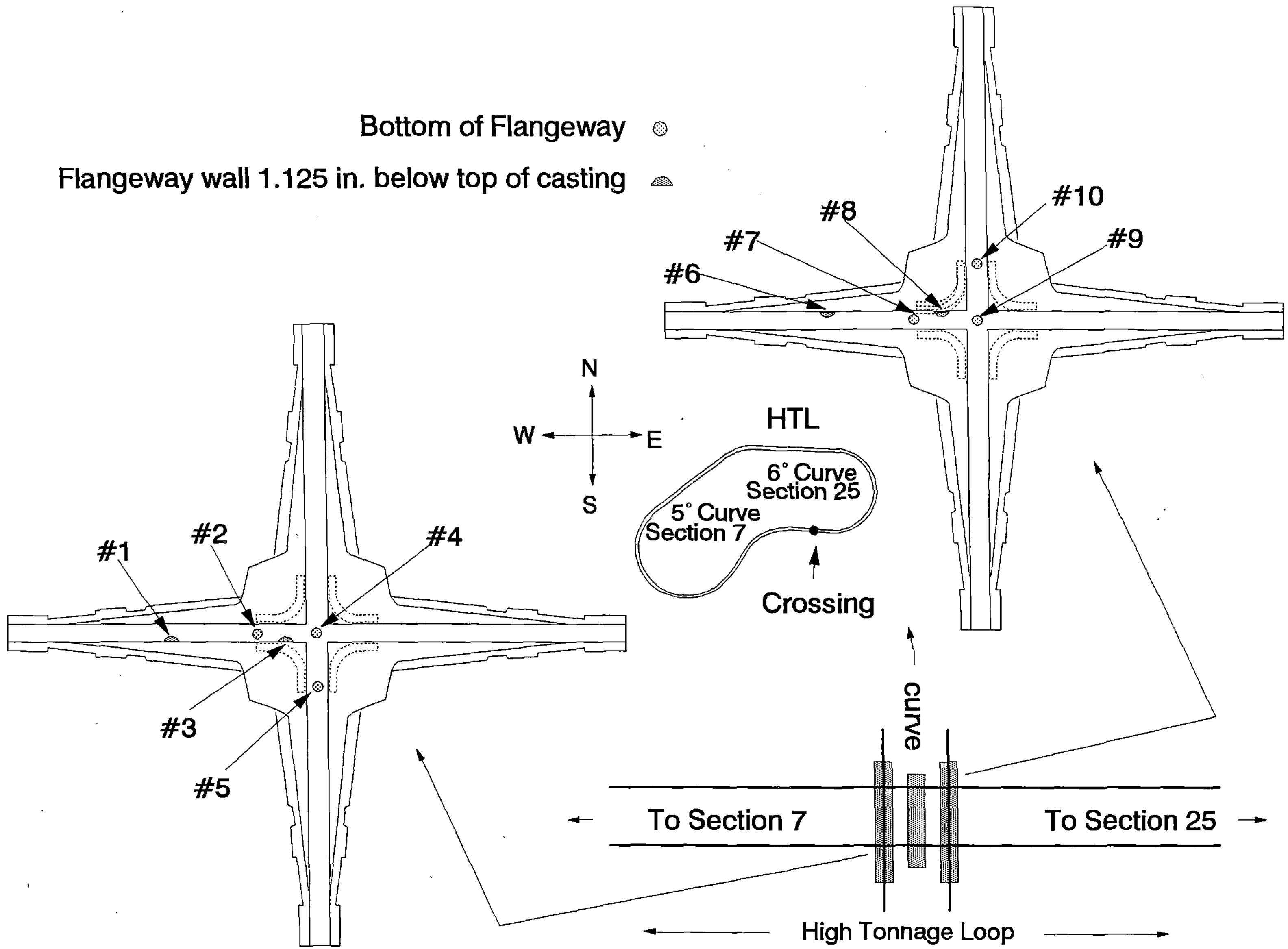
SECTION A-A



AREA Portfolio, Plan No. 790-55

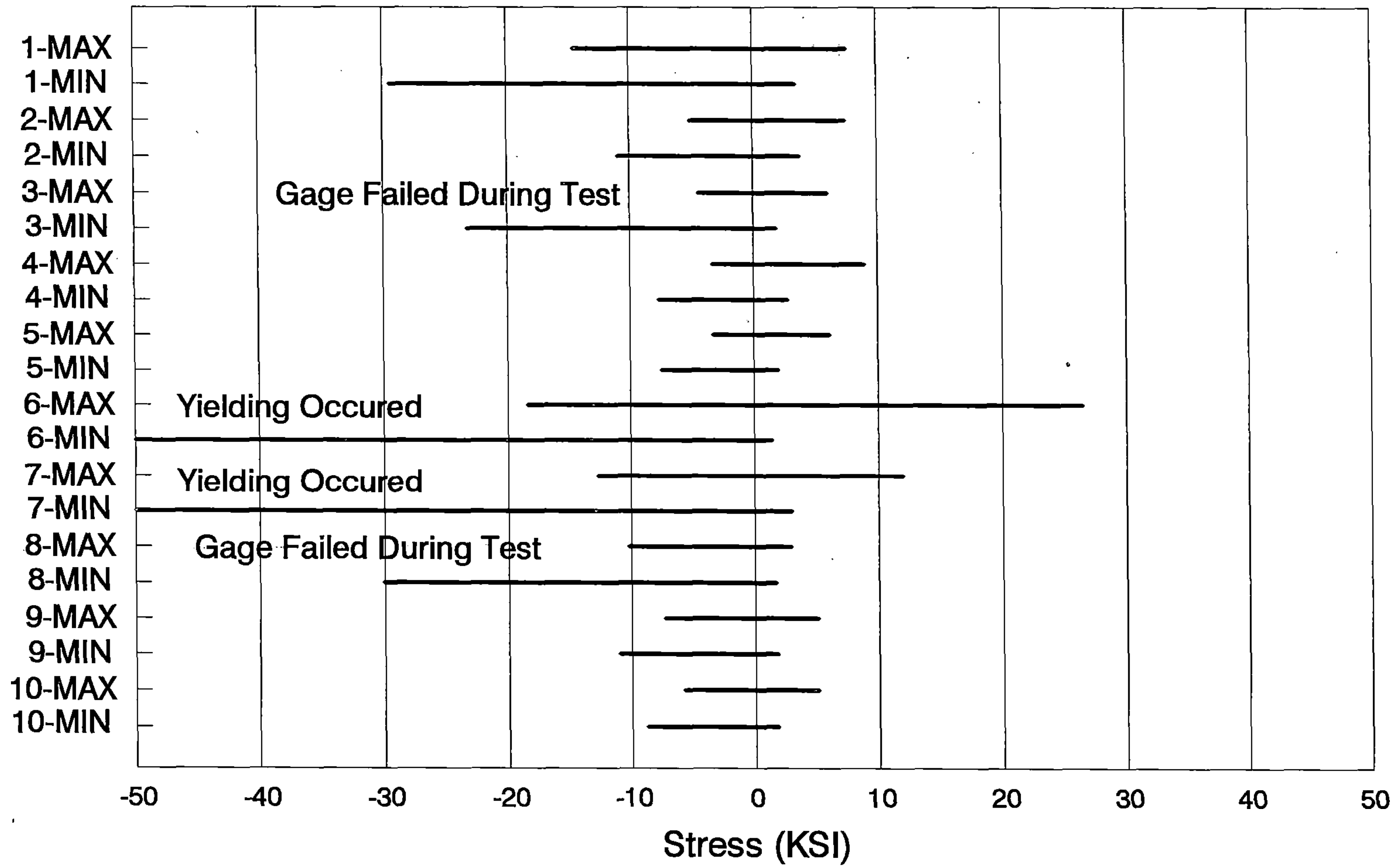
Minimum Flangeway Width 1 5/8"

Minimum Flangeway Depth 1 1/2"


Bottom of Flangeway
Flangeway wall 1.125 in. below top of casting
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
N
W
E
S
HTL
6° Curve
Section 25
5° Curve
Section 7
Crossing
curve
To Section 7
To Section 25
High Tonnage Loop

