Association of American Railroads
Research and Test Department

Field Evaluation of New and Remedial Alternative Tie Treatments - A Progress Report

(450 tags for PI @ Cordele)

Includes Jesup & Cordele

PIII MP389H PI MP67.0 US41 South - new ties 67.6

Report No. R-813 PII MP59.6 - In-track rods & sprays PII @ Cordele 400 ties

6/92

GS+Fling US41 North

D. D. Davis
K. J. Laine

Summary P.104

PIII In-track w/rail gang - pads, rods, sprays @ Jesup 1545 ties total

June, 1992

Phase I 450 ties interspersed w/non test ties ⇒ every test tie has a tag (page 29) MP67.0-67.6

Phase II 400 consecutive ties w/every tenth tagged (page 48) MP 59.6 100 ties/test section

Phase III 1545 ties consecutive w/every 10th tie (page 59) numbered & two sections w < 250 ties
MP 389.0H south east toward Brunswick

AAR Technical Center
Chicago, Illinois

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Presentation on Boultonizing partially dried crossties to relieve inventory control problems

TUE 11/6 30 minutes RTA San Antonio

1. **REPORT NO.** R-813	2. **REPORT DATE** June, 1992
3. **PERIOD COVERED** 1987 - 1990	

4. **TITLE AND SUBTITLE**
Field Evaluation of New and Remedial Alternative Tie Treatments - A Progress Report

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6. **PERFORMING ORGANIZATION NAME AND ADDRESS** Association of American Railroads Technical Center 3140 South Federal Street Chicago, Illinois 60616	7. **TYPE OF REPORT** Research 8. **CONTRACT OR GRANT NO.**
9. **SPONSORING AGENCY NAME AND ADDRESS** Association of American Railroads Technical Center 3140 South Federal Street Chicago, Illinois 60616	10. **NO. OF PAGES** 108 11. **NO. OF REFERENCES** 6

12. **SUPPLEMENTARY NOTES**

13. **ABSTRACT**

This is the first of a series of progress reports on field trials of alternative tie treatments. The test is designed to evaluate the potential of non-creosote crosstie treatments. The test consists of three phases: a new tie treatment, a remedial (in-place) tie treatment and an in-place treatment in conjunction with a rail relay operation.

Test sites were established at locations with a variety of climate and operating conditions. The performance of the ties and the treatment concentrations are monitored over time. This report contains the initial results.

14. **SUBJECT TERMS** Alternative Tie Treatments Borates In-Place Treatments Copper Naphthenate Sodium Fluoride	15. **AVAILABILITY STATEMENT** Document Distribution Center Association of American Railroads Technical Center 3140 South Federal Street Chicago, Illinois 60616

EXECUTIVE SUMMARY

The Alternative Tie Treatments project is a cooperative effort of railroads, suppliers and academicians to address several key crosstie performance issues. The program is designed to evaluate the efficacy of several products as alternatives to traditional creosote pressure treatments of green crossties. Many of these products may also be used as supplements to the typical creosote pressure treatment; providing additional protection at any time during the life of a tie.

None of the alternative treatments require pressure treatment or extensive equipment. Several of the treatments are specifically designed for treating ties already in track. The test is divided into three phases:

Phase I - Green Tie Treatments Cordele I South MP67.0-67.

Phase II - In-Track Treatments Cordele II North MP 59.0-59.

Phase III - In-Track Rail Seat Area Treatments Jesup

The potential economic benefits of in-track treatments are much greater than green tie treatments, due to the shorter period before receiving the benefit of extended tie life. This makes remedial, in-place treatments quite attractive. The Phase III approach is of relative low cost; only a small amount of additional labor is required to apply the product. Removal of the rail and tie plate is done by the rail gang.

The products under test have been proven to control wood decay in laboratory situations. The purpose of this test is to evaluate the products under field conditions.

Interested companies supplied the products under test and applied them in side by side test sections. At least two sites were built for each test phase to cover a wide range of climate and operating conditions.

Measurements taken for each test section in-track include: track performance, tie performance and treatment concentration levels.

The performance measurements are meant to provide a measure of the current condition of the track structure, as well as a tool to determine deterioration rate of the track properties which are being measured.

The majority of the sites involved in this study have only received one round of performance measurements. However, two of the sites, Somerville, Texas (Phase II) and Cordele, Georgia (Phase II) have had two measurement cycles at this time. An examination of the data collected from these two sites does show some deterioration of the track performance properties (the tie plate cutting and loose spike counts have increased as would be expected). It is too early at this time and with this limited amount of data to speculate on the differences between the various treatment groups and the control ties.

The data from the treatment analyses provide an early insight into the likely performance of alternative treatments. While the data on in-place treatments is too scant to draw firm conclusions, some conclusions about green tie dip treatment methods can be made.

These conclusions include:

- Bulk stack storage of ties for six weeks after treatment significantly increases borate retention.
- Artificial seasoning of tie (by vapor drying) reduces borate concentrations.
- Creosote pressure treatment and borate dip treatment are compatible. Creosote pressure treatment had virtually no effect on borate concentration levels in air seasoned ties. Analysis of borate levels in ties immediately before and after creosote pressure treatment showed no significant differences.

- Treatment concentration levels are still highest near the surface of the tie. Material is present at one inch depths. Along the long axis of the tie, treatment concentrations follow moisture content values: higher in the center and lower near the ends.

- The effect of species on treatment concentrations is minimal. The effects of moisture content and surface condition at the time of treatment are considered to be more important than species.

After one field inspection of each site, the following observations were made:

- Phase I tie treatment concentration levels found after one year in track indicate a loss of treatment in the top inch of tie. Whether the majority of this is from inward migration (deeper into the tie) or outward migration (out of the tie) is unknown.

- Phase II borate treatment levels (rods and sprays) are well below the treatment levels in Phase I ties. The treatment levels of all products are quite variable; due to the various tie conditions encountered.

- Phase III borate treatment levels are higher than Phase II levels, but lower than Phase I levels. Access to the adzed plate area wood probably accounts for the higher treatment levels.

- The effectiveness and long term viability of the treatments under study cannot be determined from one or two years in track. All sites will be monitored for at least five years.

- The tie plate area offers the best environment for water diffusible treatments. The moisture content in the plate area is generally higher near the tie surface than elsewhere on the tie. This will aid absorption of surface applied treatments.

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ACKNOWLEDGEMENTS

This is a cooperative research effort of railroads, suppliers, and academicians. Participants include: AAR; The Railway Tie Association (RTA); Mississippi State University (MSU); The Atchison, Topeka, and Santa Fe Railway (AT&SF); Norfolk Southern Railway (NS); Mooney Chemical Company; Osmose and Pandrol, Inc.

The RTA/AAR Wood Tie Research Committee has provided valuable guidance; from formulation through execution of this test. The members of this group include:

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Mr. V. M. Shafarenko, Manager Research/Marketing, Gross & Janes Co.

Mr. R. R. Wingard, Executive Vice President, RTA

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Mr. T. B. Hutcheson, Consultant, AAR

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Mr. J. Waits, Track Supervisor, AT&SF

Mr. P. W. Cook, Track Supervisor, NS

and numerous other division engineers, track supervisors, and track maintenance personnel on NS and AT&SF.

The following individuals were essential in collecting and analyzing the test data:

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Mr. G. Barzydlo, Test Technician, AAR

Mr. F. Niekamp, Test Technician, AAR

Mr. S. Snyder, Chemist, AT&SF

Mr. G. Bowen, Manager, Chemical Lab., AT&SF

Mr. N. Marsh, Director, Technical Research Development, AT&SF

This project was conducted by the Track Engineering section of the Track Research Division of AAR Chicago Technical Center. Dr. A. J. Reinschmidt is the Chief Research Engineer - Civil, Mr. John Choros is the Manager of Track Engineering.

1.0 INTRODUCTION

The Alternative Tie Treatment test is designed to evaluate tie life prolongation through the application of non-creosote crosstie treatments. The program is divided into three phases. Phase I addresses the borate treatment of green ties prior to air seasoning. Phase II addresses an in-place application of the products to the crossties as a remedial measure of treatment. Phase III addresses an in-place application of treatments applied to the adzed area of the crossties in conjunction with a rail relay program.

The test duration is planned for five years. Intermittent measurements and sampling are scheduled throughout this time frame. Physical measurements to assess the condition of the crossties include; unloaded gage and crosslevel, spike integrity (loose spikes), plate cutting, moisture content, and lateral track strength. Decay and treatment retention core samples are being used to assess the biological aspects of the crossties. Test locations were chosen to portray a good cross-sectional representation of environmental factors as seen on North American railroads.

1.1 Phase I Borate Treatment of Crossties

The first phase of the tie treatment program deals with the treatment of crossties prior to their installation into track. The ties used for this portion of the program consist of red oak, white oak, and gum ties (mixed hardwoods). The treatment being evaluated involves the use of water diffusable borates. It is hypothesized that treating unseasoned ties with borates can protect them from insects and decay fungi during air-seasoning, which will invariably result in a higher quality yield of ties which are installed into track. Once in-line, the ties will continue their preventative protection with an emphasis on the decay susceptible areas of the tie (checks, splits, etc.) due to the water diffusible properties of the solution.

Borate-treatment alone is not necessarily a substitute for creosote, so much as an enhancement. A subsequent application of creosote or a similar laminating type treatment could act as a barrier, preventing the borates from leaching out of the tie over time. A lower concentration of creosote is speculated to be necessary to treat ties which have been pre-treated with a borate solution as an additional benefit of the pre-treatment process. Such a combination of treatments would also be a preventative deterrent of soft-rot fungi which cannot be controlled by borates alone. Another supplemental advantage of using borates may be in their ability to resist corrosion in iron fasteners and thus reduce the number of spike killed ties due to iron degradation reactions.

Test Procedure

Four hundred and fifty (450) ties from each of the three species (red oak, white oak, and gum) were brought to the tie treatment plant in Somerville, Texas. The ties were tagged and separated into various groups with respect to the type of treatment procedure to be used. Ties were either tagged to be treated with the borates or they were tagged to be used as control ties to allow for direct comparisons at a later date.

The borate treatment procedure consisted of a 3 minute dip of the ties in a 30% solution of TimBor (100% Anhydrous Disodium Octaborate) heated to a temperature of 130 degrees fahrenheit (Exhibit 1). Following the dip treatment, the ties were either stacked in the normal air drying configuration, or they were bulk stacked and covered with a polyethylene tarp for six weeks for diffusion storage (Exhibits 2 & 3). After six weeks the bulk stacked ties were re-stacked in the normal air dry configuration for the remainder of the seasoning period.

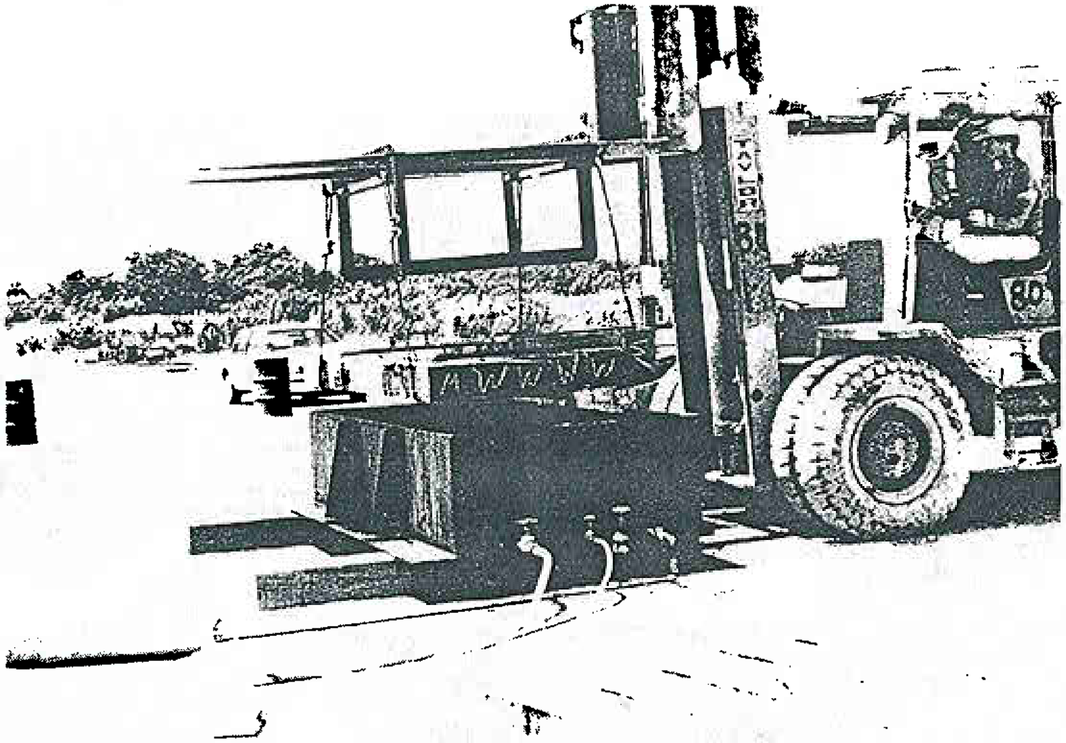


Exhibit 1. Borate Dip Process.

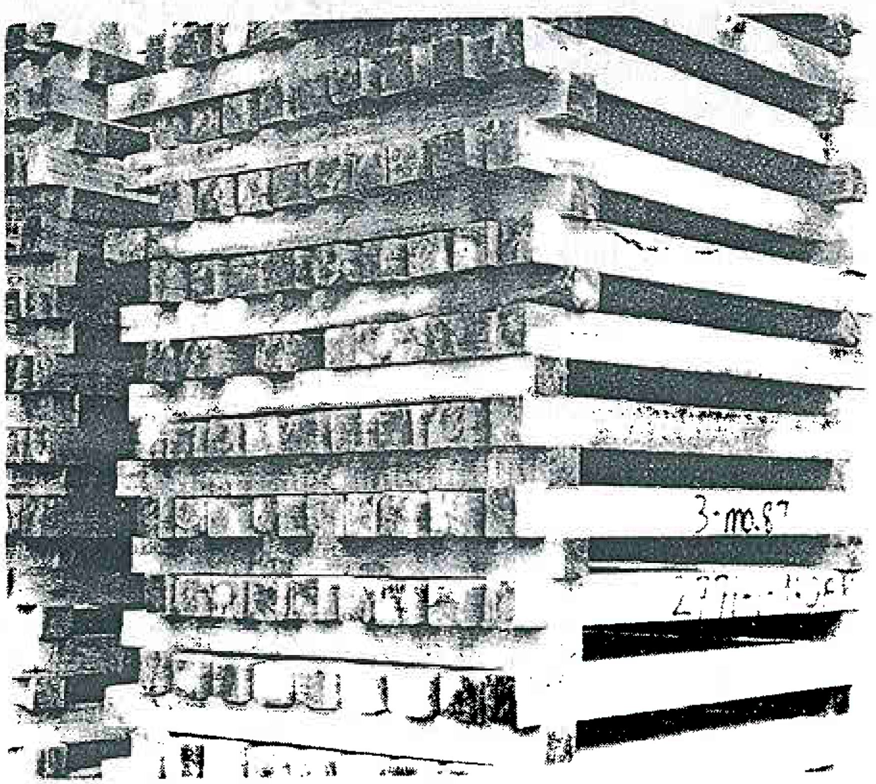


Exhibit 2. Air Dry Stack Configuration.

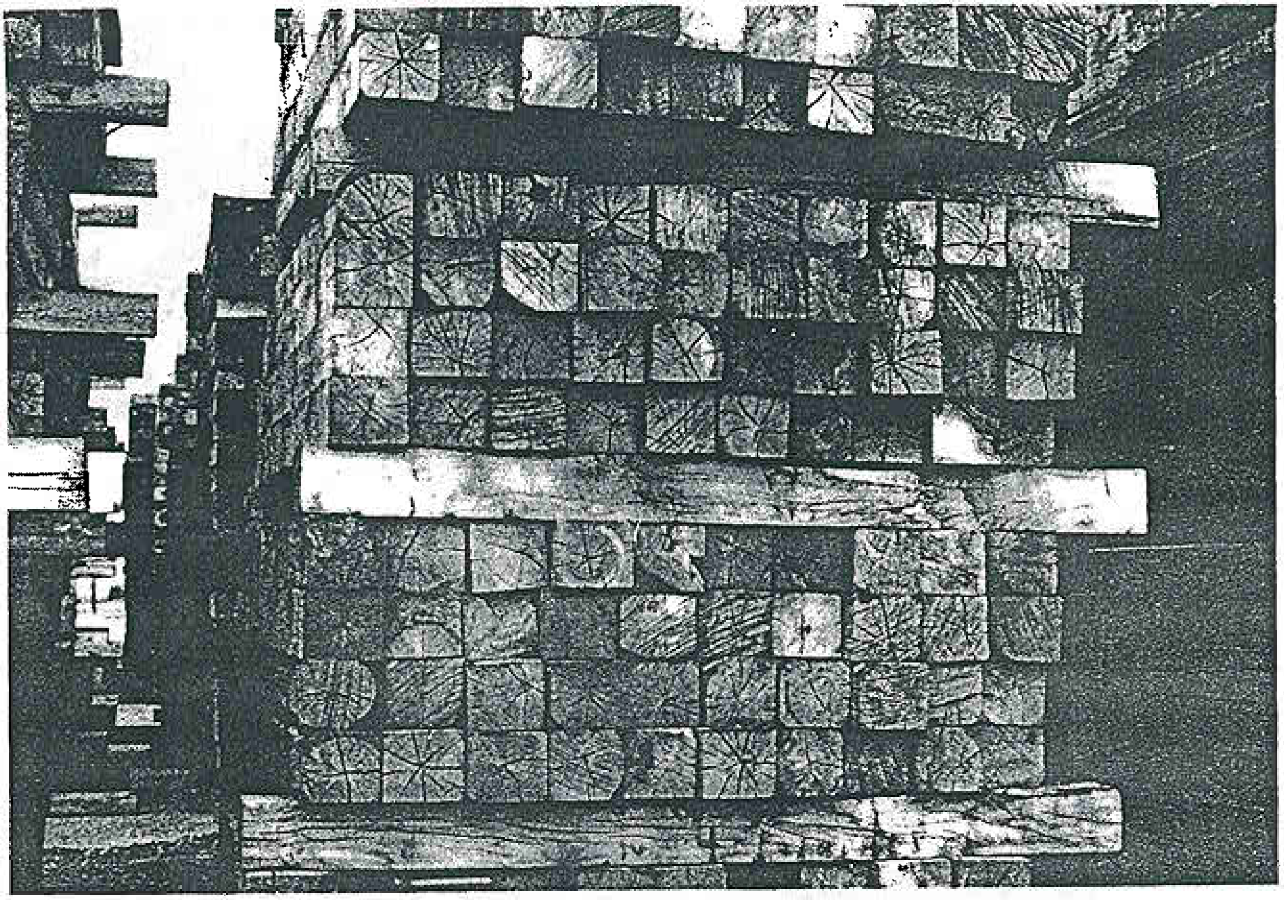


Exhibit 3. Bulk Stack Configuration.

The control ties were also separated into two groups. The first group was stacked into the normal air dry configuration for seasoning. The second group underwent vapor drying and then was immediately treated with creosote as per normal procedure for vapor dried ties. These ties were then bulk stacked in the yard for the duration of the air seasoning cycle.

Approximately 10 1/2 months later, the air dried ties were ready for creosote treatment. Most of the ties received the normal creosote treatment at this time. Two groups of 50 ties (red oak and white oak), which had been previously treated with the borates, received only a dip treatment of creosote. These groups will test the hypothesis that a relatively lower concentration of creosote may be sufficiently adequate when used in conjunction with the borate treatment.

An additional group of 30 ties (10 from each species), was being used to examine the feasibility of vapor drying ties which had previously been treated with the borate dip process. These ties were borate dipped at the onset of the study along with the other specimens. All 30 of these ties were bulk stacked and covered for diffusion for a six week period. The ties were then vapor dried and creosote treated. Borate penetration and retention samples, taken before and after the vapor drying procedure, will be used to conclude whether or not borate treated ties can be vapor dried.

Exhibit 4 summarizes the spectrum of treatment groups and their corresponding number schemes as used throughout the study.

1.1.1 Supplemental Mini-Test

Prior to treating the ties with creosote, concern was expressed with regard to the test ties having an excessive amount of checking (Exhibits 5 & 6). The primary concern at this time was that the borates may have contributed to the checking behavior. It was hypothesized that the checking may have been due to the hot, dry, windy weather that prevailed in Somerville during the seasoning period. Several participants in the study met in Somerville to assess the situation and to decide whether or not a problem actually did exist. The test party, after examining the ties in question, deemed it necessary to test out the proposed hypothesis. A test plan was submitted to, and accepted by, the committee.

SPECIES	TAG DESIGNATION	BORATE TREATMENT	CREOSOTE TREATMENT	STACK CONFIGURATION	DRYING PROCEDURE
RED OAK	RCV 1-100	NONE	AT&SF CREOSOTE TREATMENT	N/A	VAPOR DRY
RED OAK	RCA 101-200	NONE	AT&SF CREOSOTE TREATMENT	AIR DRY CONFIGURATION	AIR DRY
RED OAK	RBA 201-300	BORATE DIP TREATMENT	AT&SF CREOSOTE TREATMENT	AIR DRY CONFIGURATION	AIR DRY
RED OAK	RBB 301-400	BORATE DIP TREATMENT	AT&SF CREOSOTE TREATMENT	BULK STACK (6 WEEKS) PRIOR TO AIR DRY CONFIGURATION	AIR DRY
RED OAK	RBC 401-450	BORATE DIP TREATMENT	AT&SF CREOSOTE TREATMENT	BULK STACK (6 WEEKS) PRIOR TO AIR DRY CONFIGURATION	AIR DRY
WHITE OAK	WCV 451-550	NONE	AT&SF CREOSOTE TREATMENT	N/A	VAPOR DRY
WHITE OAK	WCA 551-650	NONE	AT&SF CREOSOTE TREATMENT	AIR DRY CONFIGURATION	AIR DRY
WHITE OAK	WBA 651-750	BORATE DIP TREATMENT	AT&SF CREOSOTE TREATMENT	AIR DRY CONFIGURATION	AIR DRY

Exhibit 4. Phase I Treatment Groups.

SPECIES	TAG DESIGNATION	BORATE TREATMENT	CREOSOTE TREATMENT	STACK CONFIGURATION	DRYING PROCEDURE
RED OAK	RCV 1-100	NONE	AT&SF CREOSOTE TREATMENT	N/A	VAPOR DRY
WHITE OAK	WBB 751-850	BORATE DIP TREATMENT	AT&SF CREOSOTE TREATMENT	BULK STACK (6 WEEKS) PRIOR TOP AIR DRY CONFIGURATION	AIR DRY
WHITE OAK	WBC 851-900	BORATE DIP TREATMENT	AT&SF CREOSOTE DIP TREATMENT	BULK STACK (6 WEEKS) PRIOR TO AIR DRY CONFIGURATION	AIR DRY
WHITE OAK	WBC 901-1000	NONE	NORFOLK SOUTHERN CREOSOTE TREATMENT	AIR DRY CONFIGURATION	AIR DRY
GUM (MIXED HARDWOODS)	GBS 1001-1050	BORATE DIP TREATMENT	AT&SF CREOSOTE TREATMENT	BULK STACK (6 WEEKS) PRIOR TO AIR DRY CONFIGURATION	AIR DRY
GUM (MIXED HARDWOODS)	GBN 10-51-1250	BORATE DIP TREATMENT	NORFOLK SOUTHERN CREOSOTE TREATMENT	BULK STACK (6 WEEKS) PRIOR TO AIR DRY CONFIGURATION	AIR DRY
GUM (MIXED HARDWOODS)	GBC 1251-1301	BORATE DIP TREATMENT	NORFOLK SOUTHERN CREOSOTE DIP TREATMENT	BULK STACK (6 WEEKS) PRIOR TO AIR DRY CONFIGURATION	AIR DRY

Exhibit 4. Phase I Treatment Groups.

SPECIES	TAG DESIGNATION	BORATE TREATMENT	CREOSOTE TREATMENT	STACK CONFIGURATION	DRYING PROCEDURE
RED OAK	RCV 1-100	NONE	AT&SF CREOSOTE TREATMENT	N/A	VAPOR DRY
GUM (MIXED HARDWOODS)	GB 1301-1350	BORATE DIP TREATMENT	NONE	BULK STACK (6 WEEKS) PRIOR TO AIR DRY CONFIGURATION	AIR DRY
RED OAK	RBV 1351-1360	BORATE DIP TREATMENT	AT&SF CREOSOTE TREATMENT	BULK STACK (6 WEEKS)	VAPOR DRY
WHITE OAK	WBV 1361-1370	BORATE DIP TREATMENT	AT&SF CREOSOTE TREATMENT	BULK STACK (6 WEEKS)	VAPOR DRY
GUM (MIXED HARDWOOD)	GBV 1371-1380	BORATE DIP TREATMENT	AT&SF CREOSOTE TREATMENT	BULK STACK (6 WEEKS)	VAPOR DRY

Exhibit 4. Phase I Treatment Groups.

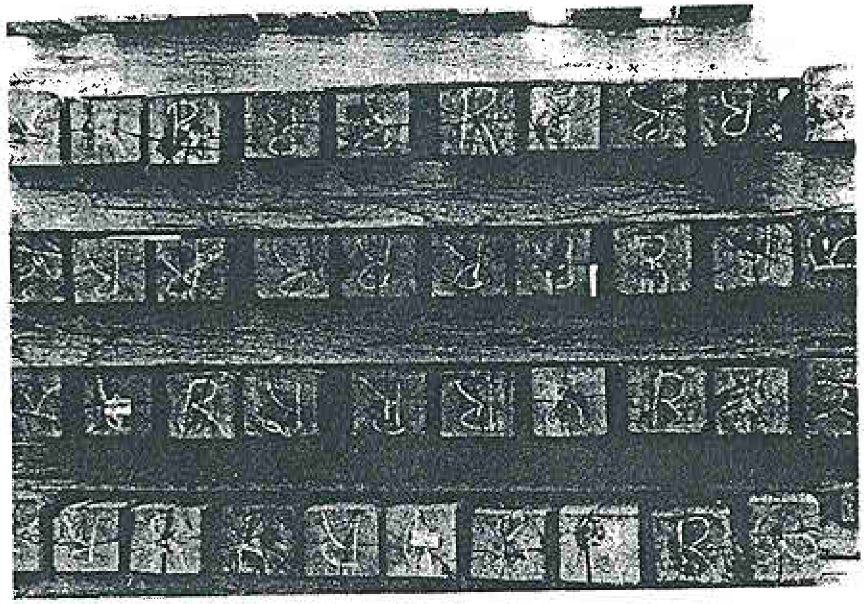


Exhibit 5. Crosstie Checking In Somerville.

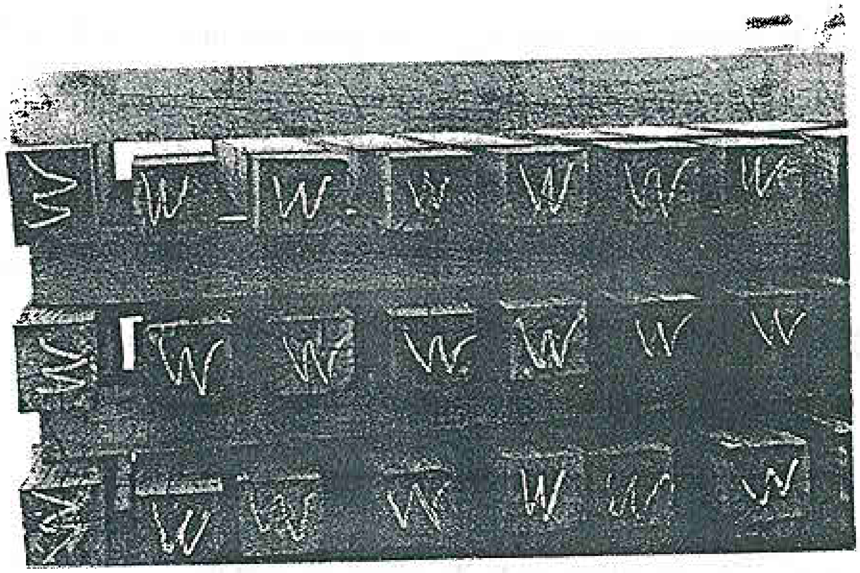


Exhibit 6. Crosstie Checking In Somerville.

In the mini-test an additional 20 green ties from the white oak species, & 20 from the red oak species were treated with borates and then bulk stacked and covered for diffusion. After 6 weeks of storage, the cover was removed and the bulk stacked ties were stacked in the normal air dry configuration. Another 20 ties from each species were borate treated and then immediately stacked for air drying. For control purpose, 20 ties from each species were stacked in air dry configuration without being treated with borates. It must be pointed out that the only difference between the test ties used in the mini-test and those previously used was that the previously used ties were incised and the mini-test ties were not. See Exhibit 7 for schematic.

The test ties were treated with borates in March, 1988. AAR personnel were present to assist in the study. A second examination of the original ties in question was undertaken with respect to the remaining air seasoned ties in the Somerville yard. The degree of checking prevalent in the test ties was also consistent throughout the majority of the yard ties, and therefore, AAR concluded at this time that there did not appear to be anything atypical about the test ties.

The borate retention cores, taken after the seasoning period, showed considerable support for this conclusion. The percent boric acid equivalent (BAE) for the first 1/2 inch of the cores was similar between the original test ties and the mini-test ties. However, the second half inch of the cores did have some variation. Therefore, it is concluded that there is no evidence that excessive seasoning checks are attributable to borate treatment.

SPECIES	TAG DESIGNATION	BORATE TREATMENT	CREOSOTE TREATMENT	STACK CONFIGURATION	DRYING PROCEDURE
WHITE OAK	WB (20 TIES)	BORATE DIP TREATMENT	N/A	BULK STACK (6 WEEKS) PRIOR TO AIR DRYING	AIR DRY
RED OAK	RB (20 TIES)	BORATE DIP TREATMENT	N/A	BULK STACK (6 WEEKS) PRIOR TO AIR DRYING	AIR DRY
WHITE OAK	WA (20 TIES)	BORATE DIP TREATMENT	N/A	AIR DRY CONFIGURATION	AIR DRY
RED OAK	RA (20 TIES)	BORATE DIP TREATMENT	N/A	AIR DRY CONFIGURATION	AIR DRY
WHITE OAK	WU (20 TIES)	NONE	N/A	AIR DRY CONFIGURATION	AIR DRY
RED OAK	RE (20 TIES)	NONE	N/A	AIR DRY CONFIGURATION	AIR DRY

Exhibit 7. Phase I Mini-Test Treatment Groups.

1.2 PHASE II - In-Place Remedial Treatment of Crossties

The primary goal of Phase II is to investigate the effectiveness of in-place, remedial treatment of wood ties. It is believed that the productive lives of these ties may be substantially increased by a topical application of treatment to the ties while in track. The advantages of such a treatment lie in the utility of being able to treat ties which are currently being used, therefore postponing the necessity of replacing existing ties with new ties which have been 'pre-treated', and also in having a method of treatment which may be accomplished in an economically efficient manner. A secondary advantage of this treatment is that it presents a viable and beneficial alternative to the disposal of the treatment solutions which may be used for treating green ties. The economic implications of prolonging current tie life, even a few years, are quite significant.[1]

The actual application of the products may be accomplished in a variety of manners. The simplest and most economical method would be to flood or spray the exposed surfaces of the tie with an aqueous solution of the treatment (Exhibit 8). This may be done from a moving vehicle or, as in the case of our study, the treatment may be applied by hand utilizing a spray container or simply pouring the solution directly onto the tie. This type of an application has several distinct advantages. Due to the relative ease of this application, it is not necessary to acquire track time, nor is it necessary to disturb the track in any manner. The amount of manpower necessary to accomplish the task should be minimal. The other type of application which was utilized for this study was to insert rods or solidified quantities of the preservatives in pre-drilled holes adjacent to the tie plate area (Exhibit 9). Although this methodology is a bit more complex, as it does include the drilling of holes in the tie prior to installation, no track disturbance or significant track time should be necessary.