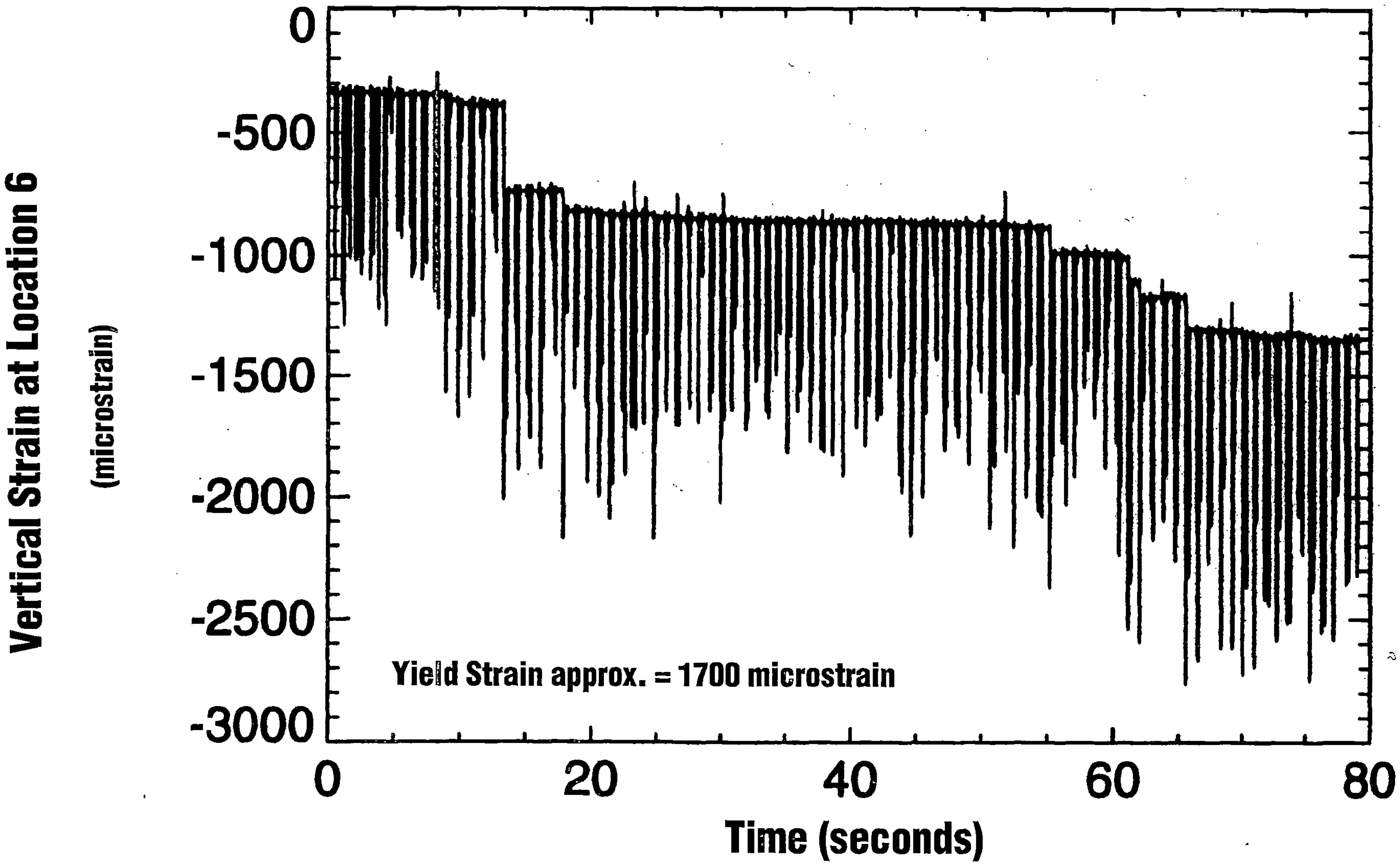
PRINCIPAL STRESS RANGES

Train Direction: CCW



Time History of Strain Data for 1 Train Pass

Train Direction: CCW



FAST CROSSING FROG EVALUATION

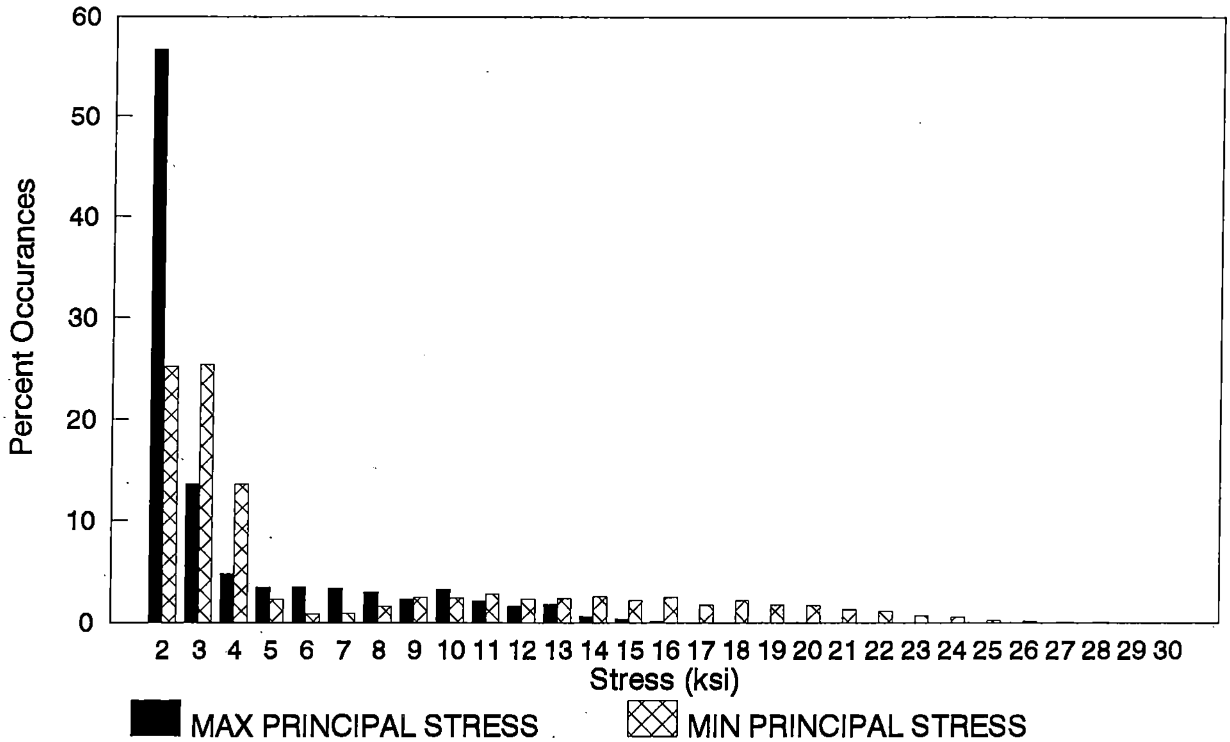
CONCLUSIONS:

- The standard-component crossing diamond was removed after 1.9 MGT of HAL traffic due to excessive batter and loss of geometry.
- Batter rate of about 1/8" per MGT was observed on flangeway wall of frog casting.
- Further testing should be conducted using a premium-component crossing diamond.

DATA NOT INCLUDED IN THE PRESENTATION

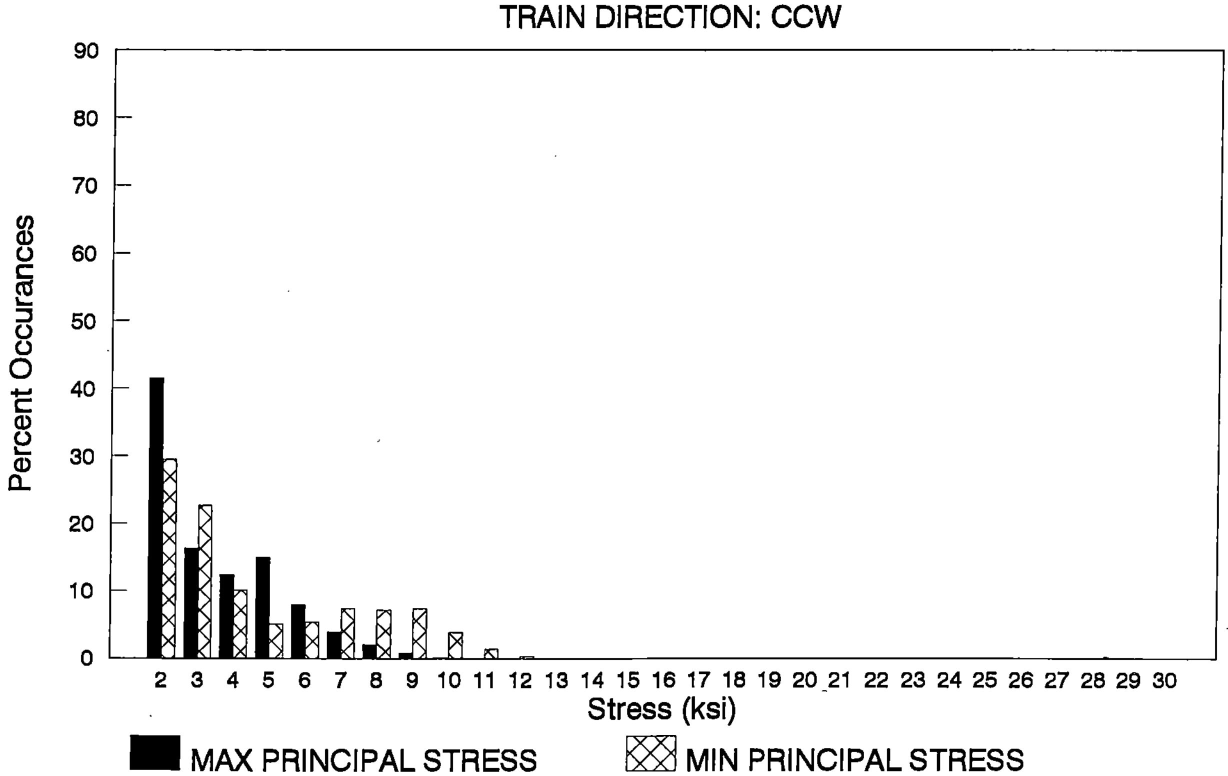
GAGE 1 STRESS CYCLES

TRAIN DIRECTION: CCW



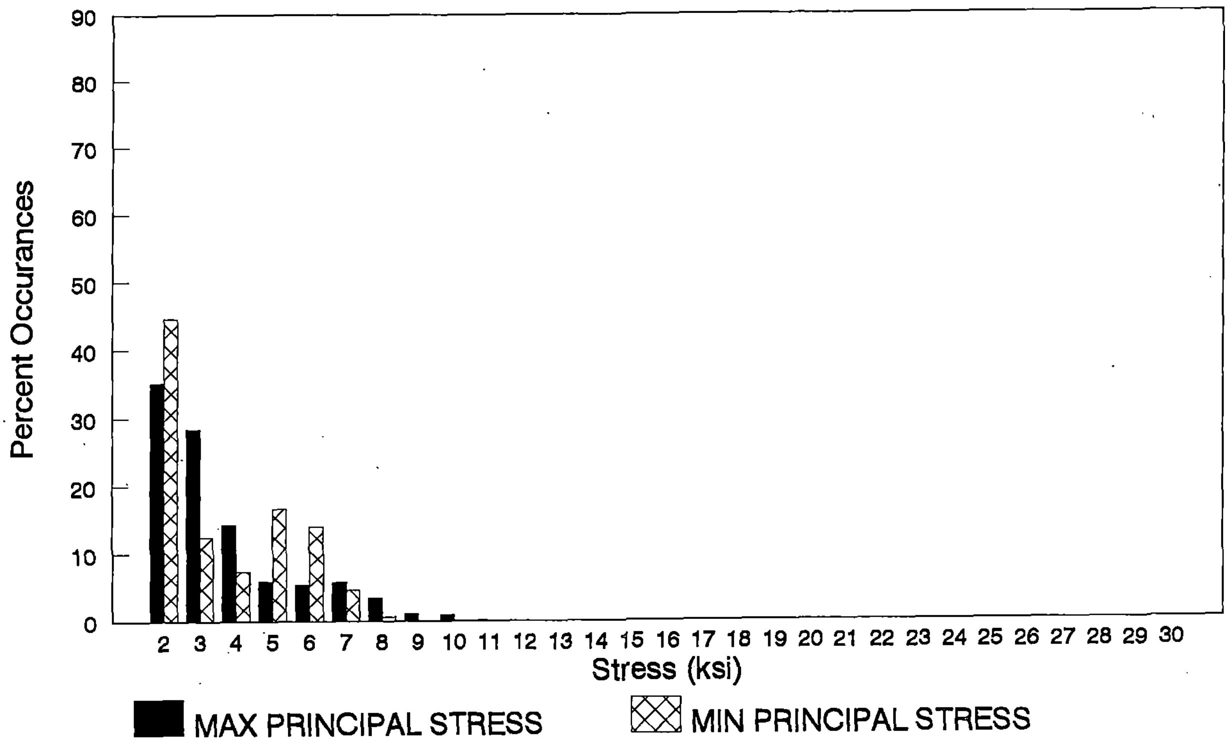
GAGE 2 STRESS CYCLES

TRAIN DIRECTION: CCW



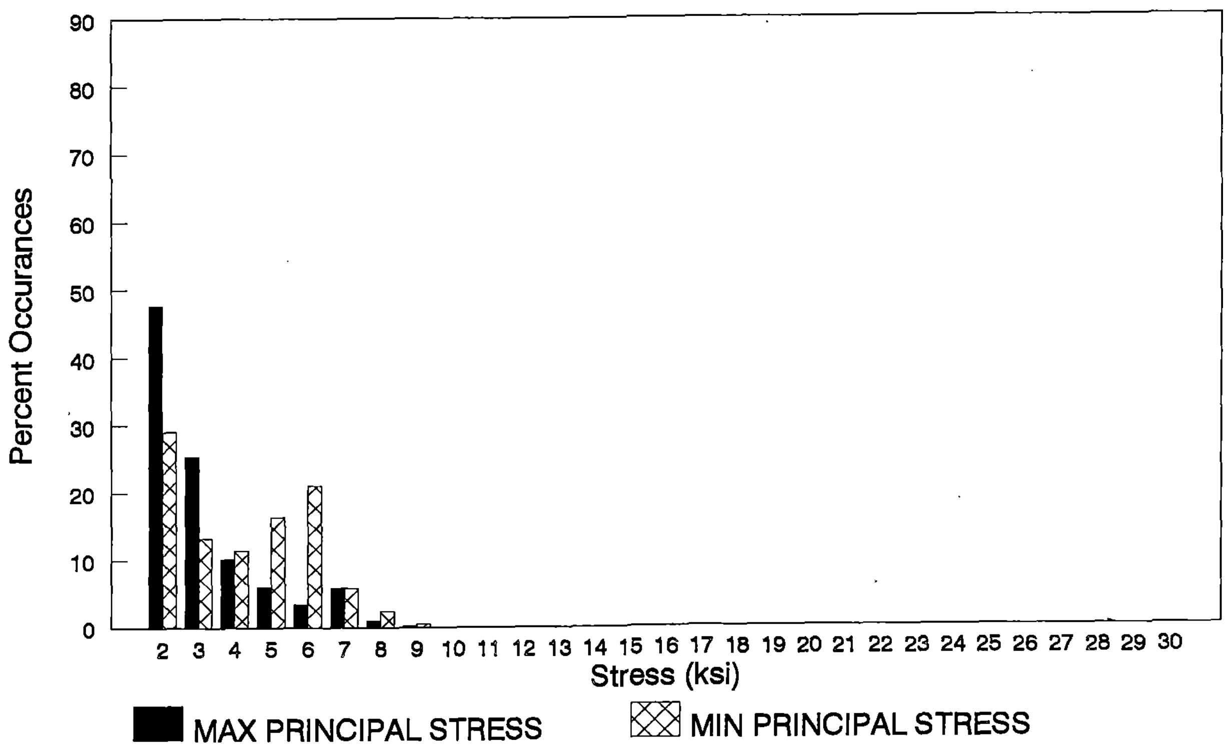
GAGE 4 STRESS CYCLES

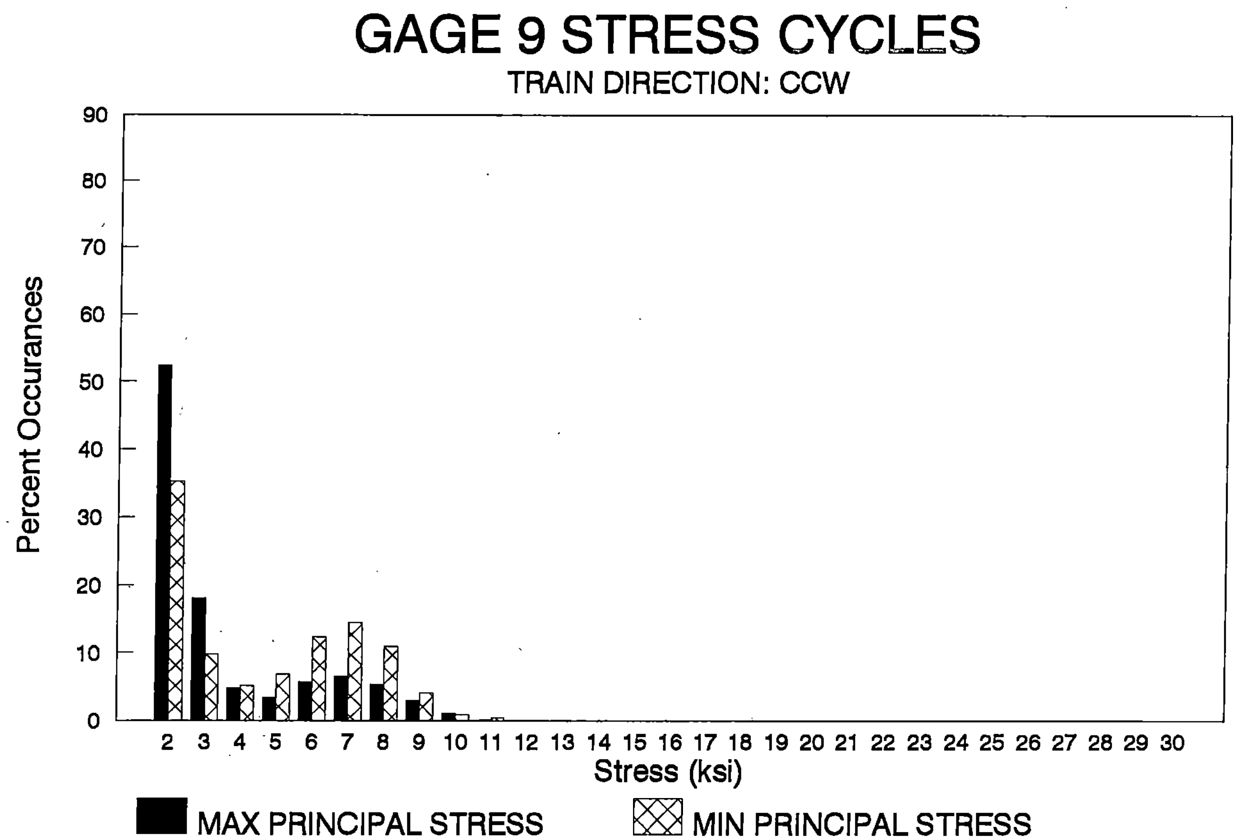
TRAIN DIRECTION: CCW

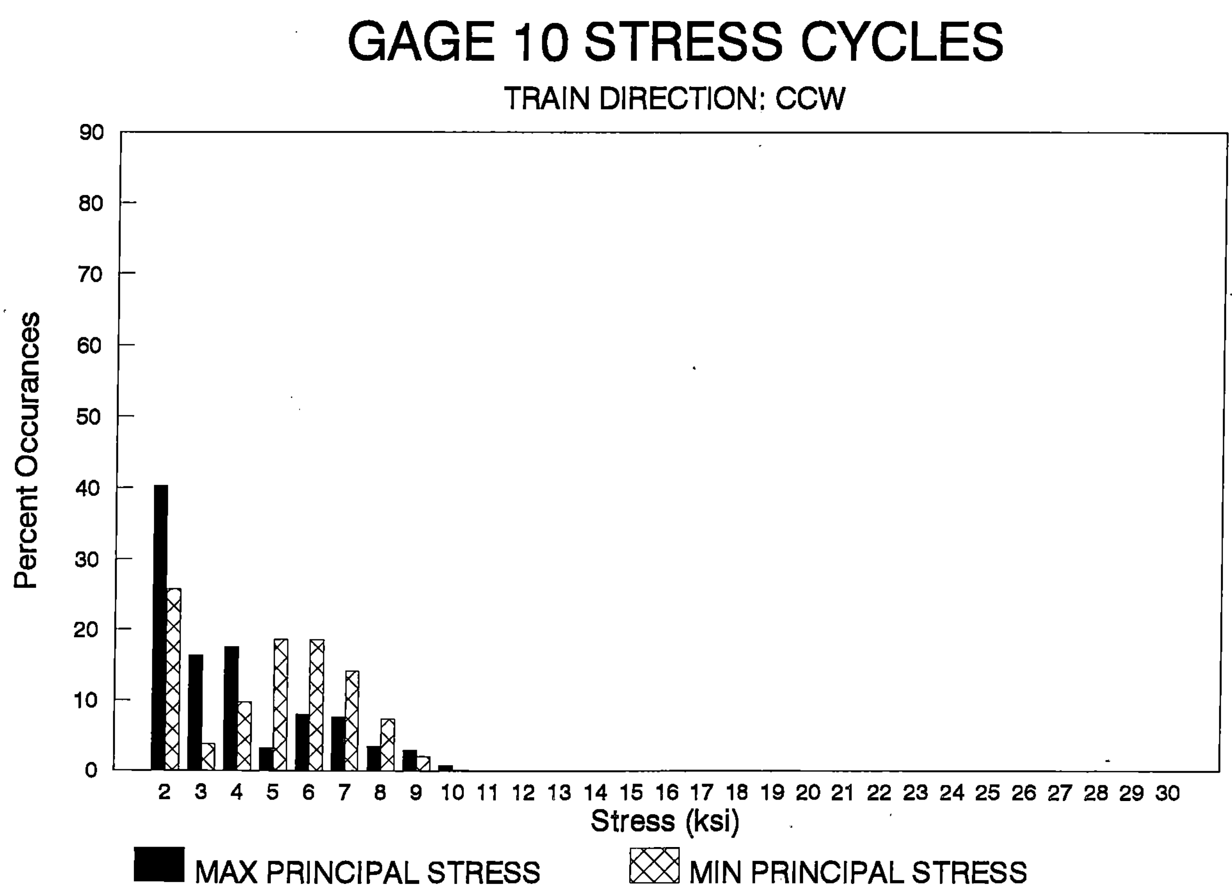


GAGE 5 STRESS CYCLES

TRAIN DIRECTION: CCW




GAGE 9 STRESS CYCLES
TRAIN DIRECTION: CCW
Percent Occurances
0
10
20
30
40
50
60
70
80
90
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Stress (ksi)
MAX PRINCIPAL STRESS
MIN PRINCIPAL STRESS


GAGE 10 STRESS CYCLES
TRAIN DIRECTION: CCW
Percent Occurances
0
10
20
30
40
50
60
70
80
90
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Stress (ksi)
MAX PRINCIPAL STRESS
MIN PRINCIPAL STRESS

FAST HAL

MECHANICAL COMPONENT PERFORMANCE EXPERIMENT

By Robert L. Florom
Experiment Manager

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HEAVY AXLE LOAD PROGRAM - PHASE I TEST

WHEEL PERFORMANCE TEST LIMITATIONS

- Unidirectional train operaion
  - Abnormal wear patterns
  - Uneven exposure levels
- Limited brake applications
  - No wheel tread conditioning
- Abnormal load cycle
  - Cars are always fully loaded
- Small sample size
  - Twelve 36-inch Class C wheels
  - Eight 38-inch Class C wheels

HEAVY AXLE LOAD PROGRAM - PHASE I TEST

WHEEL PERFORMANCE TEST RESULTS

- No statistically significant difference in the flange wear data for 33- and 39-ton axle load cars on a car mileage basis
- No statistically significant difference in the rim wear data for 33- and 39-ton axle load cars on a car mileage basis

HEAVY AXLE LOAD PROGRAM - PHASE I TEST

WHEEL PERFORMANCE TEST RESULTS

- Corrugations occurred primarily on wheels that operate on inside rail of HTL in leading axle position of truck
- Corrugations observed on wheels of 33- and 39-ton axle load cars
- Corrugations similar in appearance and severity for car types
- Corrugations DO NOT appear to be associated with the HAL condition, and may be a result of the nature the HAL consist operation and the design of the HTL

EXPERIMENT OBJECTIVES

- Monitor component performance of the freight cars used in the HAL program to identify problem areas requiring future research
- Document wheel performance of 33-ton and 39-ton axle load cars under bi-directional lubricated track operating conditions
- Investigate the effects of cyclic tread braking on the development of wheel tread irregularities

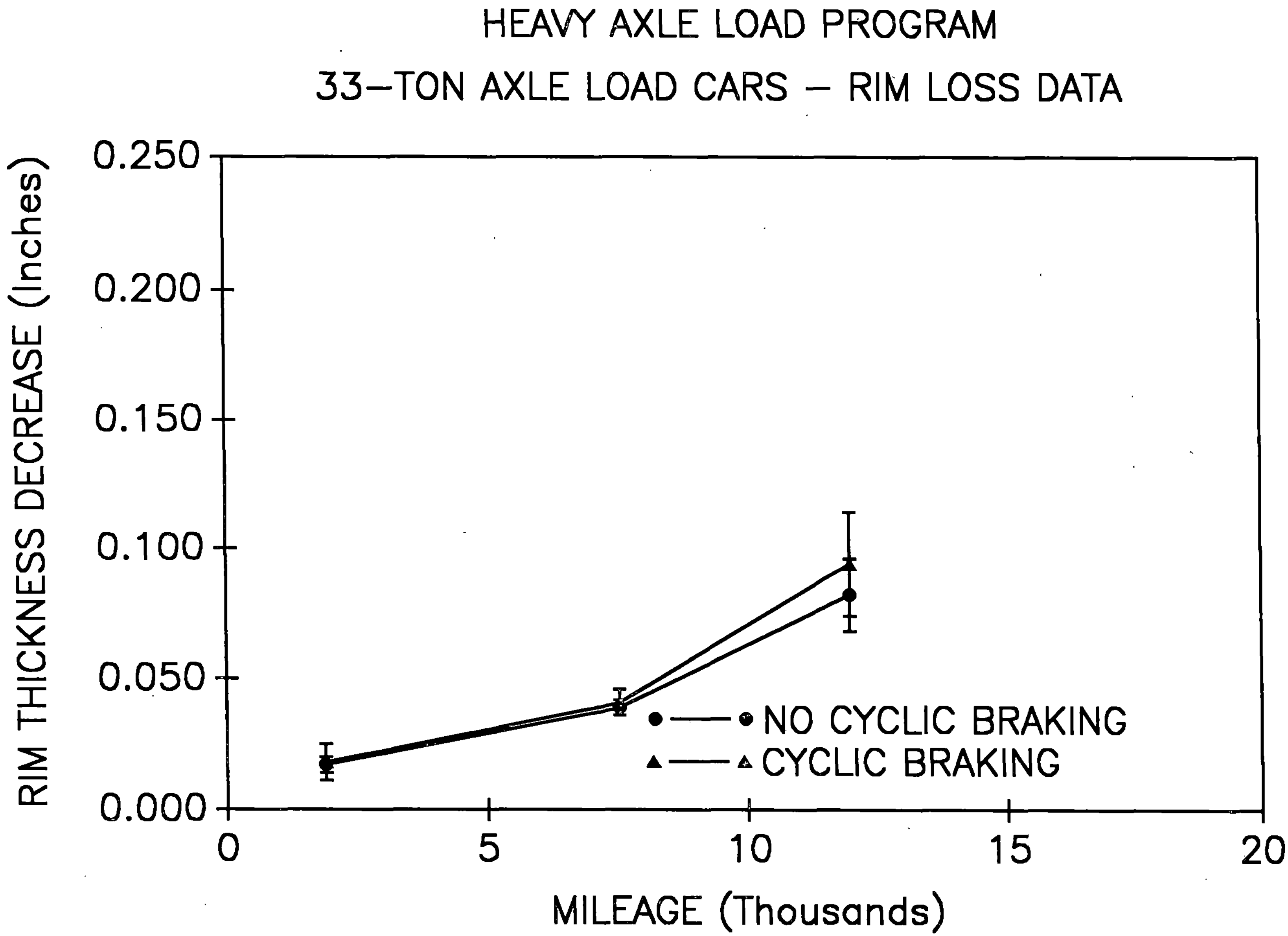
EXPERIMENT OVERVIEW

- Three fully loaded 33-ton axle load cars equipped with Barber S-2 trucks
- Three fully loaded 39-ton axle load cars equipped with Barber S-2 trucks
- New Class C wheels (321-363 BHN) installed in all axle positions of each car
- Two cars equipped with special brake control equipment to initiate brake applications independent from the HAL train
- Brakes applied once per lap (14 PSI BCP. minimum service reduction)