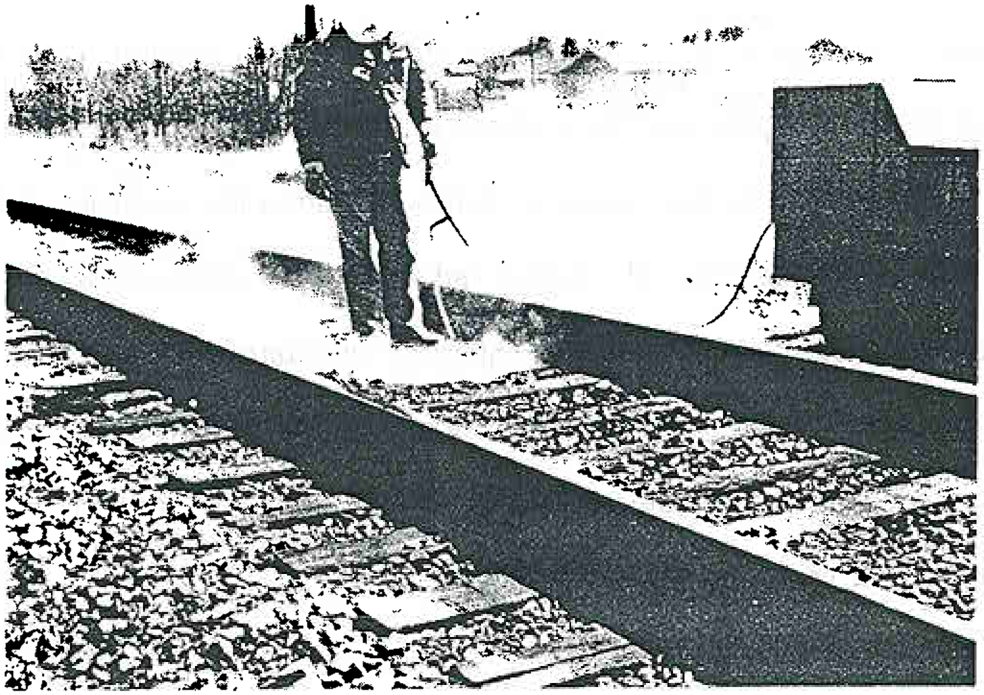


Exhibit 8. Phase II Spray Application.

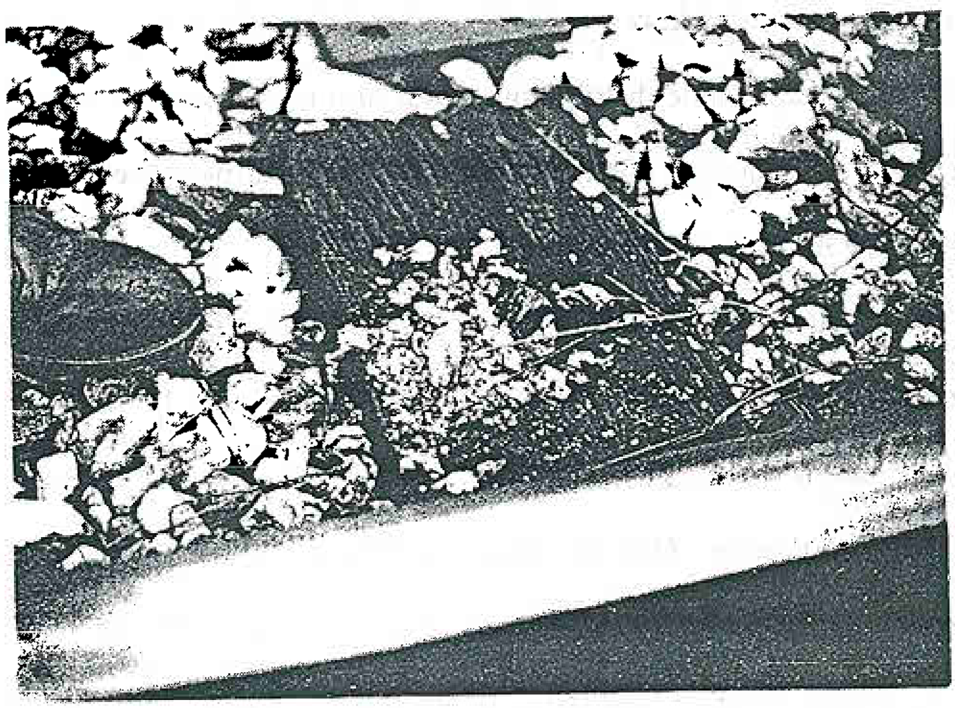


Exhibit 9. Phase II Rod Insertion Method.

Once applied, the treatments will work their way into the ties through the checks, splits, spike holes, or simply soak into the structure of the ties. Theoretically, the water diffusible substances (i.e. borates) will migrate into the tie, primarily to the areas which contain checks and splits, and those which have been worn down excessively (i.e. the tie plate area). Once in the tie, the preservatives will aid in the protection of the tie, thus leading to an extended life. The degree and longevity of effectiveness of all substances applied will be identified in a direct comparison with untreated ties.

Sections of track on the participating railroads were chosen for Phase II. It was recommended that a minimum of 100 ties per section be used for each preservative treatment. For comparison purposes, it was decided that the best assessment of the ties could be made if only one half of each tie was treated. The inherent variability of individual ties existing in track would make comparisons of two groups of ties (treated and untreated) very difficult. Therefore, the test was designed to use one half of the tie (treated) to be evaluated in respect to the other half of the tie (untreated). In order to achieve a representative tie distribution, it was also recommended that the ties be arranged in a continuum to minimize any track dissimilarities which may occur throughout the entire test section.

The initial condition of the ties was documented at the time of treatment. This documentation included at least five core samples from every 100 tie section. Laboratory tests to quantify the degree of decay initially present, as well as visual observations, were made. One year after the initiation of the study, the first inspection of the ties was undertaken. An increment core was removed from an area within one inch of the largest check or split in the upper surface of 20 ties in each test section. The cores will be examined visually for the presence of decay. Quantitative analysis of treatment concentrations will be made at several depths from the top of the crossties. The next inspection will take place two years later and will follow the same general scheme as the first inspection, except that the cores will also be cultured on Benlate-agar to determine if viable decay fungi are present. The degree of spike loosening and the moisture content of the ties will be monitored at installation of the treatments and also during this third year inspection. These may prove to be indicators of decay and may assist in the selection of ties to be cored and analyzed.

PROPOSED PHASE II PROGRAM SCHEDULE

BORE TIES (to obtain initial conditions)	APRIL-SEPTEMBER 1988
INSTALLATION OF TREATMENTS	APRIL-SEPTEMBER 1988
INITIAL CONDITIONS MEASUREMENTS (spike stiffness & moisture content)	APRIL-SEPTEMBER 1988
INSPECTION	APRIL-SEPTEMBER 1989
BORE TIES	APRIL-SEPTEMBER 1989
LABORATORY INSPECTION OF CORES	OCTOBER-DECEMBER 1989
PROGRESS REPORT	JANUARY-MARCH 1990
INSPECTION	APRIL-SEPTEMBER 1991
BORE TIES	APRIL-SEPTEMBER 1991
CONDITIONS MEASUREMENTS	APRIL-SEPTEMBER 1991
LABORATORY INSPECTION OF CORES (including culture)	OCTOBER-DECEMBER 1991
EVALUATION OF CONTINUATION	JANUARY 1992

PARTICIPATING TREATMENTS - PHASE II

1. Mississippi State University - sprayed a heated, 30% spent borate solution (timbor) left over from the Phase I borate dip treatment process. The coverage rate for the application was approximately nine square feet per gallon.
2. Mooney Chemicals Inc. - sprayed M-Gard W540, a copper naphthenate/water emulsion solution. The cover rate for the application was approximately 25 square feet per gallon.
3. Mooney Chemicals Inc. - sprayed M-Gard S540 HF, a copper naphthenate /high flash hydrocarbon solvent (oil base). The coverage rate for the application was approximately 18 square feet per gallon.
4. Pandrol - inserted two fused borate (timbor) rods into pre-drilled holes adjacent to each tie plate. The holes were then plugged with a plastic cap.

1.3 Phase III - Adzed Tie Treatment of Crossties

The third phase of the Alternative Tie Treatment program examines the treatment possibilities of the adzed area of crossties. It is hypothesized that it would be beneficial to treat the adzed area of a crosstie, especially since the adzing process may strip away the treated layers of the crosstie (in the tie plate area) down to what may be considered untreated wood. It is this wood which may invariably be susceptible to rot and/or decay in a relatively accelerated manner. The installation of such a treatment coincides with the actual adzing process, as it is being applied as part of the respective maintenance program. The treatments are applied directly behind the adzing machine and prior to the replacement of the tie plates (Exhibit 10). Other than application of the materials being in conjunction with a maintenance program, the test criteria and layout

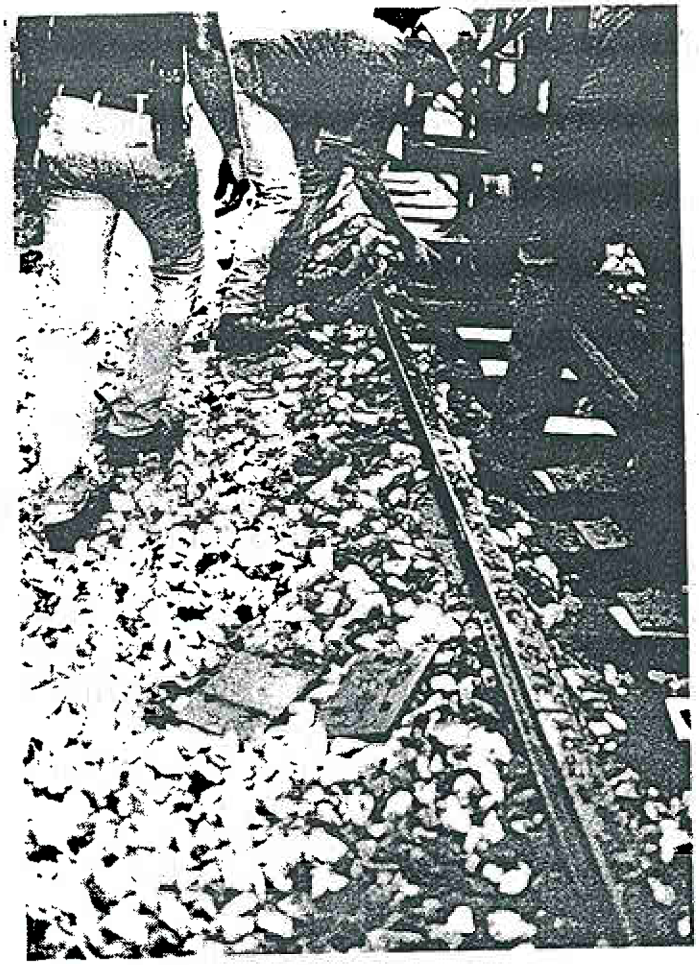


Exhibit 10. Phase III Adzed Tie Application.

basically follow the same structure as the Phase II, Remedial Treatment of Crossties, program.

The economic benefits of such an application are very favorable. The logistics of having the tie plate area exposed are taken care of when application is in conjunction with an adzing program, therefore, only necessitating minimal additional manpower for the application. A possible drawback for this type of operation may lie in the optimal timing of the treatment if it must coincide with the adzing program. Not being able to dictate the best possible time to treat the ties based on tie condition, may limit the effectiveness of the treatment.

The types of applications in this phase of the program include liquid sprays and various pads to be applied directly to the tie plate area, and solidified rods to be inserted into the unused spike holes and also adjacent to the tie plates in pre-drilled holes.

ADZED TIE TREATMENT SUMMARY

OPERATOR	TREATMENT
OSMOSE	SODIUM FLUORIDE PADS SODIUM FLUORIDE RODS
MISSISSIPPI STATE UNIVERSITY	BORATE + CUNAPSOL PADS BORATE + CUNAPSOL PADS + CORROSION INHIBITOR
MOONEY CHEMICALS	WATER BASED COPPER NAPHTHENATE SPRAY OIL BASED COPPER NAPHTHENATE SPRAY
PANDROL	BORATE RODS BORATE SPIKE HOLE RODS LIQUID GLYCOL LIQUID GLYCOL + BORATE RODS

1.4 Current Field Site Status - Phase I

1. **Cordele, Georgia:** Norfolk Southern site installed in 2/88. There were 450 ties South MP67.0-67.6 consisting of 5 treatment groups (GBN, GCN, GB, GBC, GBS) installed via the normal tie gang replacement procedure, therefore the test ties are interspersed with non-test ties. The first measurement cycle was accomplished on 9/25/89.

2. **Milano, Texas:** AT&SF site installed in 6/88. One hundred ties consisting of 10 treatment groups (RCV, RCA, RBA, RBB, RBC, WBA, WBB, WCV, WCA, WBC) were installed consecutively but somewhat intermixed. The first measurement cycle was accomplished on 5/23/89.

3. **Montgomery, Texas:** AT&SF site installed in 6/88. One hundred ties consisting of 10 treatment groups (RBA, RCA, WBA, RBC, RBB, RCV, WCA, WBB, WBC, WCV) were installed consecutively and in sequence of their respective groups. The first measurement cycle was accomplished on 5/24/89.

4. **Aikman, Kansas:** AT&SF site installed in 6/88. One hundred ties consisting of 10 treatment groups (WCV, WCA, WBC, WBB, WBA, RCV, RCA, RBC, RBB, RBA) were installed consecutively and in sequence of their respective groups. The first measurement cycle was accomplished on 6/26/90.

5. **Cajon, California:** AT&SF site installed in 10/88. 120 supplemental ties, from the Phase I mini-test, consisting of 6 treatment groups (WA, WB, WU, RA, RB,

RU) were installed consecutively but somewhat intermixed. The first measurement cycle was accomplished on 10/11/90.

6. **Toluca, Illinois:** AT&SF site installed in 6/88. There were 600 ties consisting of 13 treatment groups (GBV, RBA, RBB, RBC, RCA, RCV, RBV, WBA, WBB, WBC, WCA, WCV, WBV) installed consecutively but somewhat intermixed (groups of 10). The first measurement cycle was accomplished in 9/90.

1.5 Current Field Site Status - Phase II & III

1. **Cordele, Georgia:** Norfolk Southern Phase II site installed on 12/20/88. North Remedial treatment products have been applied to four consecutive sections, each section consisting of 100 existing ties. The four sections include; section #1 - MSU Borate Spray, section #2 - Pandrol Borate Rods, section #3 - Mooney Chemicals Water Base Cu. Naph. Spray, section #4 - Mooney Chemicals Oil Base Cu. Naph. Spray. The east half of each tie is subjected to the various treatments while the west half is left untreated as a control. The first measurement cycle was accomplished on 12/20/88 in conjunction with the installations. The second measurement cycle was accomplished on 9/26/89.

2. **Somerville, Texas:** AT&SF Phase II site was installed at various dates. There are five groups of 100 consecutive test ties. The south half of each test tie was treated with the remedial treatment products. The first group was a 1987 installation of a heated Borate Spray application by Mississippi State University.

The second group was a similar Borate Spray application installed on 3/15/88. The two Mooney Chemicals Copper Naphthenate Sprays (oil and water based), and the Pandrol Borate Rod sections were installed on 5/22/89. The first measurement cycle was accomplished on 5/22/89 in conjunction with the final treatment applications.

3. **Lorenzo, Illinois:** AT&SF Phase III site was installed on 9/87. There are 8 sections of various treatments. The first three sections are from Pandrol and include Borate Rods (250 ties), Liquid Glycol (150 ties), and a combination of the rods and liquid (100 ties). The next two sections are from Mississippi State University and include one section of "Timbor + Cunapsol + Corrosion Inhibitor" pads (167 ties), and one section of "Timbor + Cunapsol" pads (139 ties). The following two sections are from Mooney Chemicals and include an oil based copper naphthenate spray (250 ties) and a water based copper naphthenate spray (225 ties). The last section is made up of Sodium Fluoride pads from Osmose (250 ties). The east half of each tie was treated in the adzed tie plate area with the above mentioned products, while the west half was untreated as a control. The first measurement cycle was accomplished on 10/27/88.

4. **Jesup, Georgia:** Norfolk Southern Phase III site was installed on 10/2/88. Seven consecutive sections of approximately 250 ties were treated. The first section, installed by Osmose, consisted of Sodium Fluoride Rods (30 ties) and Sodium Fluoride Pads (220 ties). The next two sections, installed by Pandrol, consisted of Timbor Rods (250 ties) and Timbor Spike Hole Rods (75 ties). The fourth and

fifth sections, installed by Mooney Chemicals, included water and oil based Copper Naphthenate Sprays (250 ties each). The last two sections, installed by Mississippi State University, included Timbor-Cunapsol pads (250 ties) and Timbor-Cunapsol pads with an iron inhibitor (220 ties). The north half of each tie was treated in the adzed tie plate area. The first measurement cycle was accomplished on 9/28/89.

2.0 TRACK PERFORMANCE MEASUREMENTS

Each measurement cycle in the Alternative Tie Treatment Test has included a battery of track performance measurements. These six measurements are used to assess the physical strength of the track components, and to determine the current state of deterioration of the track section. All measurements are not available for every test site due to logistical, environmental, and time constraints.