MEASUREMENTS

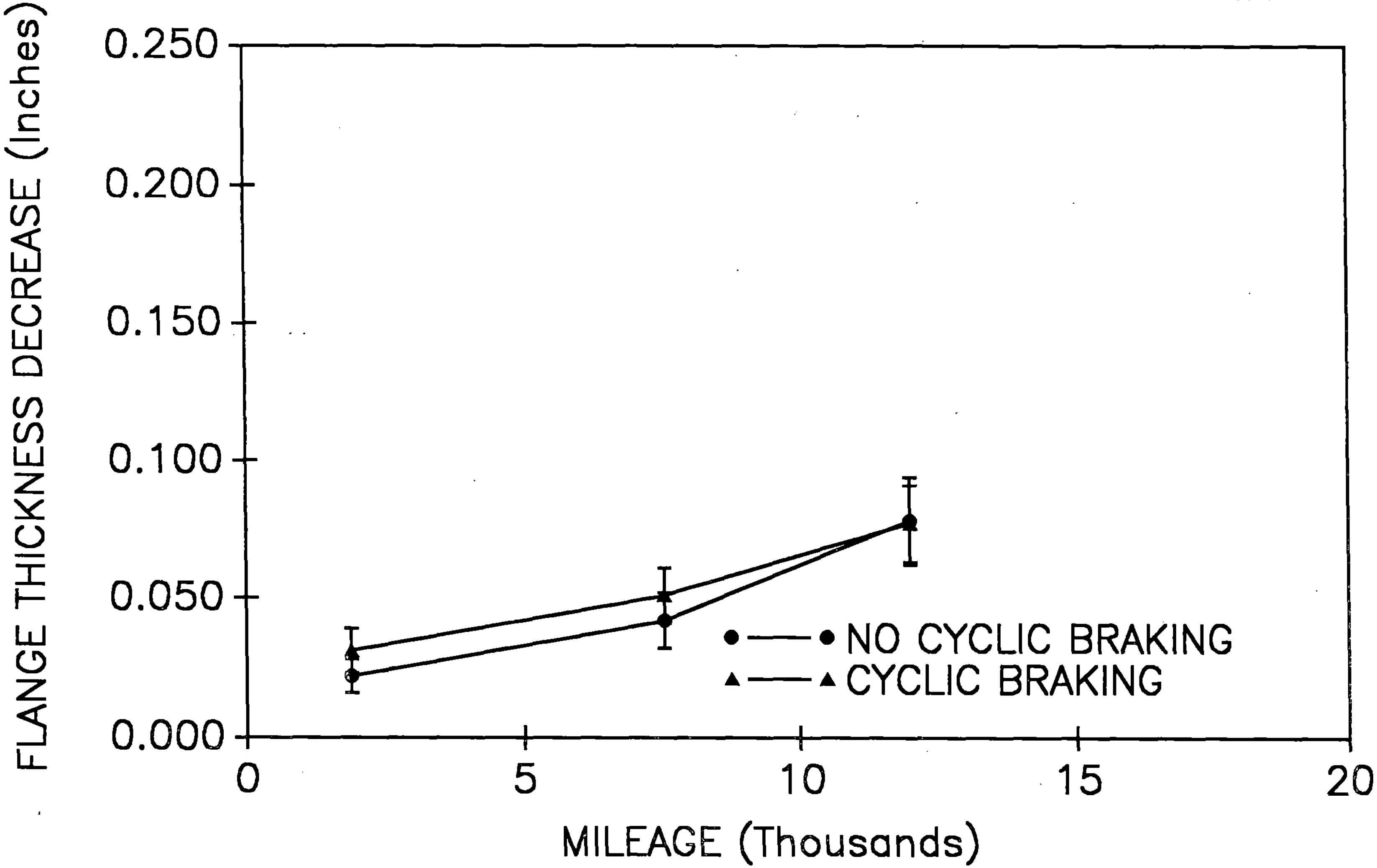
- Flange material loss -- TTC snap gage
- Rim material loss -- TTC snap gage
- Lateral profiles -- CN-Profilometer
- Wheel irregularities -- Circumferential Profilometer

CIRCUMFERENTIAL PROFILE DATA SUMMARY			
CAR	AXLE POSITION	MAXIMUM RADIAL RUNOUT	
		RIGHT SIDE	LEFT SIDE
132	1	0.020	0.015
132	2	0.008	0.010
132	3	0.006	0.012
132	4	0.010	0.015
137	1	0.010	0.022
137	2	0.010	0.012
137	3	0.018	0.022
137	4	0.015	0.018
165	1	0.024	0.020
165	2	0.022	0.012
165	3	0.012	0.010
165	4	0.005	0.010
305	1	0.015	0.017
305	2	0.005	0.010
305	3	0.011	0.008
305	4	0.002	0.024
326	1	0.020	0.005
326	2	0.013	0.024
326	3	0.020	0.018
326	4	0.020	0.015
339	1	0.013	0.012
339	2	0.008	0.018
339	3	0.010	0.022
339	4	0.012	0.018


HEAVY AXLE LOAD PROGRAM
33–TON AXLE LOAD CARS – RIM LOSS DATA
RIM THICKNESS DECREASE (Inches)
0.250
0.200
0.150
0.100
0.050
0.000
0
5
10
15
20
MILEAGE (Thousands)
NO CYCLIC BRAKING
CYCLIC BRAKING

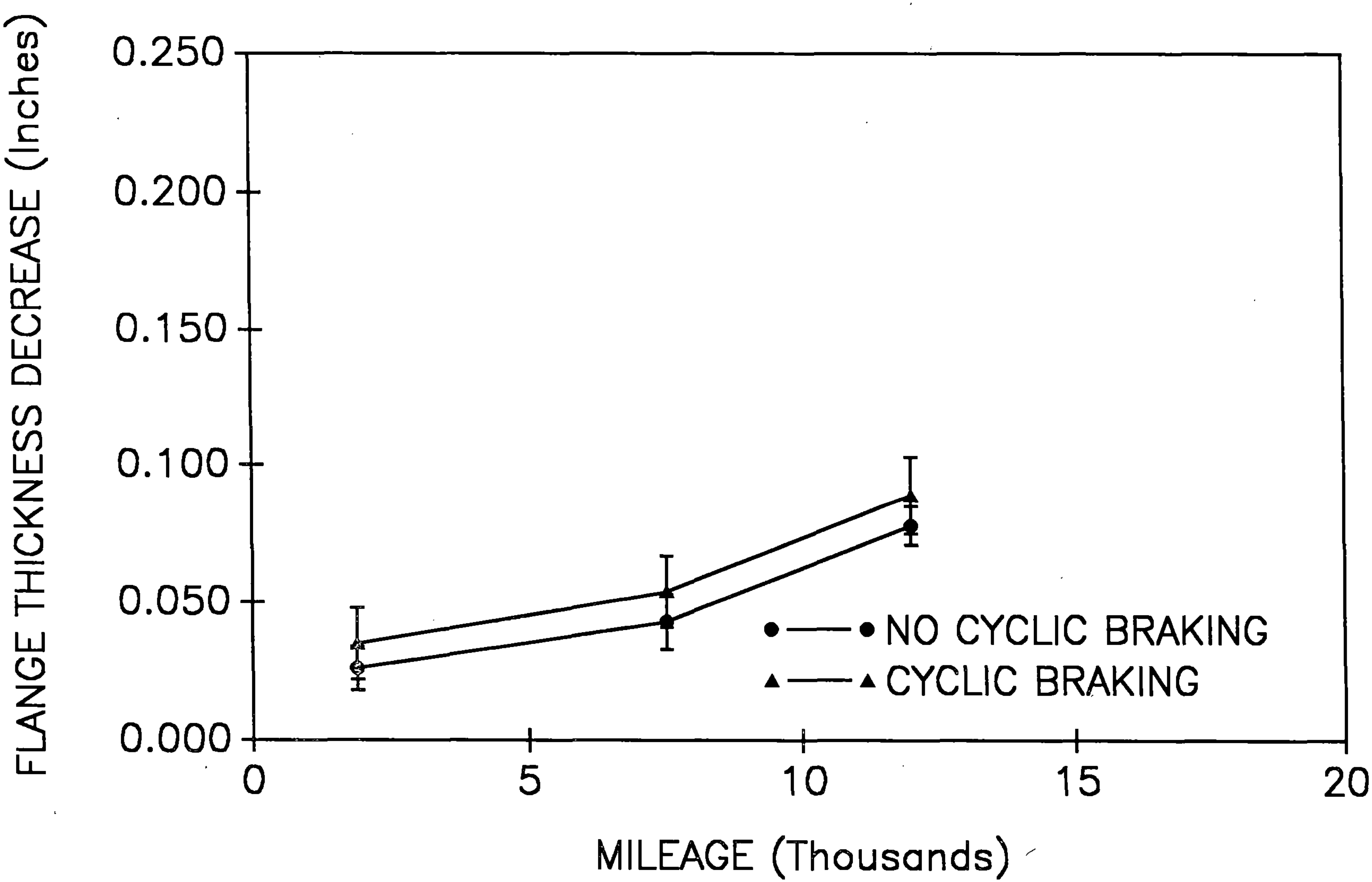
HEAVY AXLE LOAD PROGRAM

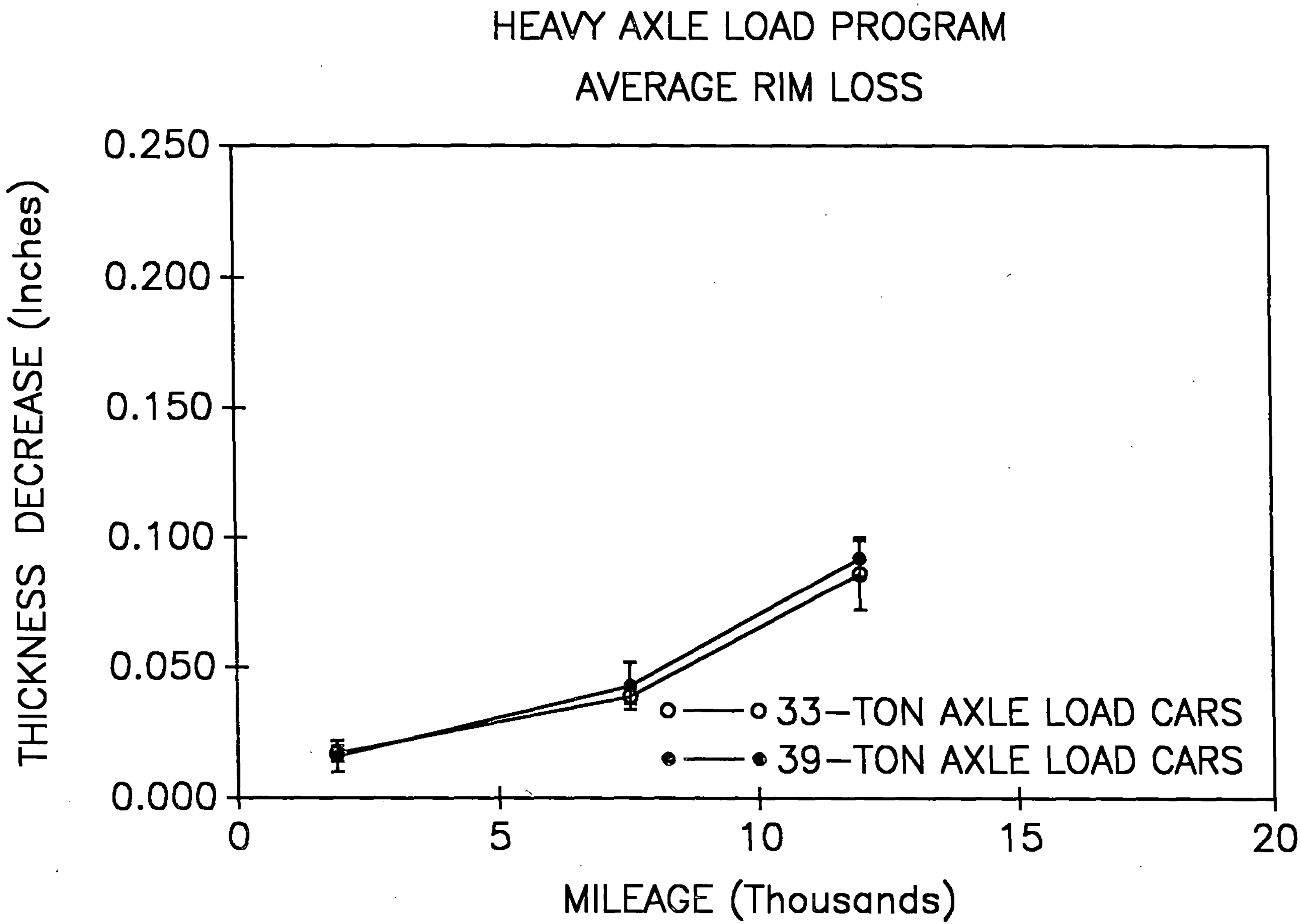
33–TON AXLE LOAD CARS – FLANGE LOSS DATA

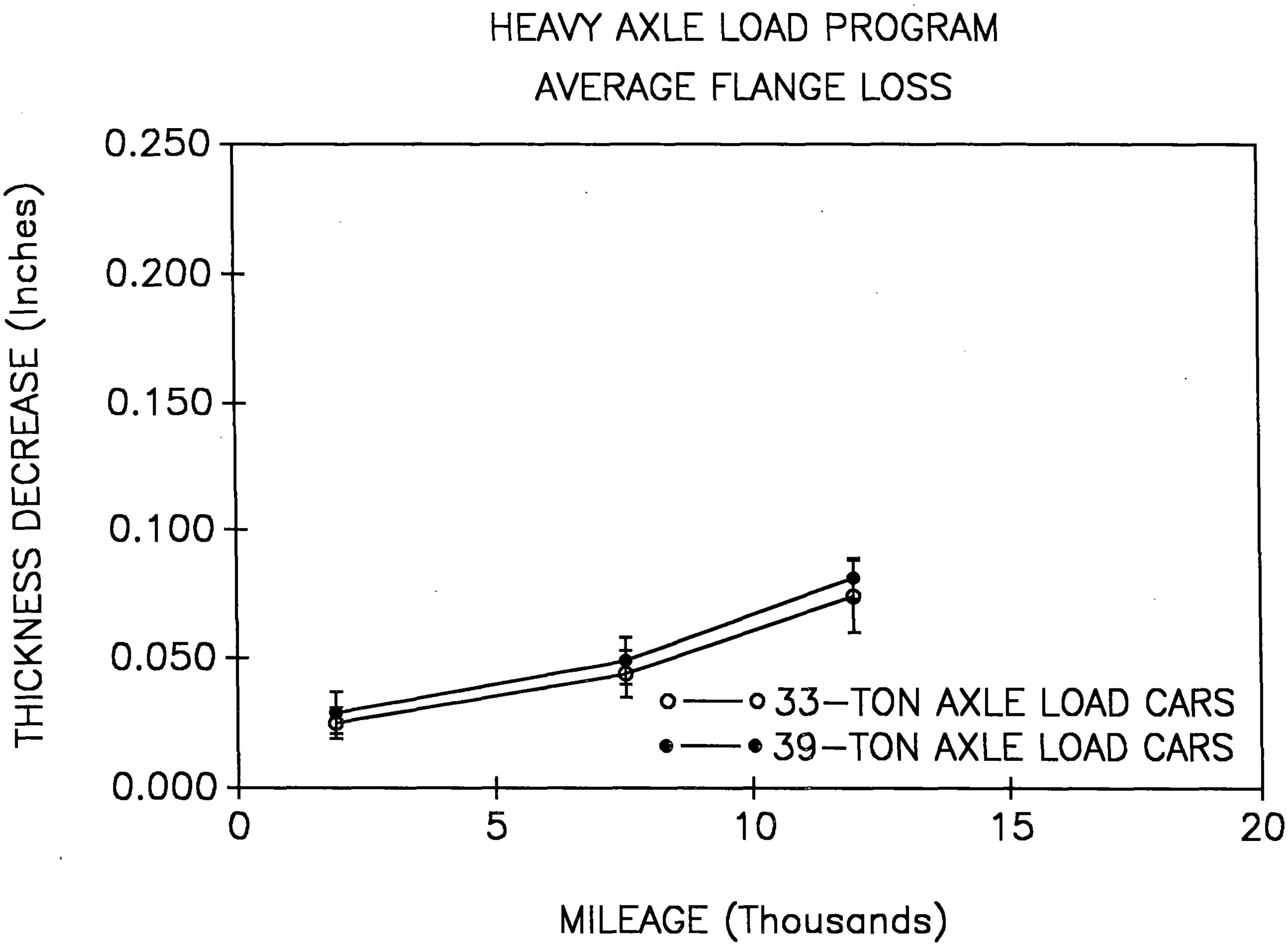


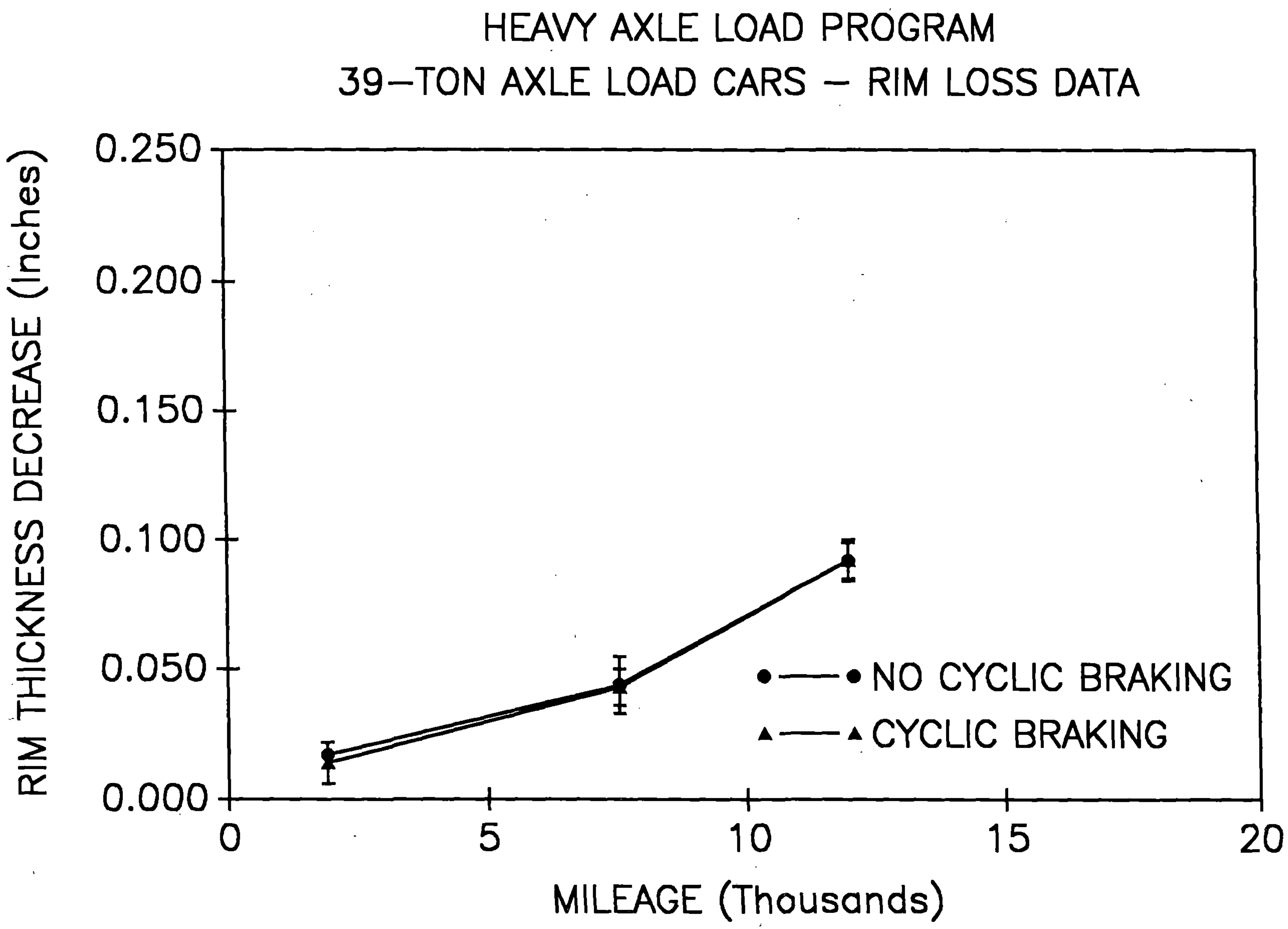
HEAVEY AXLE LOAD PROGRAM

39—TON AXLE LOAD CARS — FLANGE LOSS DATA




HEAVY AXLE LOAD PROGRAM
AVERAGE RIM LOSS
THICKNESS DECREASE (Inches)
0.250
0.200
0.150
0.100
0.050
0.000
0
5
10
15
20
MILEAGE (Thousands)
33-TON AXLE LOAD CARS
39-TON AXLE LOAD CARS


HEAVY AXLE LOAD PROGRAM
AVERAGE FLANGE LOSS
THICKNESS DECREASE (Inches)
0.250
0.200
0.150
0.100
0.050
0.000
0
5
10
15
20
33–TON AXLE LOAD CARS
39–TON AXLE LOAD CARS
MILEAGE (Thousands)


HEAVY AXLE LOAD PROGRAM
39—TON AXLE LOAD CARS — RIM LOSS DATA
RIM THICKNESS DECREASE (Inches)
0.250
0.200
0.150
0.100
0.050
0.000
0
5
10
15
20
MILEAGE (Thousands)
NO CYCLIC BRAKING
CYCLIC BRAKING

RESULTS

Wheel Wear Performance

- Wheel performance cars completed 12,000 miles of operation
- Bi-directional operation has resulted in uniform wheel profiles
- On a car mileage basis there is no statistically significant difference in the flange wear data obtained for the two car types
- On a car mileage basis there is no statistically significant difference in the rim wear data obtained for the two car types