Unloaded Track Gage: One of the main functions of a crosstie is to hold the rail in alignment. The best measure of horizontal alignment is track gage. A loaded track gage measurement would be preferable because it can eliminate any slack in the track system which may be misleading as in an unloaded measurement. The logistics of having a loaded track gage measurement at all of the sites and for the numerous measurement cycles is not feasible. Therefore, a hand held gage bar was used for the measurements (Exhibit 11). Typically, the gage measurements were taken at every tenth tie for the larger test sections, and at every fifth tie for the shorter sections. The measurement is a much better indicator of treatment group behavior for those groups which are consecutively arranged in track, since the values obtained are dependent on the condition of a number of ties in the vicinity of the measurement, not on individual ties. FRA limits are set for wide and tight gage for the obvious reasons, but another indicator of a possible problem may lie in the variance seen in the measurements over a stretch of track. A large variation could signify an unstable track or a lot of slack in the track system.

Unloaded Crosslevel: Crosslevel, defined as the difference in top of rail elevation of the two rails at a given point in track, is a good indicator of vertical track alignment.

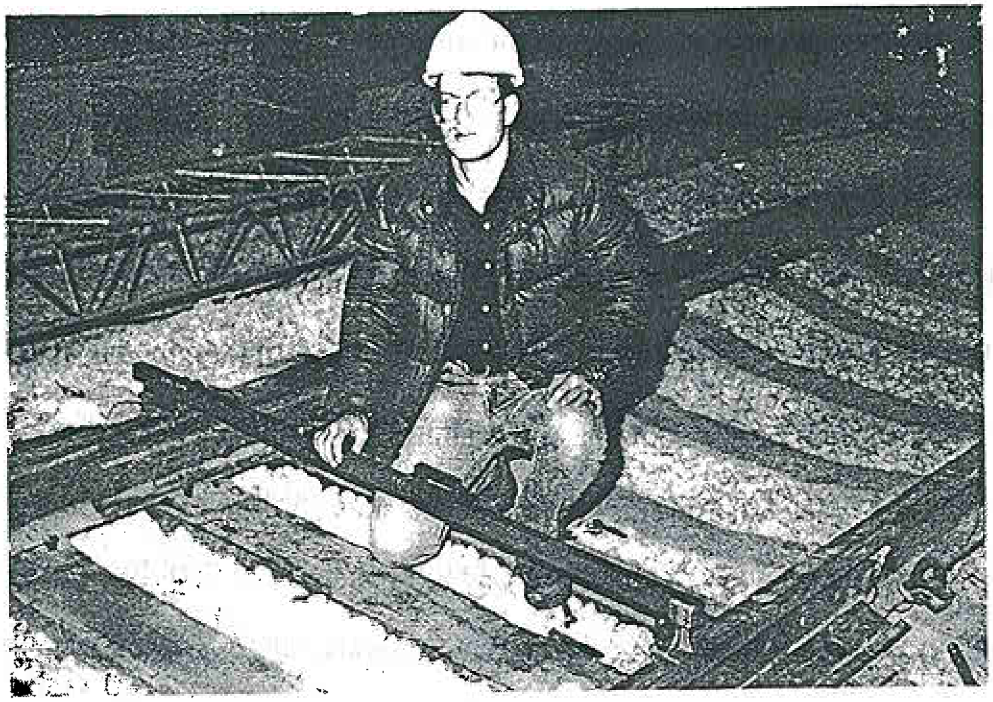


Exhibit 11. Track Gage and Crosslevel Bar.

For the same reasoning as stated for the gage measurements, a loaded crosslevel measurement would be better than an unloaded crosslevel measurement (Exhibit 11), but it is simply not practical. However, the average and standard deviation of crosslevel errors do give an indication of relative performance of a particular section with respect to other sections as well as to itself over time.

Spike Integrity: One of the important characteristics of a crosstie is its ability to hold spikes effectively. Due to train action, decay, rot, iron degradation, or fatigue from removing and replacing, the spikes tend to become loose over time. This measurement is a count of the number of loose spikes per section as a percentage. Any track maintenance work must be accounted for, since it would have a definite impact on this measurement.

Tie Plate Cutting: Plate cutting is defined as the amount of recession into a tie that a tie plate has achieved relative to the top of that particular tie. Extensive plate cutting is a fairly reliable indicator of overall tie deterioration. Both lateral and vertical support capabilities are affected by plate area deterioration.

Measurements are taken using a specially built plate cutting measuring device. This device, shown in Exhibit 12, has electronic transducers and is attached to a datalogger for automated data storage. The device operates by measuring the difference in elevation between the top of the tie plate at a known distance from the edge, and the top surface of the tie adjacent to the plate. Factors which can affect the accuracy of the measurement include: plate thickness tolerance, plate slope and warping, tie surface damage, and presence of debris such as lubricants, oils, sand, etc.

Plate cutting is, largely, a wear process. The tie plate, under the action of traffic, moves relative to the tie while in contact with the tie. The resulting action wears/abrades the wood fibers under the tie plate. Thus, the plate "cuts" through the tie. New ties resist plate cutting very well. They have sufficient hardness and strength to withstand 400-500 MGT of simulated traffic in laboratory testing with virtually no plate cutting.[2] Over time and with traffic, the tie deteriorates in strength. Weathering alone can reduce wood strength by 50 percent in 20 years of crosstie service.[2] This significant strength loss leaves the tie more susceptible to mechanical damage such as spike killing or plate cutting. Subsequently, this damage opens the tie for bacteriological decay. Chemical reactions between the steel plate and the wooden tie are also believed to

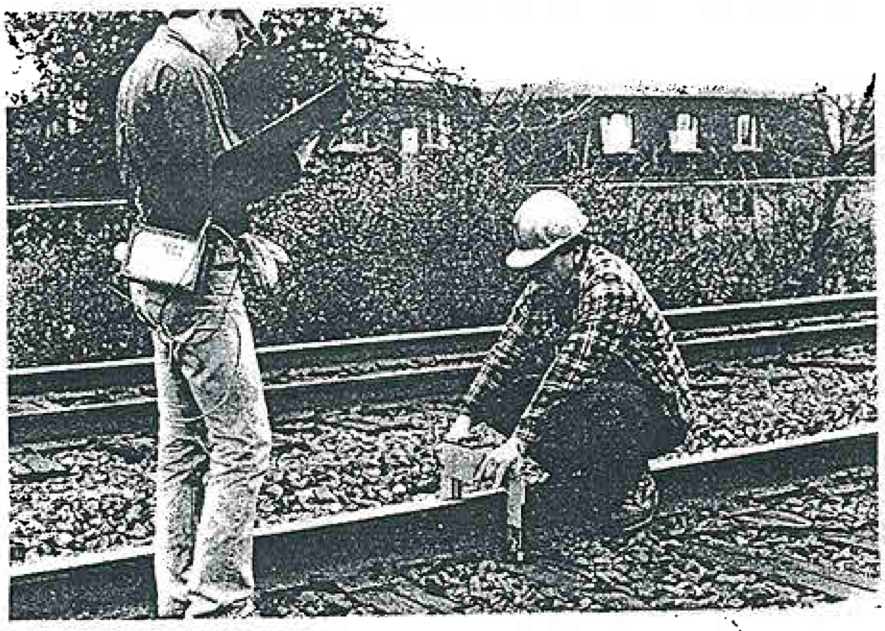


Exhibit 12. Plate Cutting Device.

contribute to plate area tie deterioration. Thus, extensive plate cutting is a good indicator that a tie has, at least, diminished capabilities.

Lateral Track Strength: The lateral track strength of a section of track, its ability to hold gage, is of the utmost importance for track safety. Unlike the unloaded gage and crosslevel measurements, the Light-weight Track Loading Fixture (LTLF) allows for a loaded measure of strength in a feasible manner. The LTLF (Exhibit 13) operates by a hydraulic cylinder which applies a simultaneous lateral force to the web of each rail. By measuring the resultant deflection for a sequence of applied loads, one can determine the lateral resistance characteristics, such as lateral stiffness or Gage Restraint Index (GRI), for each section of track.

The LTLF is used to load the rails laterally up to 10,000 pounds. Gage measurements are taken at various levels in order to construct an accurate

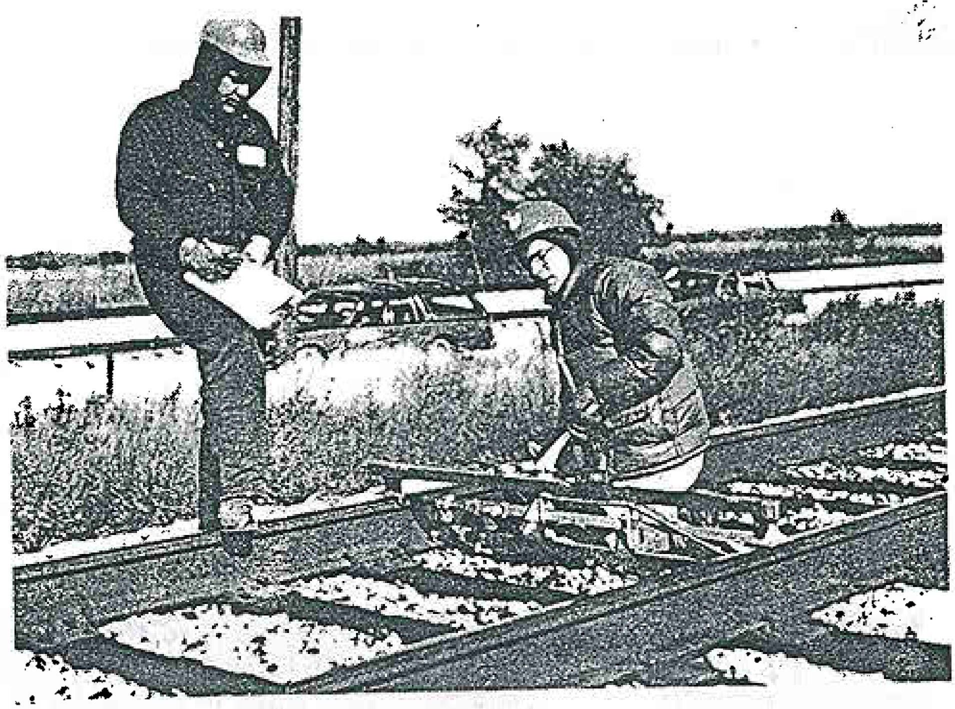


Exhibit 13. Light Weight Track Loading Fixture.

load/deflection curve. Values of lateral modulus and/or stiffness are then extrapolated from the data. Being the only true "loaded" track measurement incorporated into this study, the LTLF data should prove to be of significant value.

Tie Moisture Content: The moisture content of test ties was measured using a Delmhorst RC-1C moisture meter. The device works by measuring the electrical resistance of the wood between two probes spaced approximately one inch apart and driven about one inch into the top surface of the tie (Exhibit 14). Tie moisture contents were taken for a representative sample of ties from each section. These ties were generally the same ties that the treatment cores were extracted from.

The moisture content distribution of a section of ties can give an indication of the tie strength/age distribution which may also be present throughout the section. Moisture contents of individual ties may also be an indication of how well a tie will accept remedial treatments, primarily water diffusible types (ie. borates).

Exhibit 14. Moisture Content Device.

2.1 Cordele, GA (Phase I)

ALTERNATIVE TIE TREATMENT STATUS SHEET

SITE: Cordele, GA.
PHASE: I
RAILROAD: Norfolk Southern, Coastal Division, GS&F Line
TRAFFIC: 20 MGT
LOCATION: MP 67, US 41 south from Cordele

INSTALLATION DATE: 02/88
MEASUREMENT DATE: 09/25/89
PERSONNEL PRESENT: K. J. Laine, D. D. Davis
MEASUREMENT SCHEDULE: Initial Measurements

Total 450 Tags

INSTALLATION METHODOLOGY: 200 GBN, 100 GCN, 50 GB, 50 GBC, 50 GBS, installed as tie gang replacements but consecutive within the groups.

TAGGING SCHEME: GB, GBC, GCN, GBN, GBS

TRACK SPECIFICATIONS: TANGENT, 131RE, 132RE, CWR, 14" tie plates. Farm crossing on south end of section.

MEASUREMENTS TAKEN:

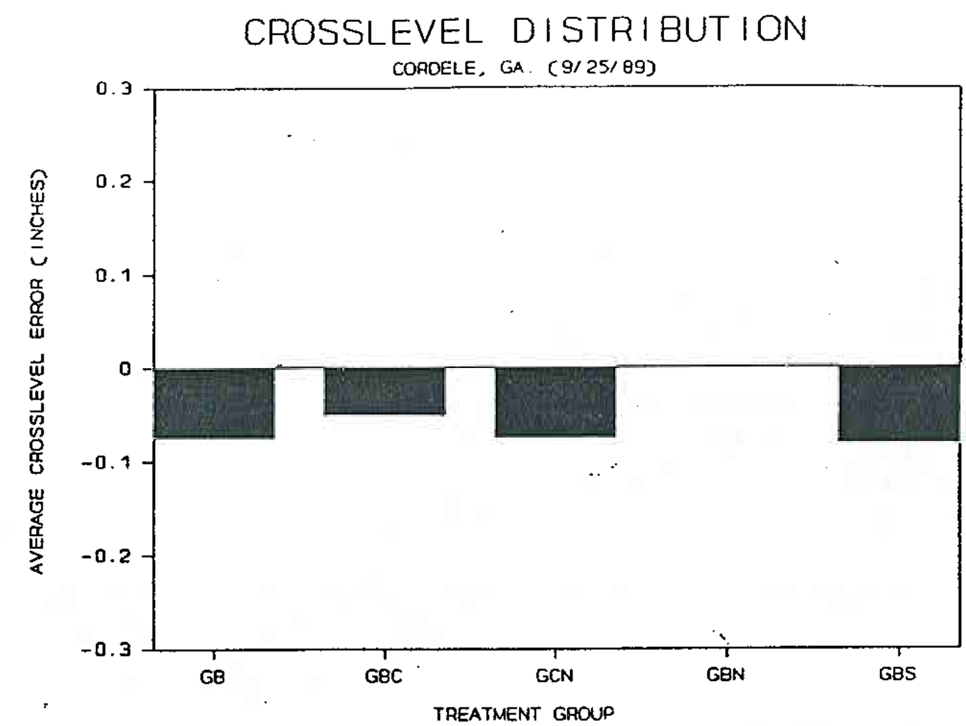
1989
GAGE
CROSSLEVEL
LTLF

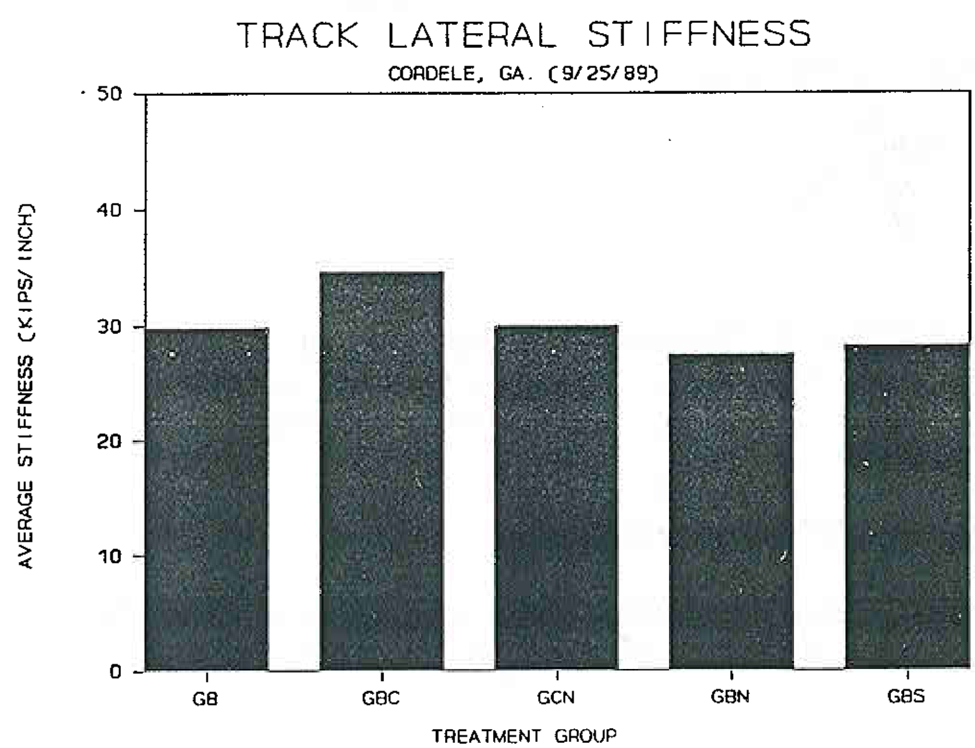
PROBLEMS ENCOUNTERED: Moisture content and plate cutting measurement rained out - very minimal plate cutting observed.