RESULTS

Wheel Tread Irregularities and Cyclic Tread Braking

- No significant wheel tread irregularities have occurred on any of the test wheels during 12,000 miles of operation on the HTL
- There was no significant correlation between cyclic tread braking and the occurrence of wheel tread irregularities
- Cyclic tread braking did not compromise the wheel wear data

FAST
HAL

RAIL ROLLOVER DERAILMENT EXPERIMENT

By Stephen E. Mace
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RAIL ROLLOVER DERAILMENT STUDY

Introduction

- In 1991, Several (6-8) 125-ton Cars in the FAST/HAL Consist Produced Low Rail Lateral Deflections Exceeding 0.5" on the HTL
- The Largest Deflections were Measured in the Two-point Contact Grind Zone of the 6-Degree Curve in Section 25
- Both Leading and Trailing Trucks of the Bad Actor Cars Produced Large Gage Widening Forces
- The Greatest Deflections Occurred When a Car with a Trailing Gage Widening Truck was Coupled to a Car with a Leading Gage Widening Truck

Objectives

- To Understand the Origin of the Excessive Rail Lateral Deflections Measured During Recent FAST Operations
- To Identify a Strategy for Continuing FAST Operation with "Normal" Track Lubrication, i.e. with the High Rail Lubricated and the Top of the Low Rail Lightly Lubricated
- To Confirm the Essential Safety of Continued FAST Operations
- To Establish Guidelines, if Necessary, for Track Strength and Car Mechanical Conditions for Both FAST and Revenue Operations
- To Improve Knowledge of the Factors Causing Rail Lateral Deflections and Potential Gage Widening Derailments

RAIL ROLLOVER DERAILMENT STUDY

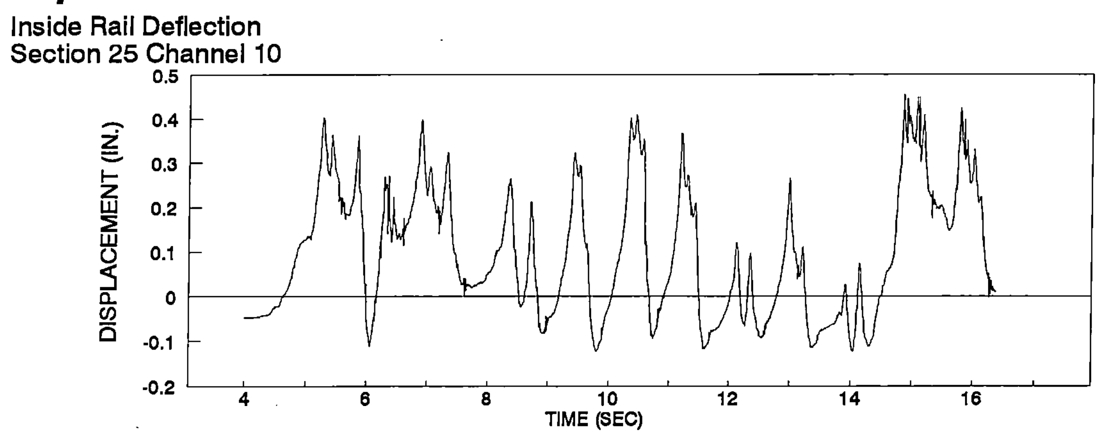
Approach

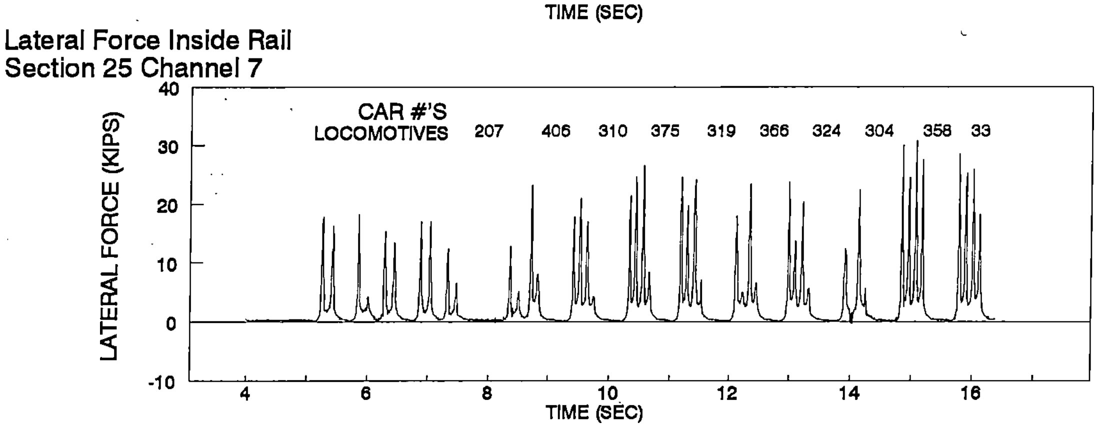
- Gage Widening Cars Tested in FAST/HAL Section 25 6-Degree Curve
- Wheel/Rail Forces and Axle Angles-of-Attack Were Measured
- Wheel and Rail Profiles Were Measured
- Wheel Sets From a Gage Widening Car Were Exchanged With a Normally Behaving Car
- Rail Lubrication Conditions Were Varied
- NUCARS Model Predictions Were Made to Determine the Influence of Wheel/Rail Profile and Rail Lubrication on Gage Spreading Forces

Major Accomplishments

- Low Rail Lateral Deflection Approaching 0.5 inch and Trailing Truck Side L/V Ratios of 0.6 Were Measured During the Track Test
- The Effects of Variable Rail Lubrication and Wheel/Rail Contact Geometry on Gage Widening Behavior Were Demonstrated During the Track Test
- The Effect of Adjacent Gage Widening Trucks on Total Gage Widening was Demonstrated
- A NUCARS Model of the FAST/HAL Gondola Car 125-ton Trucks was Developed Which Predicted the Gage Widening Behavior Observed During the Track Test

Sample Inside Rail Lateral Defections and Forces





Major Accomplishments

- NUCARS Predictions Indicate that Conditions Causing Reduction in Wheel Set Steering Moment can Cause Truck Frame Warp and Excessive Gage Spreading Forces

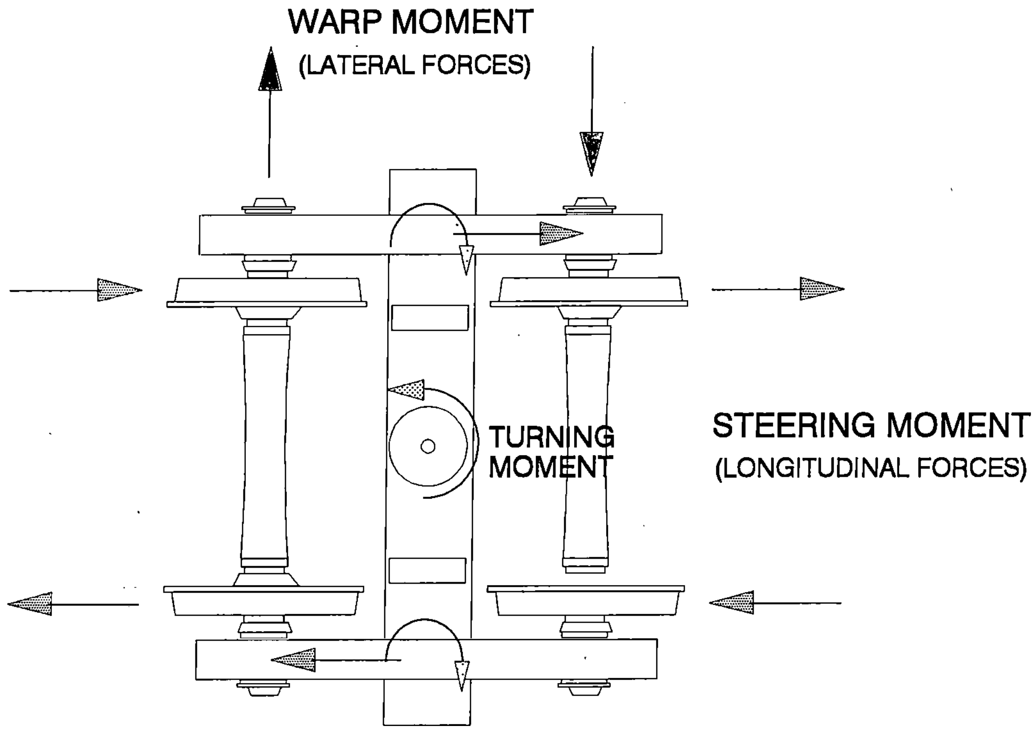
- NUCARS Predictions Show that Severe Two-point Wheel/Rail Contact can Drastically Reduce or Reverse the Wheel Set Steering Moment

- NUCARS Predictions Indicate that Lubricating Only the High Rail in Curves Reduces the Steering Moment and Provides the Potential for Large Gage Spreading Forces

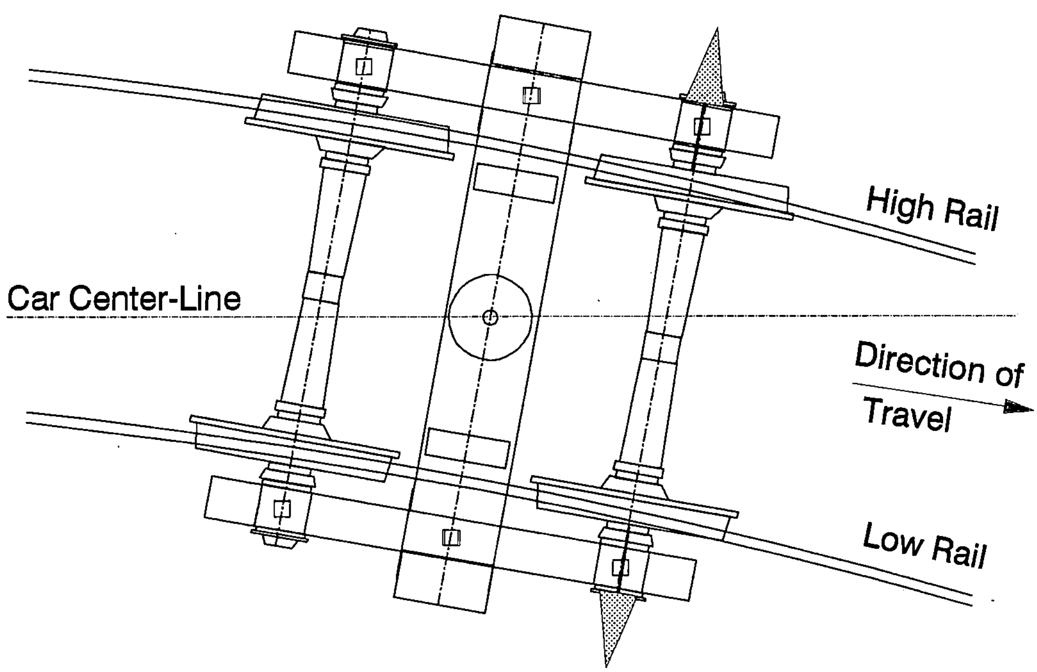
- NUCARS Predictions Demonstrated that Low Effective Warp Restraint of a Three-piece Truck Increases the Potential for Producing Large Gage Spreading Forces