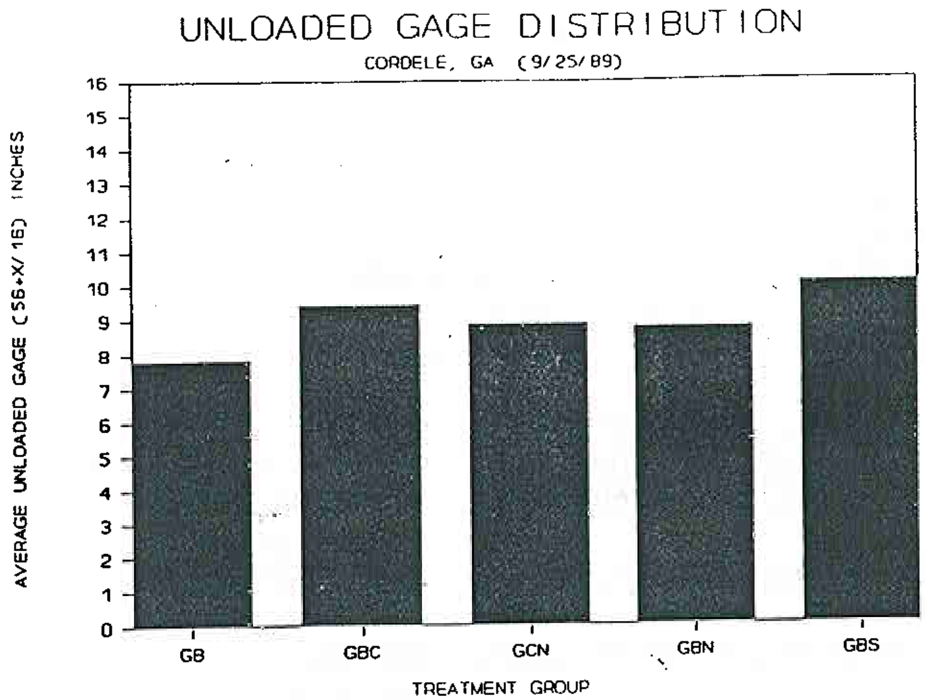
INTERMITTENT TRACK WORK:

GRAPHS: Initial Average Gage and Crosslevel for each tie treatment category, LTLF - average track stiffness for each treatment category.

COMMENTS:


CROSSLEVEL DISTRIBUTION
CORDELE, GA. (9/25/89)
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
AVERAGE CROSSLEVEL ERROR (INCHES)
GB
GBC
GCN
GBN
GBS
TREATMENT GROUP


TRACK LATERAL STIFFNESS
CORDELE, GA. (9/25/89)
50
40
30
20
10
0
AVERAGE STIFFNESS (KIPS/INCH)
GB
GBC
GCN
GBN
GBS
TREATMENT GROUP



UNLOADED GAGE DISTRIBUTION
CORDELE, GA (9/25/89)
AVERAGE UNLOADED GAGE (56+X/16) INCHES
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
GB
GBC
GCN
GBN
GBS
TREATMENT GROUP

2.2 Milano, TX (Phase I)

ALTERNATIVE TIE TREATMENT STATUS SHEET

SITE:	Milano, Texas
PHASE:	I
RAILROAD:	ATSF, Galveston Subdivision, just south of MP 170
TRAFFIC:	30 MGT, 100-ton unit traffic
LOCATION:	4 miles south of Milano, Texas

INSTALLATION DATE:	06/88
MEASUREMENT DATE:	05/23/89 Cores - 07/89
PERSONNEL PRESENT:	K. J. Laine, D. D. Davis, Jerry Waits (Track Supervisor)
MEASUREMENT SCHEDULE:	Initial Measurements

INSTALLATION METHODOLOGY: 100 consecutive borate-creosote treated ties, (groups of ten).

TAGGING SCHEME: RCV, RCA, RBA, RBB, RBC, WBA, WBB, WCV, WCA, WBC, somewhat intermixed.

TRACK SPECIFICATIONS: 3 degree curve, crossing just south of MP 170.

MEASUREMENTS TAKEN:

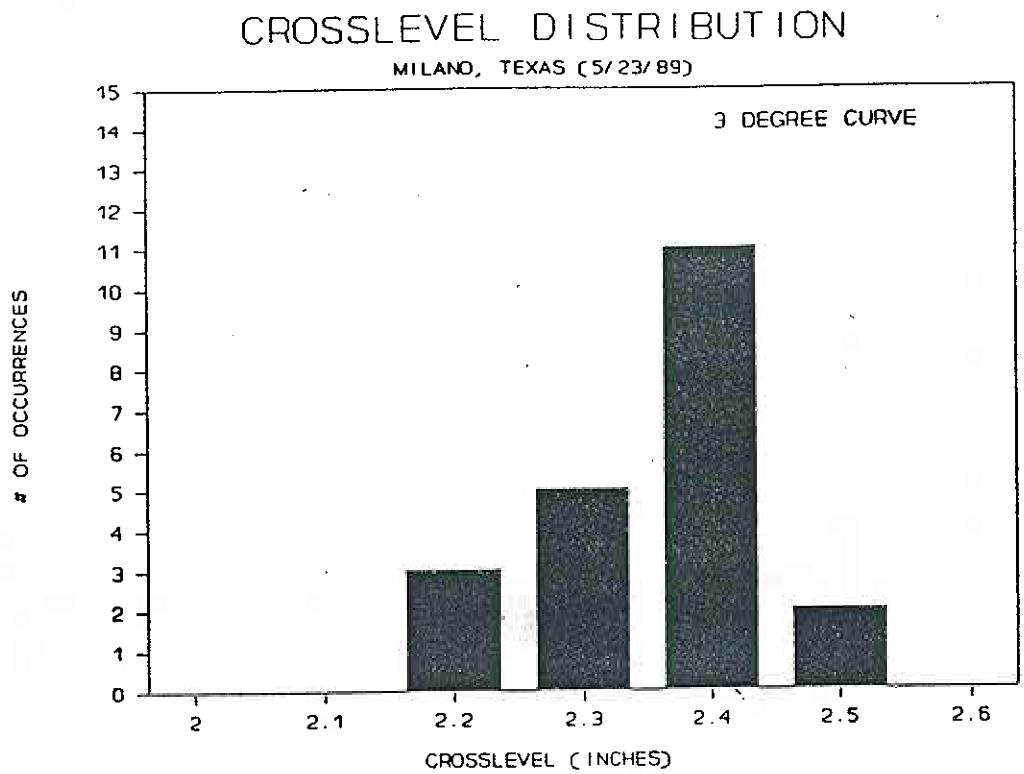
1989
- GAGE
- CROSSLEVEL
- PLATE CUTTING
- MOISTURE CONTENT

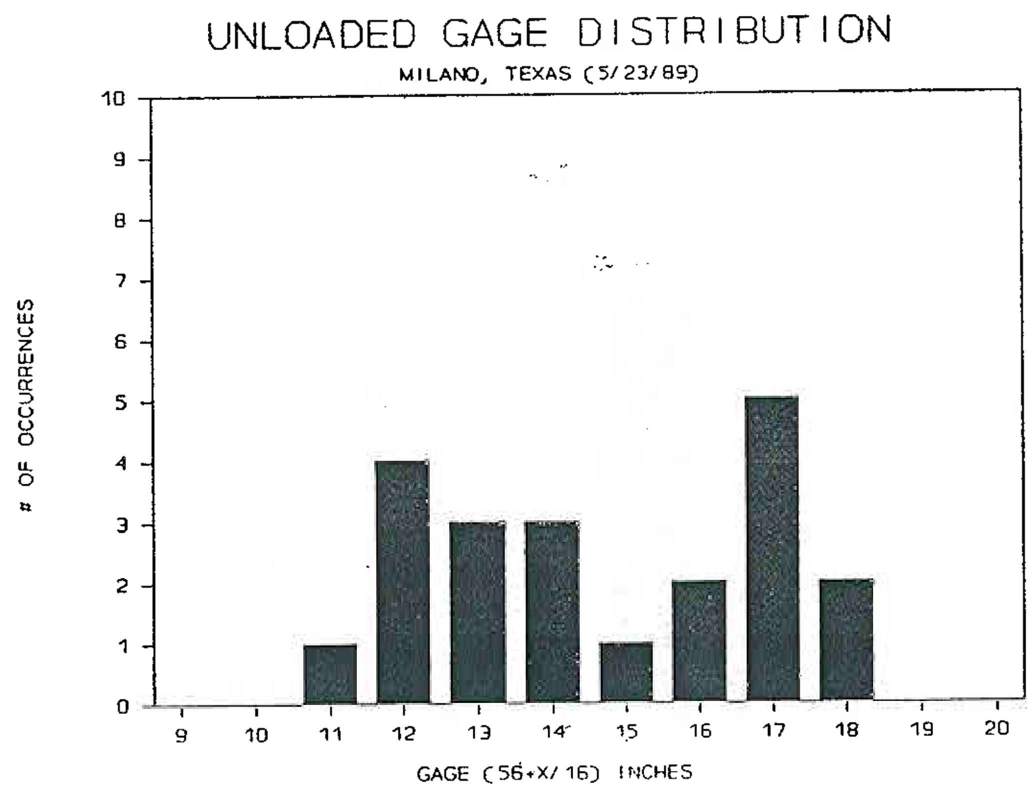
PROBLEMS ENCOUNTERED:

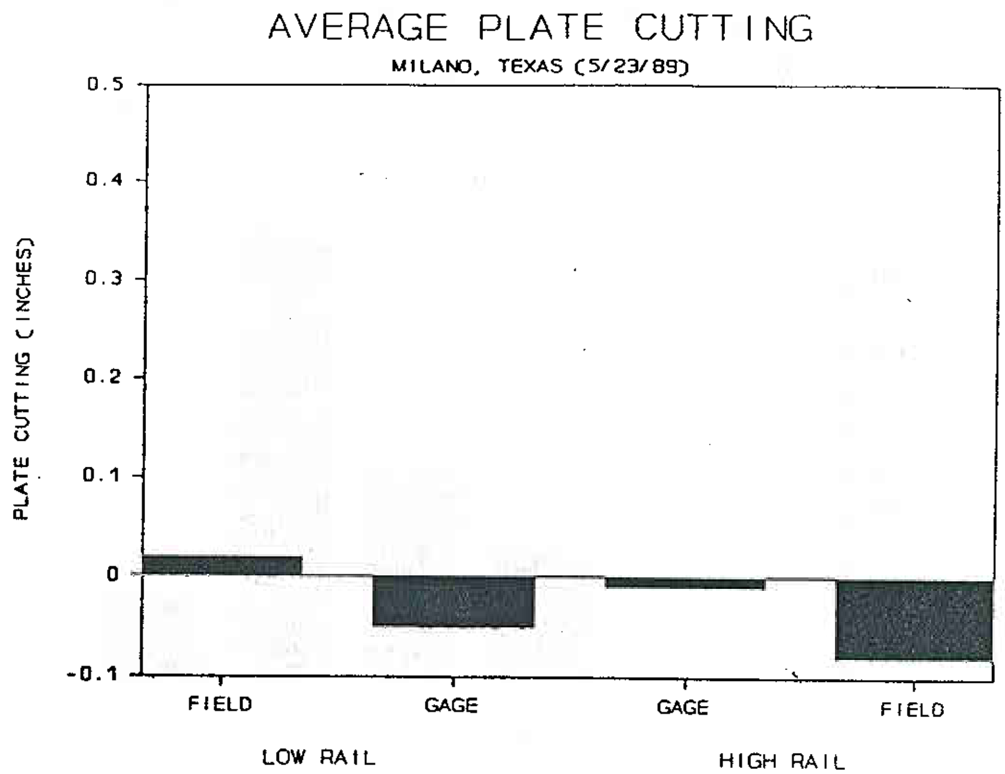
INTERMITTENT TRACK WORK:

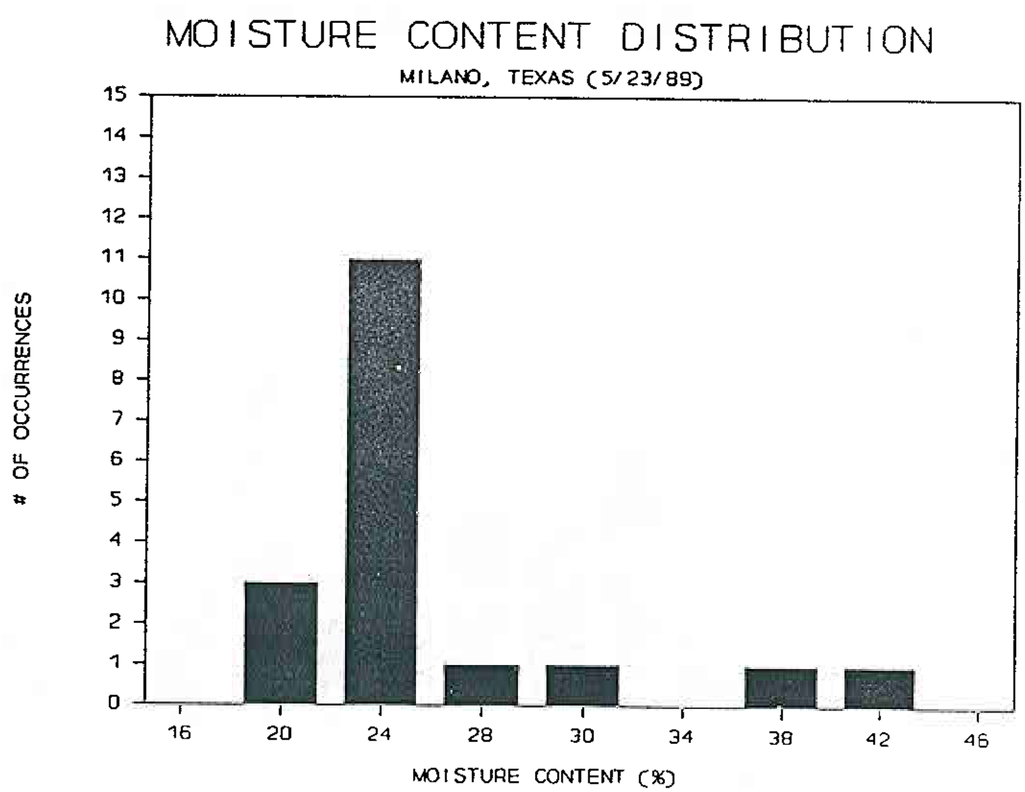
GRAPHS: Initial condition graphs of entire test section distribution, Unloaded Gage, Crosslevel, Moisture Content, and Average Plate Cutting.

COMMENTS: 100+ temperature, considerable wear on high rail, low rail has been transposed (from high rail position). Other Santa Fe test ties in adjacent sections.


CROSSLEVEL DISTRIBUTION
MILANO, TEXAS (5/23/89)
3 DEGREE CURVE
OF OCCURRENCES
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
2
2.1
2.2
2.3
2.4
2.5
2.6
CROSSLEVEL (INCHES)


UNLOADED GAGE DISTRIBUTION
MILANO, TEXAS (5/23/89)
OF OCCURRENCES
0
1
2
3
4
5
6
7
8
9
10
9
10
11
12
13
14
15
16
17
18
19
20
GAGE (56+X/16) INCHES


AVERAGE PLATE CUTTING
MILANO, TEXAS (5/23/89)
PLATE CUTTING (INCHES)
0.5
0.4
0.3
0.2
0.1
0
-0.1
FIELD
GAGE
GAGE
FIELD
LOW RAIL
HIGH RAIL


MOISTURE CONTENT DISTRIBUTION
MILANO, TEXAS (5/23/89)
OF OCCURRENCES
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
16
20
24
28
30
34
38
42
46
MOISTURE CONTENT (%)

2.3 Montgomery, TX (Phase I)

ALTERNATIVE TIE TREATMENT STATUS SHEET

SITE: Montgomery, Texas
PHASE: I
RAILROAD: ATSF, Conroe Subdivision, Near MP 53
TRAFFIC: 15 MGT
LOCATION: West of Montgomery, Texas

INSTALLATION DATE: 06/88
MEASUREMENT DATE: 05/24/89 cores taken 07/89
PERSONNEL PRESENT: K. J. Laine, D. D. Davis, Jerry Waits (Track Supervisor)

MEASUREMENT SCHEDULE:

INSTALLATION METHODOLOGY: 100 ties consecutively installed in sequence of their respective groups.