RAIL ROLLOVER DERAILMENT STUDY

TURNING MOMENT = WARP MOMENT + STEERING MOMENT

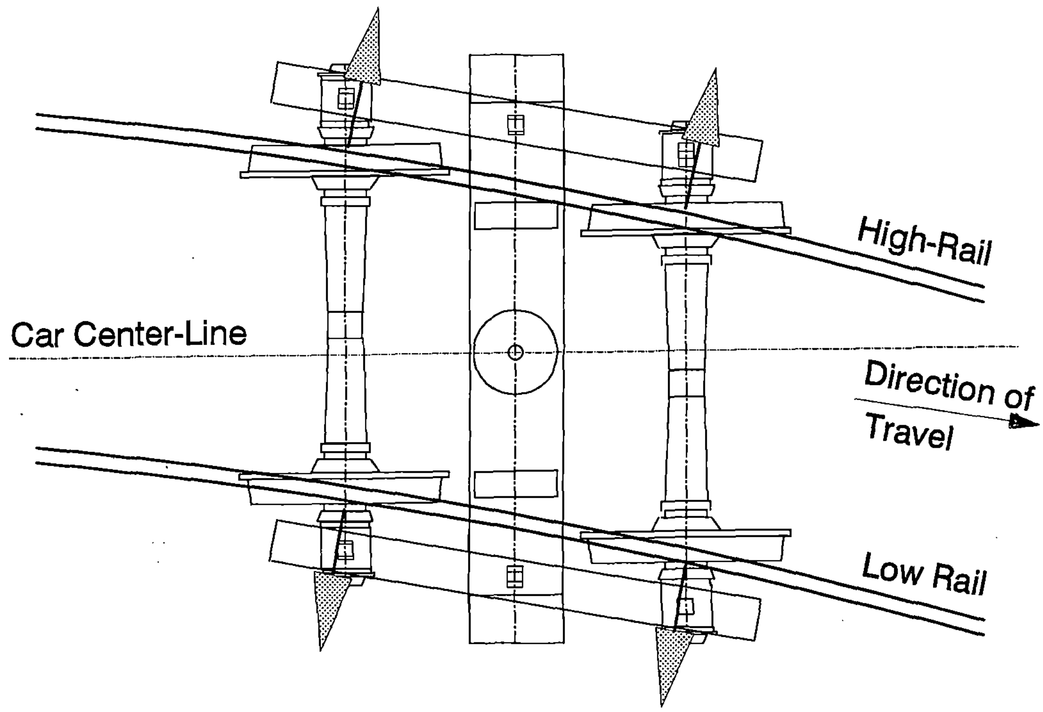


Truck Frame Turned During Curve Negotiation



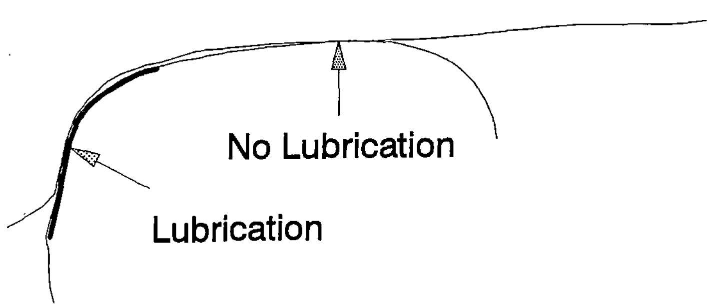
RAIL ROLLOVER DERAILMENT STUDY

Truck Frame Warped During Curve Negotiation

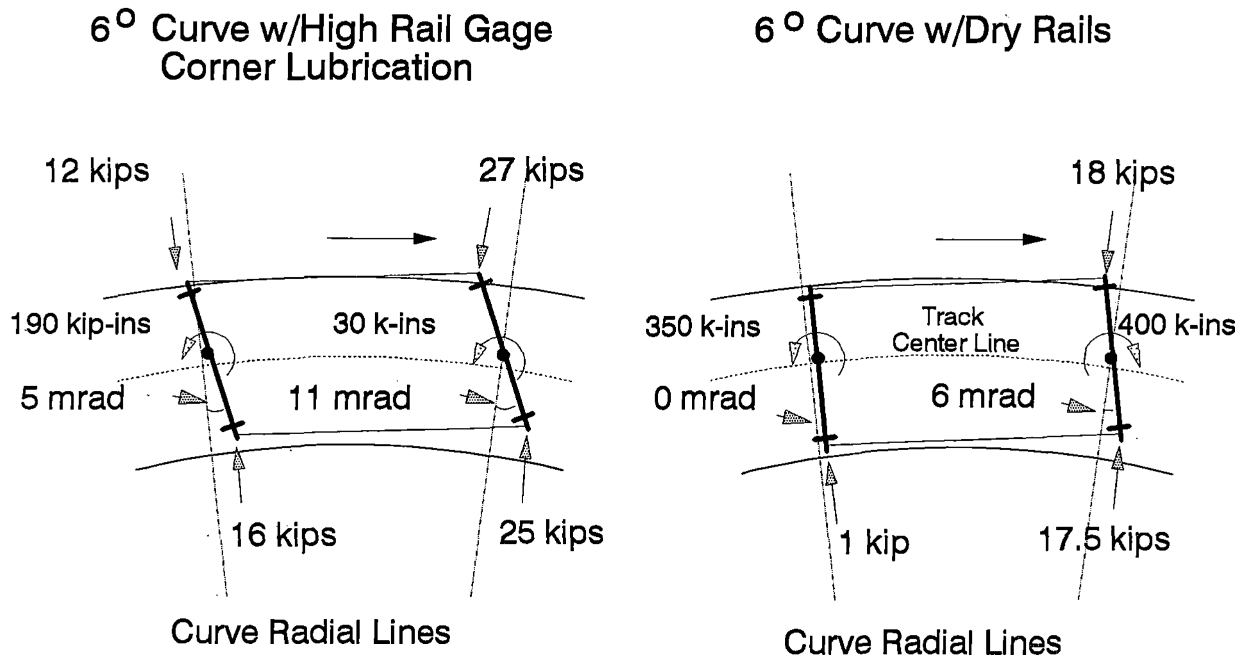


FAST Car #406 Wheel Profile

HTL Section 25 RSG High Rail



Curving Diagram for Trailing Truck



Conclusions

- Gage Corner Grinding of the High Rail in Curves Leading to Severe Two-point Contact Can Result in Large Gage Widening Forces
- Lubricating only the High Rail in Curves can Create the Potential for Large Gage Widening Forces
- The Low Effective Warp Restraint of the Three-piece Truck Increases the Likelihood of Large Gage Spreading Forces Due to Truck Warp
- Several Adjacent Gage Widening Trucks Increases the Potential for a Gage Spreading Derailment

RAIL ROLLOVER DERAILMENT STUDY

Mechanical Recommendations:

- Maintain Conformal Profiles on Wheels
- Increase Three-piece Truck Warp Restraint

Track Recommendations:

- Lubricate Both Rails in Curves
- Avoid Two-point Contact Grinding on High Rails
- Increase Rail Rollover Strength, Especially on the Low Rail, with Premium Fasteners

FAST
HAL

HAL ALTERNATIVE SUSPENSION SYSTEM EXPERIMENT

By Curtis L. Urban
Experiment Manager

TRANSPORTATION TEST CENTER
PUEBLO, COLORADO

HAL ALTERNATIVE SUSPENSION SYSTEMS

Primary Objective:

Determine the effects of alternative suspension designs to reduce costs of heavy axle loads associated with track degradation

Secondary Objective:

Provide dynamic performance data for the establishment of 125-ton truck performance specifications

Benefits of New Truck Designs

- Premium trucks provide:
  - Improvements in steering which reduces lateral loads
  - Improvements in suspension systems reduce dynamic vertical loads
  - High warp/shear stiffness reduces curving forces and the likelihood of hunting
- Reduced track wear and damage to rail, ties, ballast, sub-grade
- Reduced truck wear and damage to vehicle/lading, bolster, side frames, wheels, brakes
- Reduced track and vehicle maintenance
- Reduced fuel consumption
- Reduced likelihood of derailment

HAL ALTERNATIVE SUSPENSION SYSTEMS

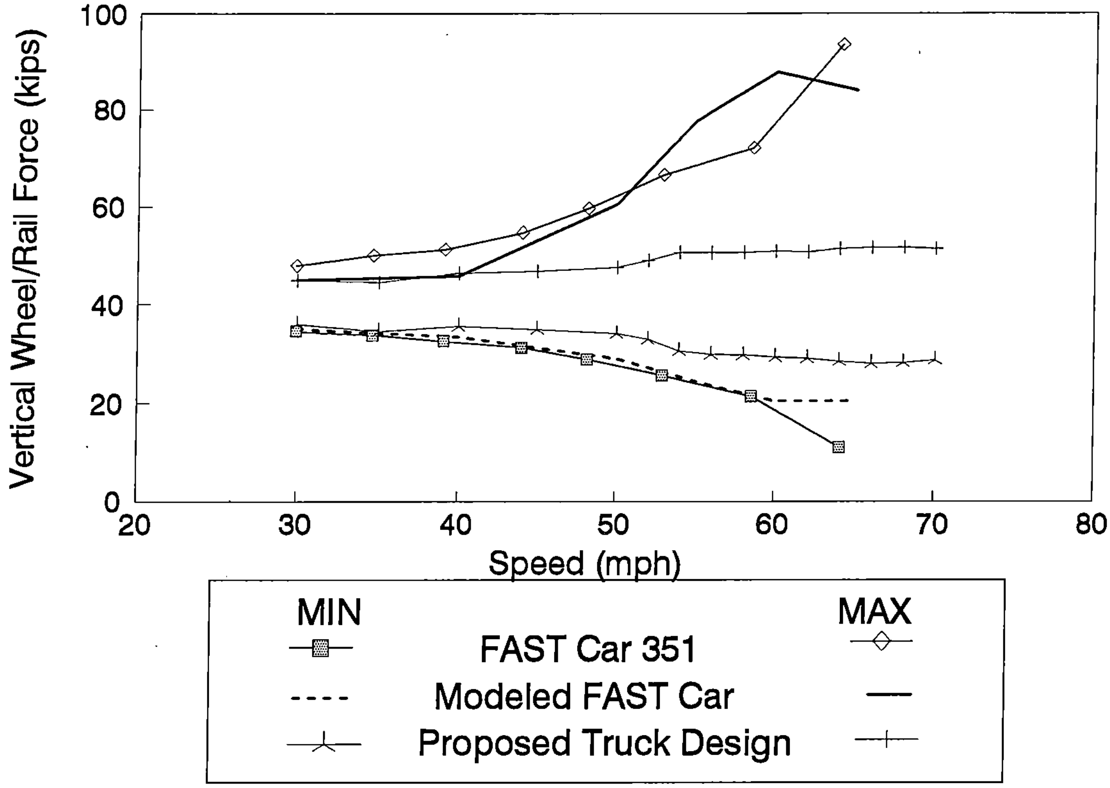
Six Proposed Truck Designs

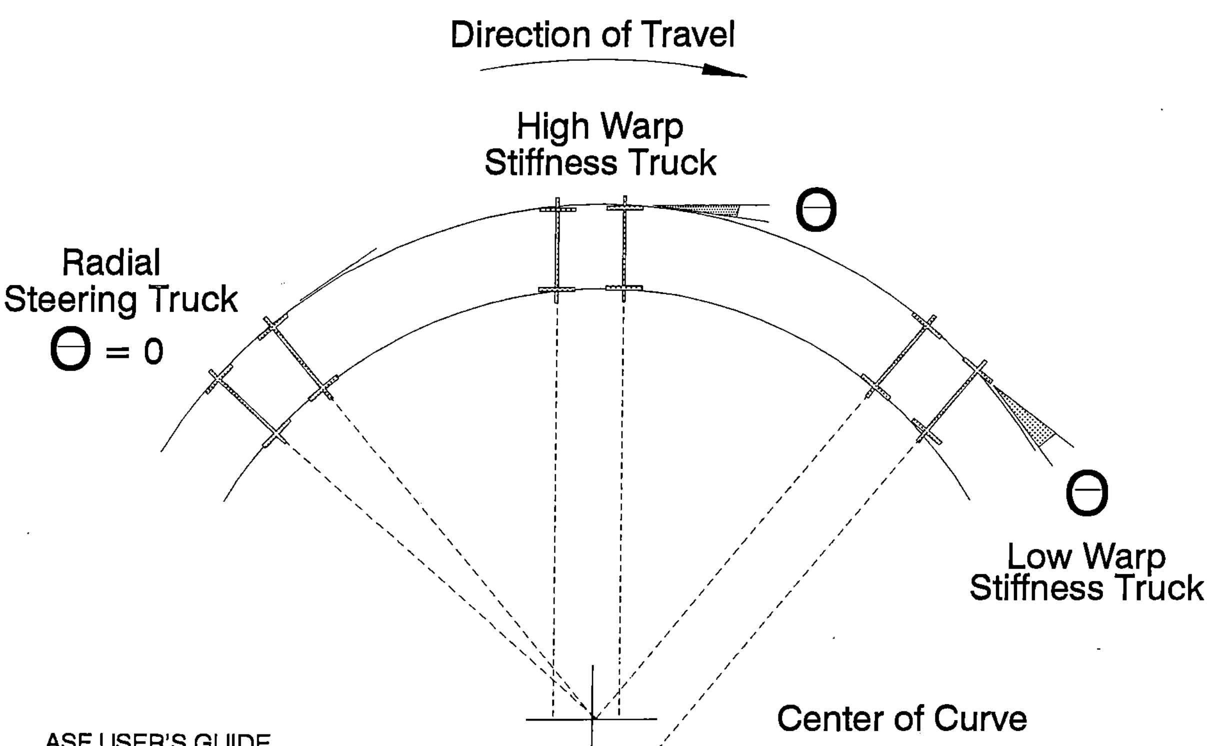
- ASF - American Steel Foundries
  - Shear Plate Truck
  - AR-1 Radial Steering Truck
- A. Stucki Company
  - Squared Dynamic Control Truck
  - Dynamic Control Truck
- Buckeye Steel Casting Company
  - Buckeye XC-R VII Truck
- Standard Car Truck Co. & Resco Engineering
  - Barber-Resco Stabilizer Frame Truck

Truck Selection

- NUCARS Modeling
  - Pitch and Bounce (L)
  - Twist and Roll (L)
  - Curve Entry/Exit (L)
  - HTL/FAST measured Track Geometry
  - Dynamic Curving (L)
  - Yaw and Sway (L)
  - Hunting (E)
- Select test trucks based on modeling
- Mini-Test on HTL and selected Chapter XI test sections
- Chapter XI test of candidate truck

Pitch & Bounce Test





HAL ALTERNATIVE SUSPENSION SYSTEMS

Proposed Delivery Dates

- ASF - American Steel Foundries
  Prototype 100-Ton to 125-Ton Trucks are Fabricated
- A. Stucki Company
  Existing Design
- Buckeye Steel Casting Company
  Experimental Version in October, 1992
- Standard Car Truck Co. & Resco Engineering
  Existing Design

Initial Train Operations

- New Truck Syndrome

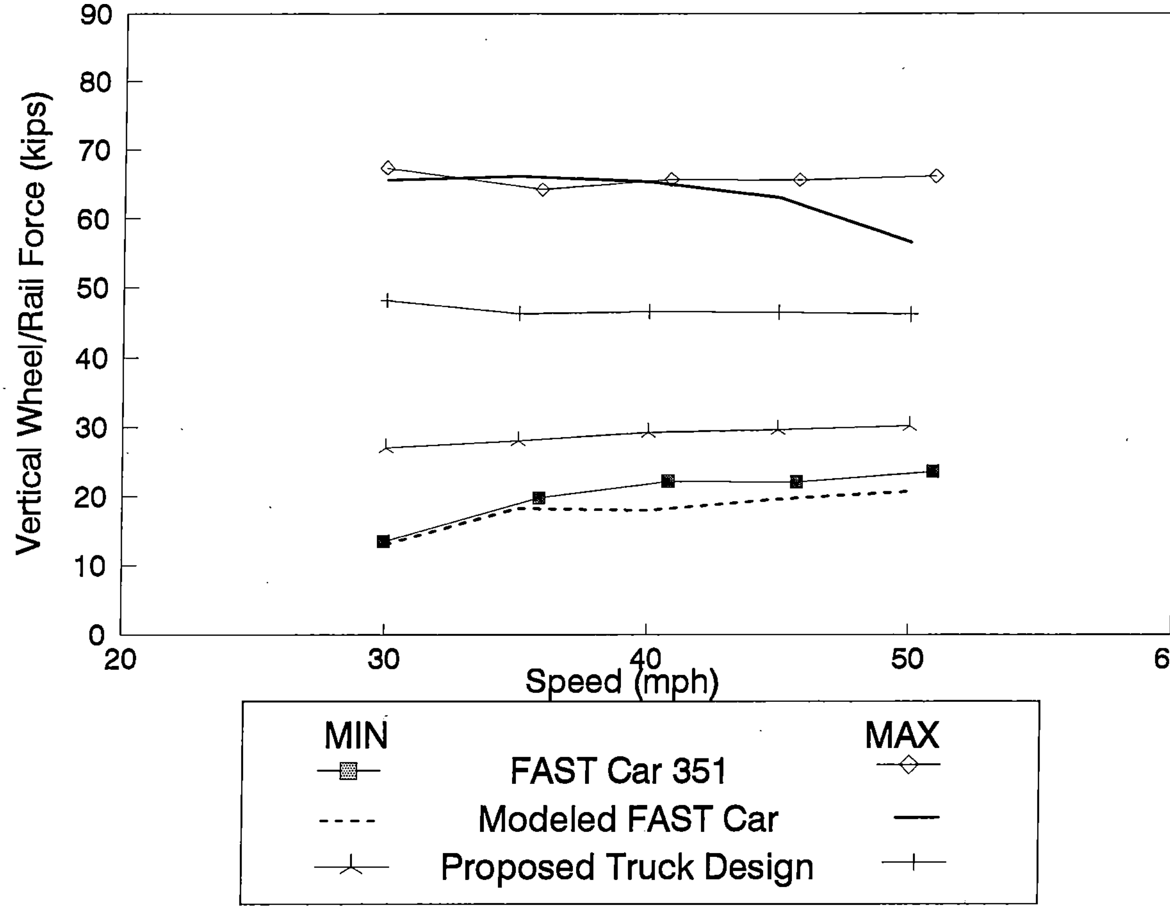
  New trucks require an initial break-in period to mate friction surfaces

  New trucks could exhibit poor performance until after break-in period

Comparison

- New Suspension vs Older Supension
- Existing Car Bodies Utilized

Twist & Roll Test



FAST HAL

NEW CAR AND TRUCK PERFORMANCE EXPERIMENT

By Robert L. Florom
Experiment Manager

TRANSPORTATION TEST CENTER
PUEBLO, COLORADO

EXPERIMENT OBJECTIVES

- Quantify the performance characteristics of generic HAL vehicles and truck configurations selected using NUCARS through tests on the HTL

EXPERIMENT OVERVIEW

- Test zone locations
  - Section 25 (6 Degree Curve)
  - Section 29 (Low Track Modulus Test Zone)
  - Section 33 (Low Track Modulus Test Control Zone)
  - Section 33 (Concrete Cross Ties)

MEASUREMENTS

- Wheel/Rail Angle of Attack
- Vertical and Lateral Wheel/Rail Force
- Rail/Cross Tie Vertical Force
- Tie/Ballast Pressure
- Ballast/Subgrade Pressure

EXPERIMENT STATUS

- Load path data has been collected on 39-ton axle load cars equipped with the following truck types:
    - National C-1 Wedgelock
    - Barber S-2
    - ASF Ride Control with D-7 Springs

Part 3

Future FAST/HAL Investigations

1995 and Beyond

...by Albert J. Reinschmidt
Chief, Research Engineering
Chicago Technical Center

FAST FUTURE

- **BACKGROUND**
  - Existing car suspensions unchanged from 100-ton designs
- **LONG TERM GOAL**
  - Reduce dynamic loads into the track structure
  - Equip HAL train with new trucks, repeat selected tests
  - Quantify the benefits in terms of reduced track damage using HAL vehicles with advanced suspensions
  - Compare to current FAST data base

- **SHORT TERM GOAL**
  - Bench mark performance of other HAL type vehicles - 286,000 lb. and double stacks
  - Select best alternative design(s)
  - Evaluate alternative suspension designs
  - Conduct full scale evaluation on TTC tracks

HEAVY AXLE LOAD TEST PROGRAM

Alternative Suspension System Timeline

1991	- Base Car Test
April 1992	- Complete Modeling of Base Car
*June 1992	- Receive Suspension Information on Advanced Trucks; Begin Nucars Modeling
January 1992	- Begin Testing in Existing Consist at FAST
March 1993	- Begin Mini Tests of Advanced Trucks
March 1993	- Complete Nucars Modeling of Advanced Trucks
Sept 1993	- Complete Testing in Existing HAL Consist
March 1994	- Complete Mini Tests and Select Advanced Trucks
Oct 1994	- Delivery of Trucks to TTC; Begin Train Retrofit
March 1995	- Begin Train Operation for Phase III

Part 4

Summation

Phase II -- 100 MGT Extension

...by Richard P. Reiff

SUMMARY OF RESULTS
100-MGT EXTENSION

The preceding presentations have offered a number of suggestions for improved components and maintenance techniques necessary when a large percentage of HAL traffic is to be operated. Results of the first 160 MGT experiment gave us an indication as to where the track structure must be improved. The supply industry was quick to respond with a host of higher quality products. What we have seen today is an example of how research results conducted in the controlled environment of FAST can be used to improve the materials used in tracks.

To summarize these findings, and act as a catalyst for the discussion session to follow, a quick review of some of these findings is offered.

Rail strength continues to be an important issue. Data indicates that rail 300 Bhn or higher is necessary to reduce metal flow and corrugations on tangent track. In special trackwork, such as turnouts and crossing frogs, a 340 Bhn or higher strength rail is mandatory, otherwise the result will be a severe and rapid degradation of the running surface. Curve track also shows a need for rail of 340 Bhn or higher to resist wear and metal flow.

Turnouts continue to be a high maintenance area. The spring frog installation indicated a very high maintenance demand when compared to that of traditional railbound manganese frogs. The advanced design turnout did reduce loads into the track structure; however, the use of rail with insufficient hardness resulted in higher than desirable maintenance efforts.

Use of premium thermite field welds, instead of standard materials, which suffered a significant increase in failure rate during the initial phase of HAL, indicated lower failure rates. Field weld failures are still an issue as they continue to show relatively short lives. There are, however, some techniques and materials that appear to extend life, even though training and quality control of field techniques continue to be a critical issue.

In the area of conventional wood ties and fasteners, the cut spike continues to show more degradation than direct fixation/elastic fasteners. Also under the FAST environment the difference between conventional hardwood and softwood ties is very small.

Finally, track support conditions show a dramatic effect on maintenance demand. The FAST loop is constructed on a very stiff subgrade and has shown little increase in demand for surfacing with the introduction of HAL traffic. In the area where the support condition was made intentionally, soft maintenance demand skyrocketed, indicating possible concern where HAL traffic is contemplated over areas of marginal track support.

FAST/HAL PROGRAM SUMMARY
PHASE II

Rail Strength continues to be an important issue

- 340/360 minimum for special track work
- 300 or higher for tangent
- 340/360 minimum for curves

Rail/Wheel profile match critical to rail fatigue performance

FAST/HAL PROGRAM SUMMARY
PHASE II

Turnout components continue to be high maintenance items

- Spring Frog maintenance high compared to conventional RBM frogs
- Advanced design components show promise, but:
  - require uniformity of material quality
  - high degree of QC in design, fabrication, fit and installation
  - premium materials required even with advanced design and lower forces

Premium Field Weld materials can lower failure rates; but thermite welds still a weak link in the track structure

- There are some techniques and materials that appear to show promise
- Personnel training, field techniques critical

FAST/HAL PROGRAM SUMMARY
PHASE II

Lower strength track support results in significant increase in maintenance, degradation

- Surfacing
- Dynamic loads

Wood Ties/Fastening systems

- DF/Elastic fasteners continue to show less degradation than conventional cut spikes
- Little difference in strength between softwood/hardwood after 260 MGT, but gage degradation shows wood influence

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Welcome to the FAST/HAL Open House Workshop: Phase II, 1992
Transportation Test Center

FAST Facility for Accelerated Service Testing
HAL Heavy Axle Load