TAGGING SCHEME: RBA, RCA, WBA, RBC, RBB, RCV, WCA, WBB, WBC, WCV.

TRACK SPECIFICATIONS: 3 degree curve, 131RE Colorado '46 '44, box anchored every other tie.

MEASUREMENTS TAKEN:

1989

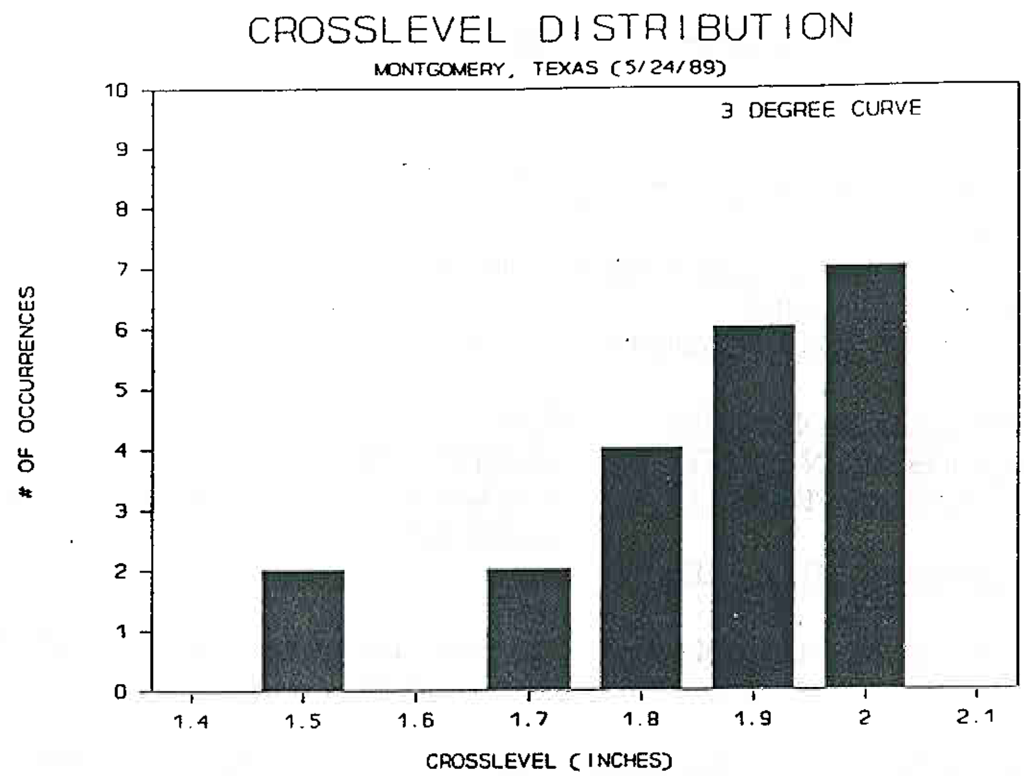
PLATE CUTTING
GAGE
CROSSLEVEL
MOISTURE CONTENT

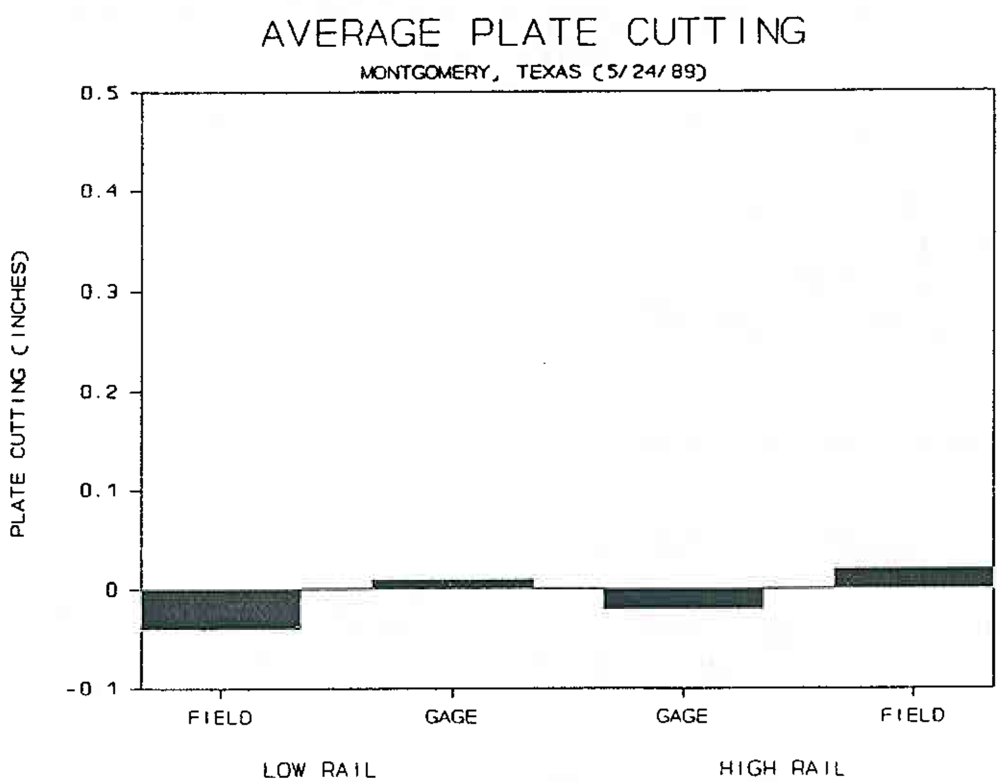
PROBLEMS ENCOUNTERED:

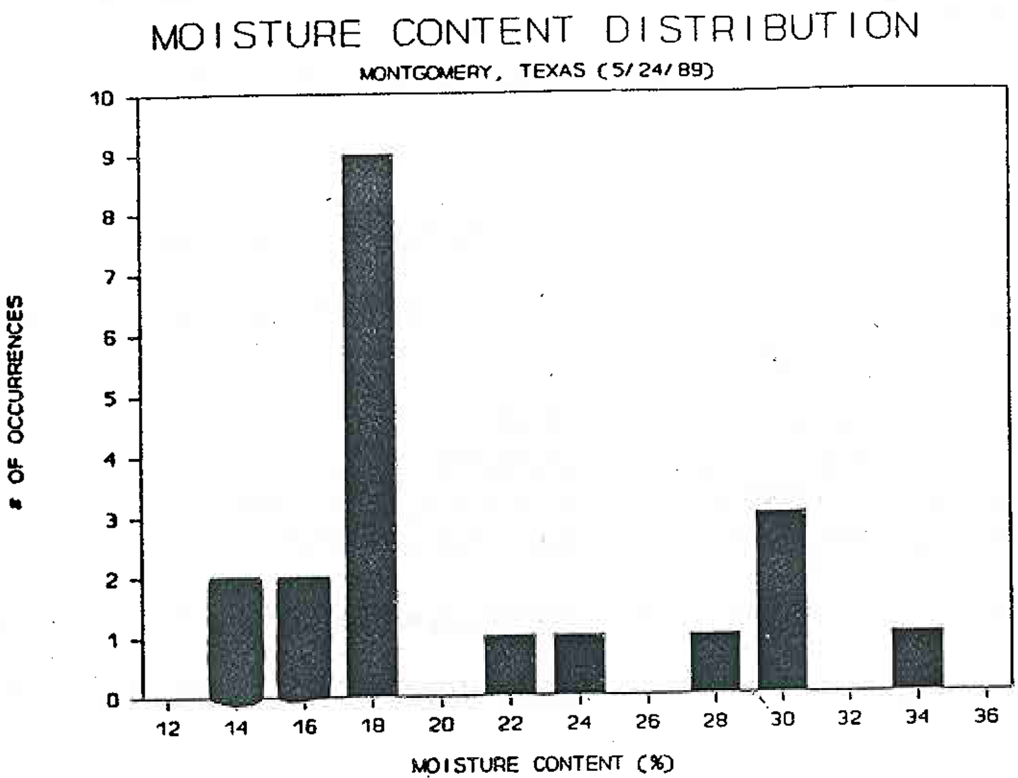
INTERMITTENT TRACK WORK:

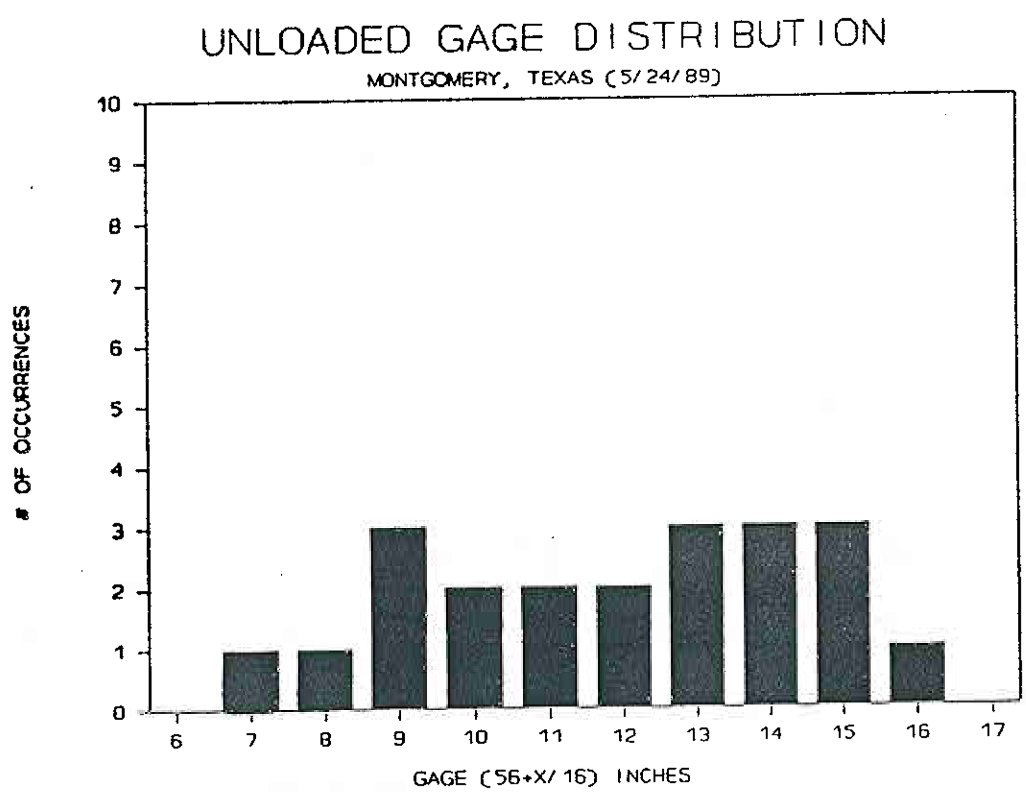
GRAPHS: Initial condition graphs of entire test section distribution; Unloaded Gage, Crosslevel, Moisture Content, and average Plate Cutting for the section.

COMMENTS: Vapor dry ties are oily in appearance, creosote ties show brown patches.


CROSSLEVEL DISTRIBUTION
MONTGOMERY, TEXAS (5/24/89)
3 DEGREE CURVE
OF OCCURRENCES
10
9
8
7
6
5
4
3
2
1
0
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
CROSSLEVEL (INCHES)


AVERAGE PLATE CUTTING
MONTGOMERY, TEXAS (5/24/89)
PLATE CUTTING (INCHES)
0.5
0.4
0.3
0.2
0.1
0
-0.1
FIELD
GAGE
GAGE
FIELD
LOW RAIL
HIGH RAIL


MOISTURE CONTENT DISTRIBUTION
MONTGOMERY, TEXAS (5/24/89)
OF OCCURRENCES
10
9
8
7
6
5
4
3
2
1
0
12
14
16
18
20
22
24
26
28
30
32
34
36
MOISTURE CONTENT (%)


UNLOADED GAGE DISTRIBUTION
MONTGOMERY, TEXAS (5/24/89)
OF OCCURRENCES
10
9
8
7
6
5
4
3
2
1
0
6
7
8
9
10
11
12
13
14
15
16
17
GAGE (56+X/16) INCHES

2.4 Aikman, KS (Phase I)

ALTERNATIVE TIE TREATMENT STATUS SHEET

SITE:	Aikman, Kansas
PHASE:	I
RAILROAD:	ATSF, 5 miles north of El Dorado line change, MP 159.9
TRAFFIC:	70 MGT
LOCATION:	I-35 south to Cassoday exit (35 Miles South of Emporia), south on 177 thru town (~5 miles)

INSTALLATION DATE:	06/88
MEASUREMENT DATE:	06/26/90
PERSONNEL PRESENT:	K. J. Laine, D. D. Davis
MEASUREMENT SCHEDULE:	Initial Measurements

INSTALLATION METHODOLOGY: 100 ties in groups of 10, consecutively installed.

TAGGING SCHEME: WCV, WCA, WBC, WBB, WBA, RCV, RCA, RBC, RBB, RBA.

TRACK SPECIFICATIONS: 14" tie plates, 136RE rail, additional ballast needed on shoulder.

MEASUREMENTS TAKEN:

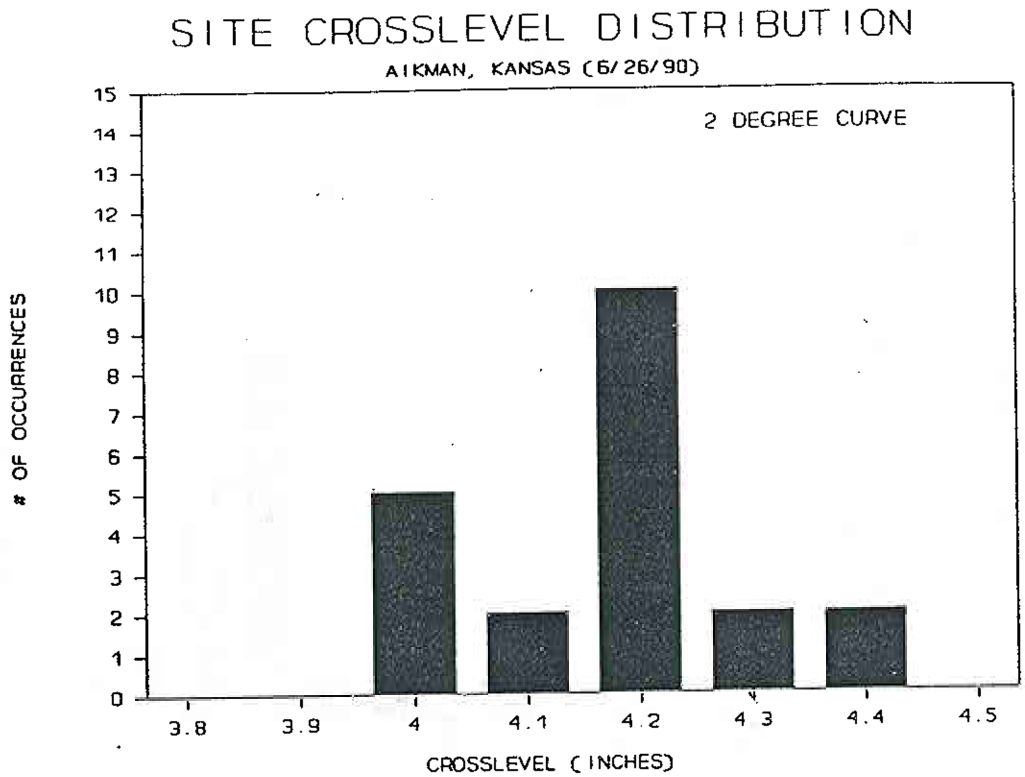
1990
UNLOADED GAGE
CROSSLEVEL
PLATE CUTTING
MOISTURE CONTENT (1", 2", 3")

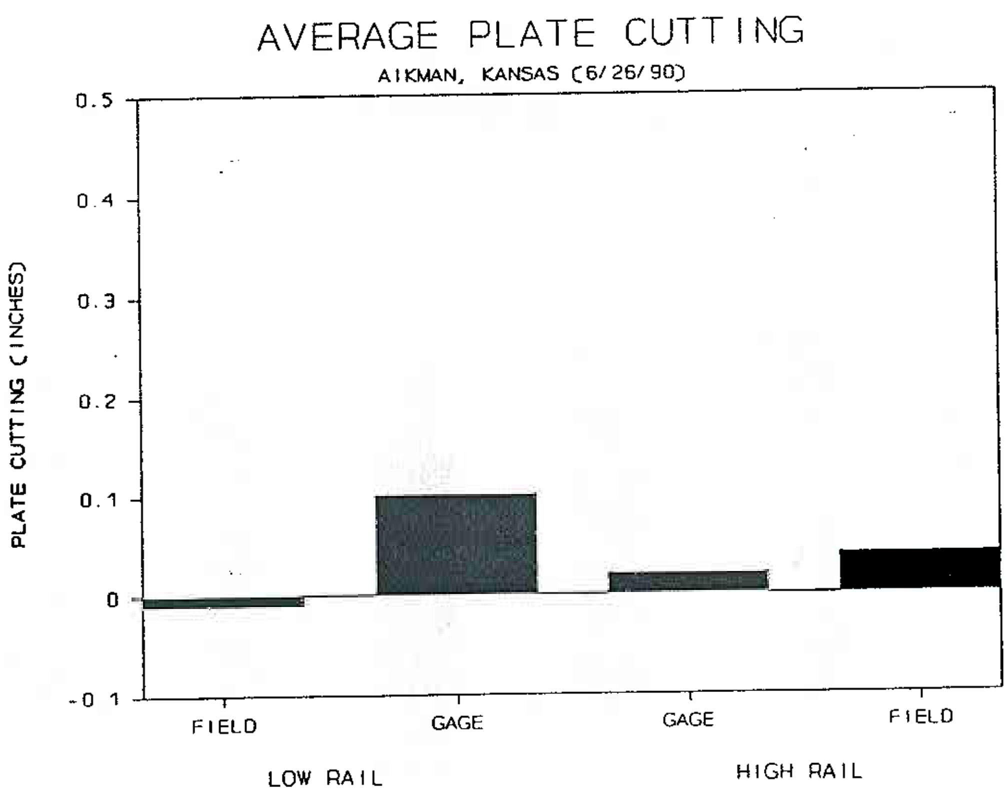
PROBLEMS ENCOUNTERED:

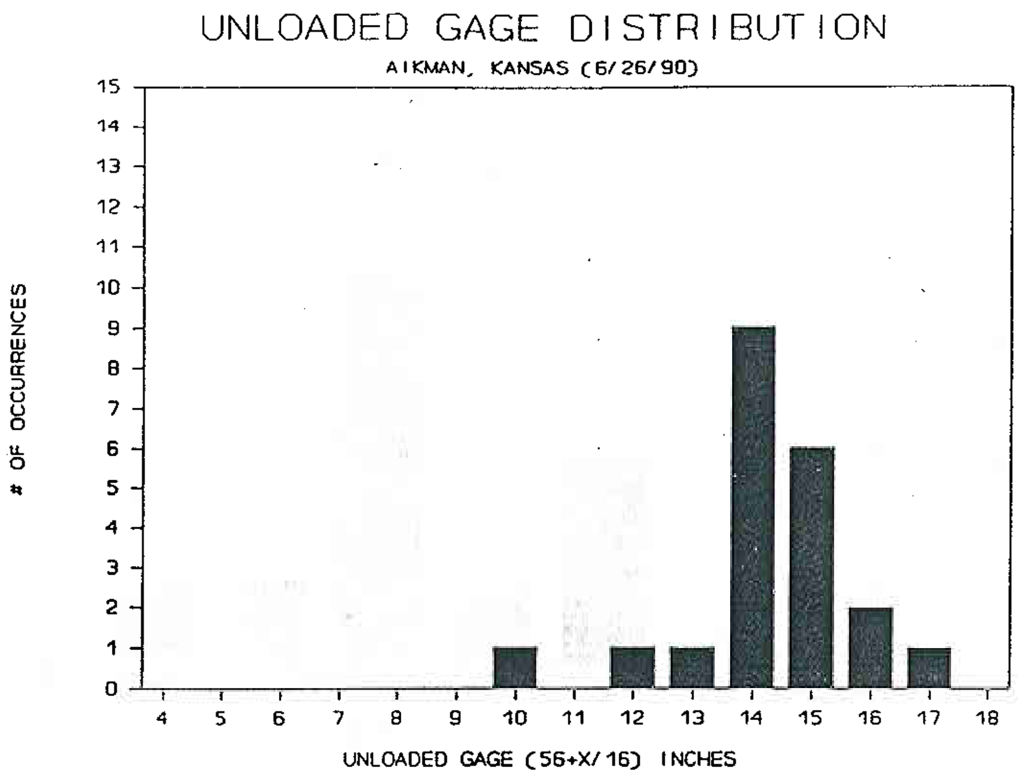
INTERMITTENT TRACK WORK:

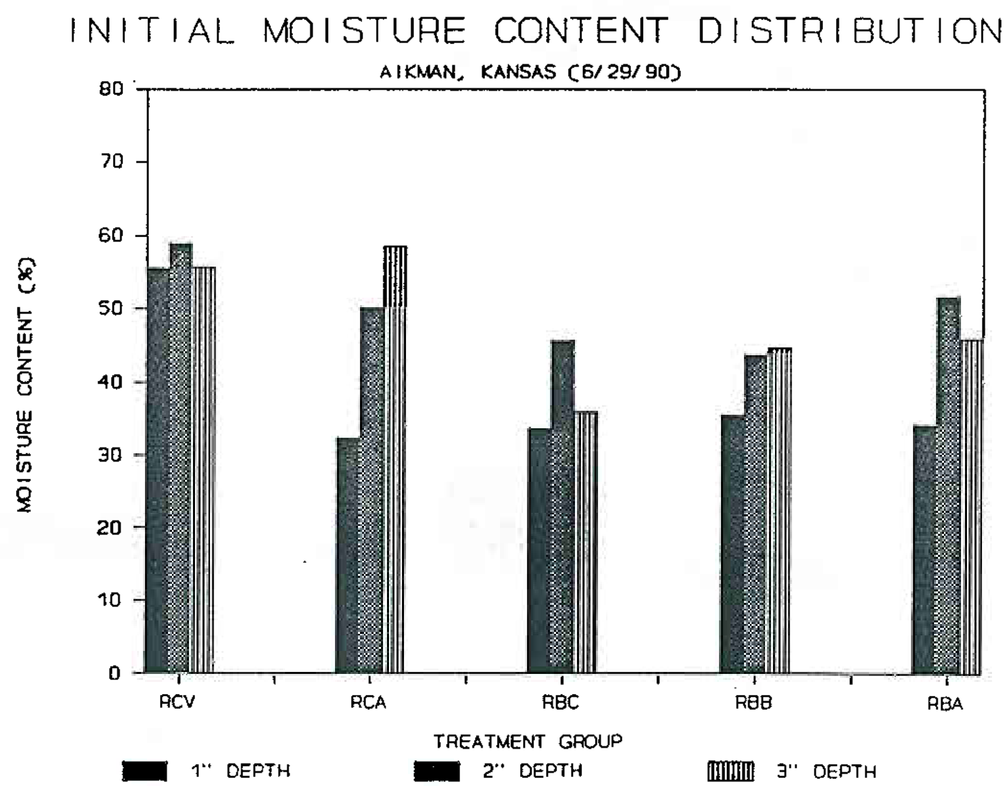
GRAPHS: Moisture content for 1, 2, and 3" for each treatment group (red and white oak separated). Initial gage for the entire test section. Initial crosslevel for the entire test section. Average plate cutting for the entire test section. No loose spikes.

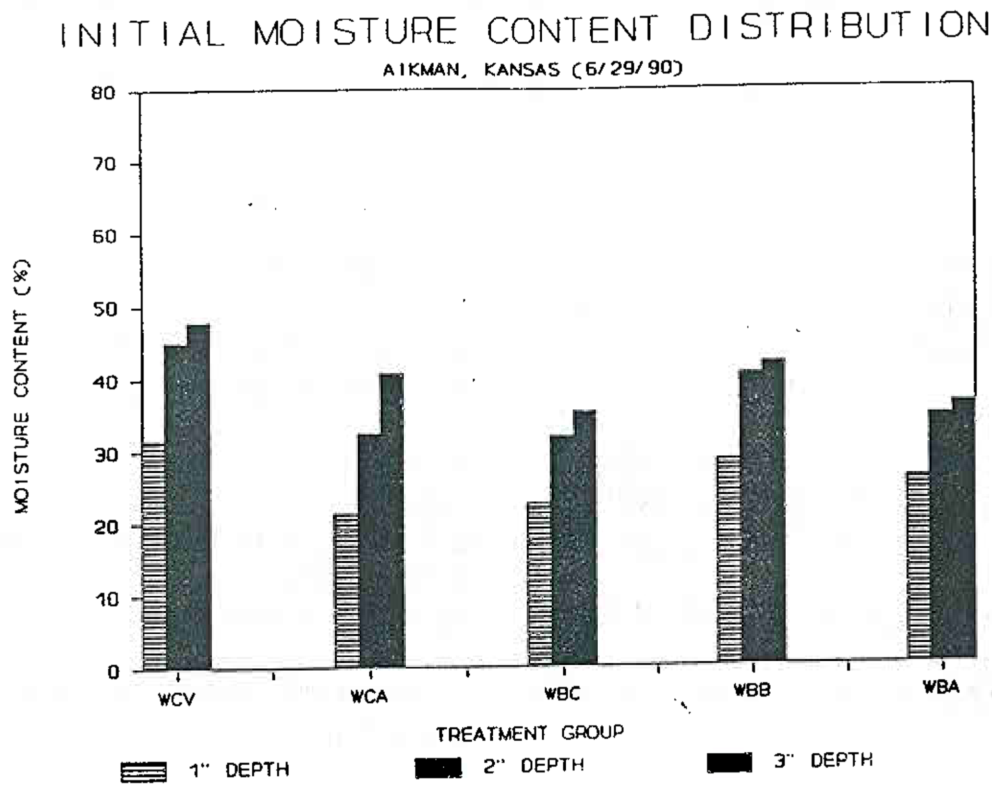
COMMENTS: Vapor dried ties have a layer of mushy material constituting the first 1/4" of the tie. Vapor dry ties look darker (more creosote?) and wetter. Superelevation has apparently caused the ties to bleed creosote mostly on the low end.


SITE CROSSLEVEL DISTRIBUTION
AIKMAN, KANSAS (6/26/90)
2 DEGREE CURVE
OF OCCURRENCES
CROSSLEVEL (INCHES)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
3.8
3.9
4
4.1
4.2
4.3
4.4
4.5


AVERAGE PLATE CUTTING
AIKMAN, KANSAS (6/26/90)
PLATE CUTTING (INCHES)
0.5
0.4
0.3
0.2
0.1
0
-0.1
FIELD
GAGE
GAGE
FIELD
LOW RAIL
HIGH RAIL


UNLOADED GAGE DISTRIBUTION
AIKMAN, KANSAS (6/26/90)
OF OCCURRENCES
UNLOADED GAGE (56+X/16) INCHES


INITIAL MOISTURE CONTENT DISTRIBUTION
AIKMAN, KANSAS (6/29/90)
MOISTURE CONTENT (%)
RCV
RCA
RBC
RBB
RBA
TREATMENT GROUP
1" DEPTH
2" DEPTH
3" DEPTH


INITIAL MOISTURE CONTENT DISTRIBUTION
AIKMAN, KANSAS (6/29/90)
MOISTURE CONTENT (%)
80
70
60
50
40
30
20
10
0
WCV
WCA
WBC
WBB
WBA
TREATMENT GROUP
1" DEPTH
2" DEPTH
3" DEPTH

2.5 Cajon, CA (Phase I)

ALTERNATIVE TIE TREATMENT STATUS SHEET

SITE: Cajon, CA.
PHASE: I
RAILROAD: ATSF, North Main Track, MP 62.6X
TRAFFIC: 30 MGT, mixed traffic
LOCATION: 2 miles east of Cajon, CA., I-15 north to Cal 138 West, 1/2 mile to a series of unmarked dirt roads (bring water).

INSTALLATION DATE: 10/88
MEASUREMENT DATE: 10/11/90
PERSONNEL PRESENT: K. J. Laine, D. D. Davis, G. D. Lake (Roadmaster)
MEASUREMENT SCHEDULE: Initial Measurements

INSTALLATION METHODOLOGY: 120 consecutive borate ties, somewhat intermixed.

TAGGING SCHEME: WA, WB, WU, RA, RB, RU.

TRACK SPECIFICATIONS: Located in spiral, 14 inch plates, 140 RE, 4 cut spikes/plate.

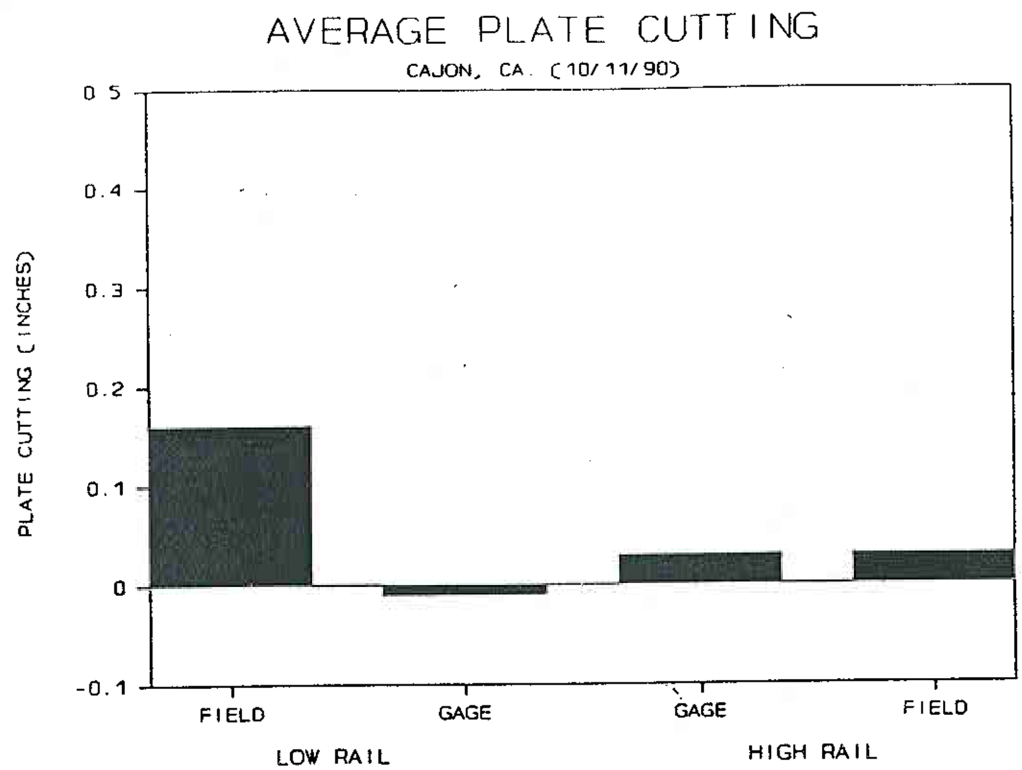
MEASUREMENTS TAKEN:
1990
UNLOADED GAGE
CROSSLEVEL
PLATE CUTTING
MOISTURE CONTENT

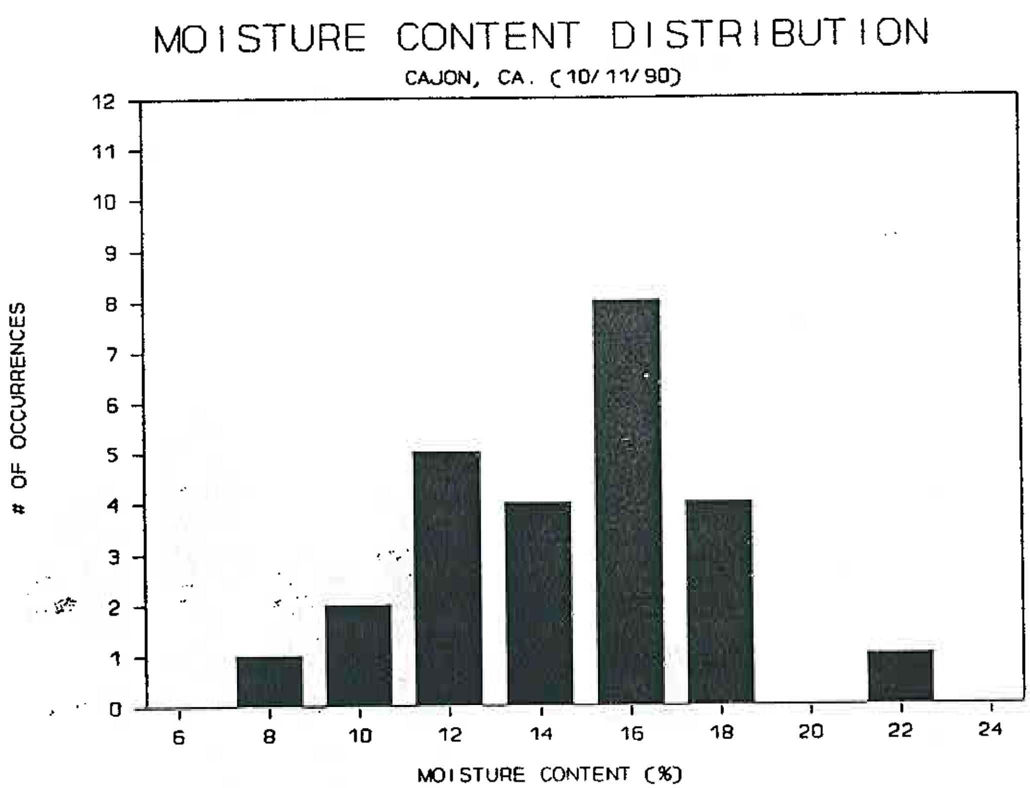
PROBLEMS ENCOUNTERED:

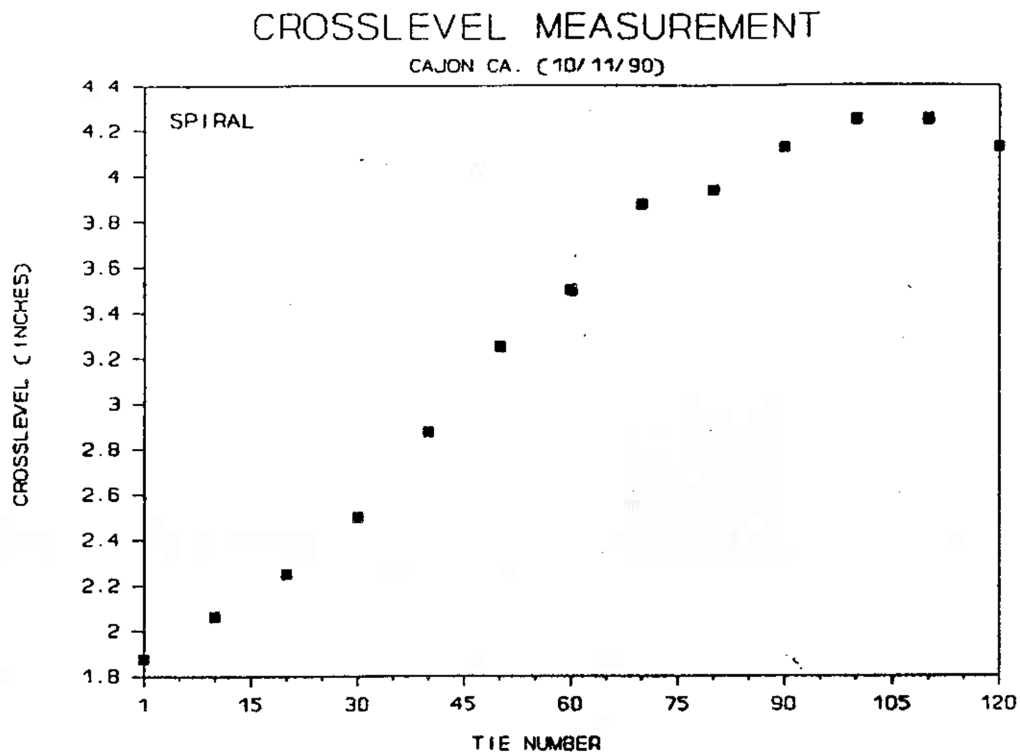
INTERMITTENT TRACK WORK:

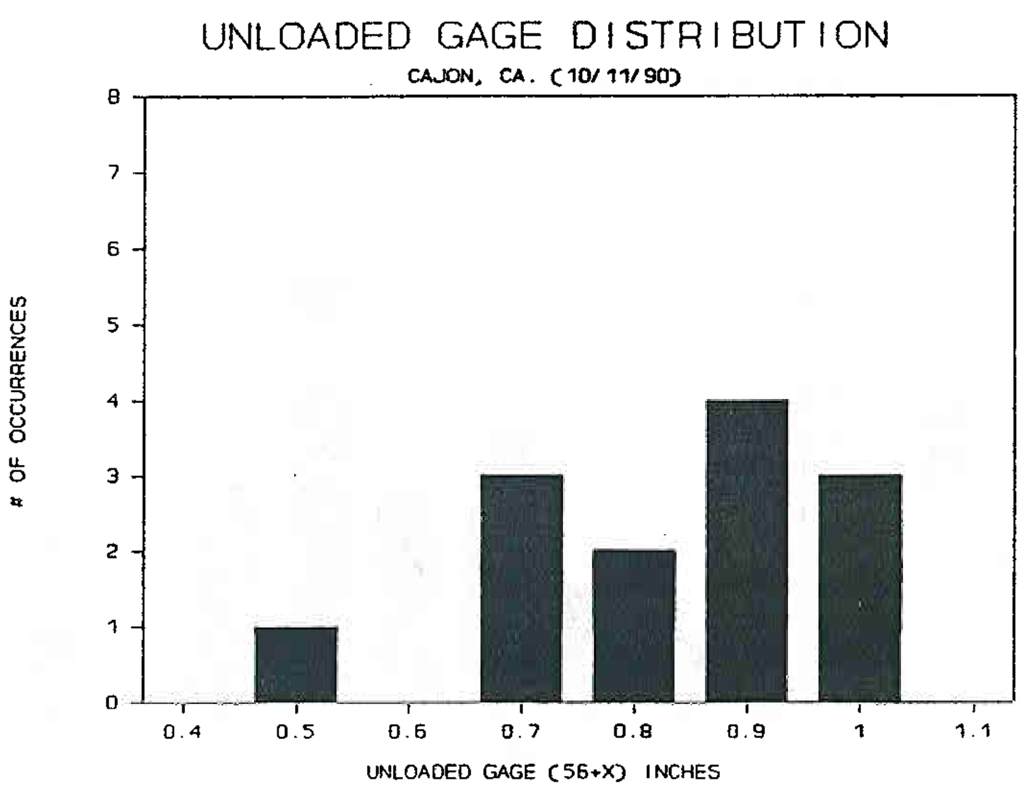
GRAPHS: Site Unloaded Gage and Moisture Content distributions, consecutive Crosslevel readings through spiral, and Average Plate Cutting measurements.

COMMENTS: Ties appear to have layers of varying hardness - air drill would advance bit 1/2-1" easily before suddenly stopping. This caused cores to fracture and drill bits to break.


AVERAGE PLATE CUTTING
CAJON, CA. (10/11/90)
PLATE CUTTING (INCHES)
0.5
0.4
0.3
0.2
0.1
0
-0.1
FIELD
GAGE
GAGE
FIELD
LOW RAIL
HIGH RAIL


MOISTURE CONTENT DISTRIBUTION
CAJON, CA. (10/11/90)
OF OCCURRENCES
12
11
10
9
8
7
6
5
4
3
2
1
0
6
8
10
12
14
16
18
20
22
24
MOISTURE CONTENT (%)


CROSSLEVEL MEASUREMENT
CAJON CA. (10/11/90)
SPIRAL
CROSSLEVEL (INCHES)
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1
15
30
45
60
75
90
105
120
TIE NUMBER


UNLOADED GAGE DISTRIBUTION
CAJON, CA. (10/11/90)
OF OCCURRENCES
8
7
6
5
4
3
2
1
0
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
UNLOADED GAGE (56+X) INCHES

2.6 Toluca, IL (Phase I)

ALTERNATIVE TIE TREATMENT STATUS SHEET

SITE: Toluca, IL.
PHASE: I
RAILROAD: ATSF, north track, Joliet subdivision, MP 109.5
TRAFFIC: 30 MGT, mixed traffic, high speed intermodal
LOCATION: I-55 south to IL 17, west to Toluca east end of town.

INSTALLATION DATE: 06/88
MEASUREMENT DATE: 09/13/90
PERSONNEL PRESENT: K. J. Laine, D. D. Davis, Larry Buehl (Roadmaster)

MEASUREMENT SCHEDULE: Initial Measurements

INSTALLATION METHODOLOGY: 600 consecutive ties installed somewhat intermixed.

TAGGING SCHEME: GBV, RBA, RBB, RBC, WBA, WBB, WBC, WBV.

TRACK SPECIFICATIONS: 14 inch plates, 136 RE, 4 cut spikes/plate. Road crossing @ east end of test section.

MEASUREMENTS TAKEN:

1990

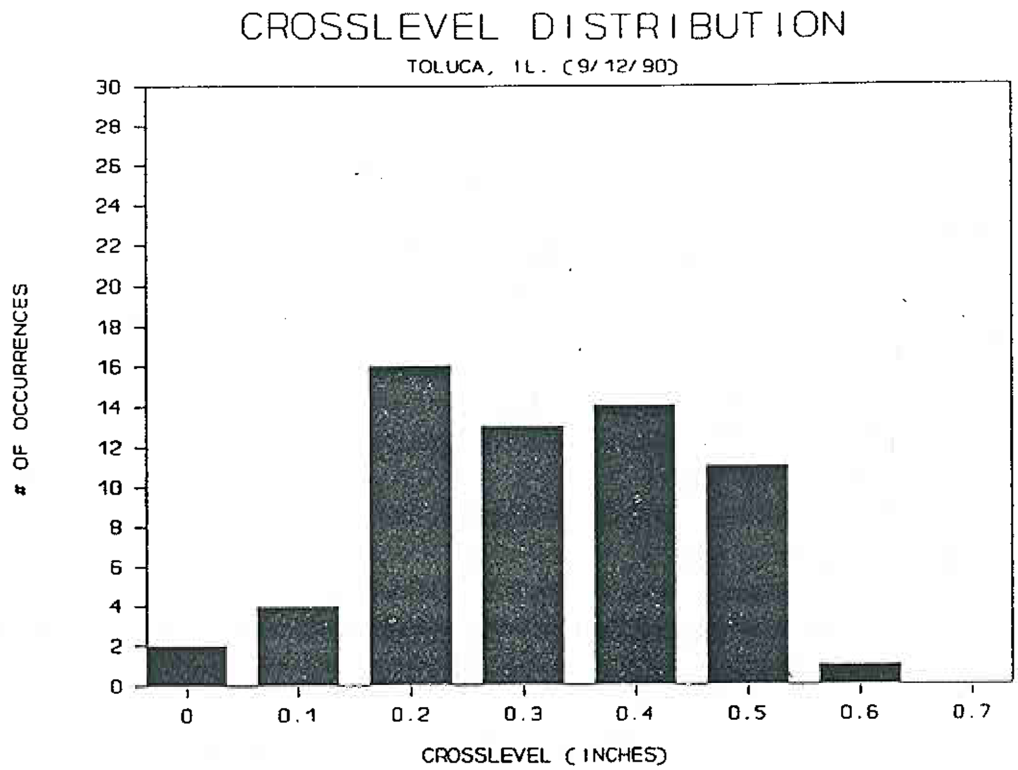
- UNLOADED GAGE
- CROSSLEVEL
- MOISTURE CONTENT
- PLATE CUTTING
- KICK SPIKES

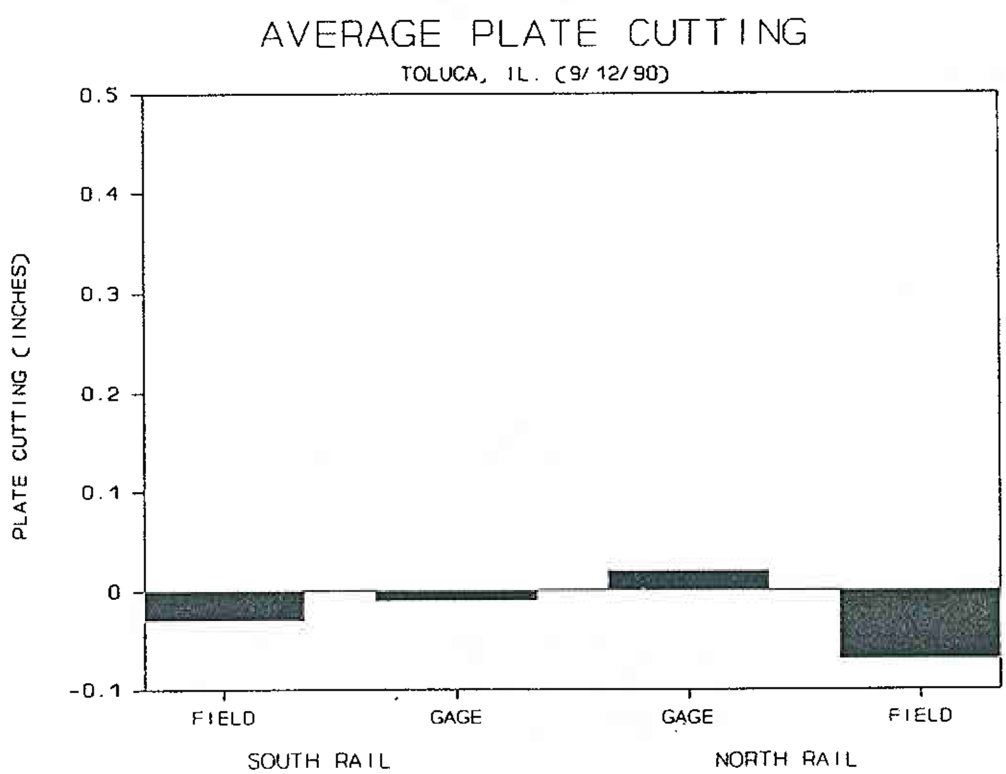
PROBLEMS ENCOUNTERED:
Moisture content readings for only 28 ties due to broken needles, spike integrity showed only one loose spike, numbering scheme off by one (601 ties total).

INTERMITTENT TRACK WORK:

GRAPHS: Site distribution graphs of Unloaded Gage and Crosslevel, Average Plate Cutting graph, Moisture Content graph for 1, 2, and 3 inch intervals (not a complete representation).

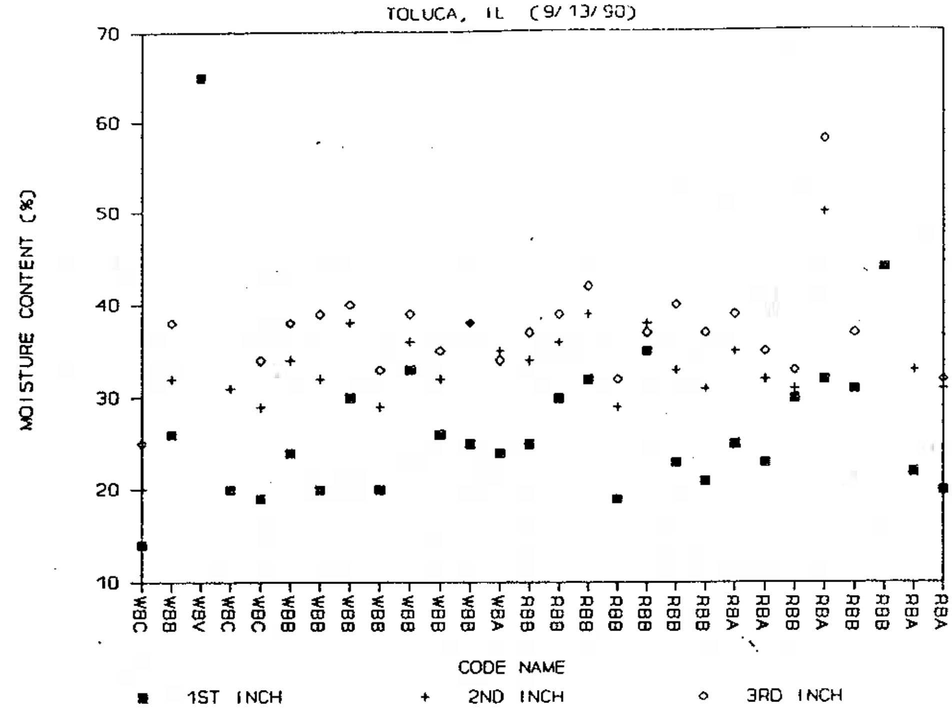
COMMENTS:


CROSSLEVEL DISTRIBUTION
TOLUCA, IL. (9/12/90)
OF OCCURRENCES
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
CROSSLEVEL (INCHES)


AVERAGE PLATE CUTTING
TOLUCA, IL. (9/12/90)
PLATE CUTTING (INCHES)
0.5
0.4
0.3
0.2
0.1
0
-0.1
FIELD
GAGE
GAGE
FIELD
SOUTH RAIL
NORTH RAIL

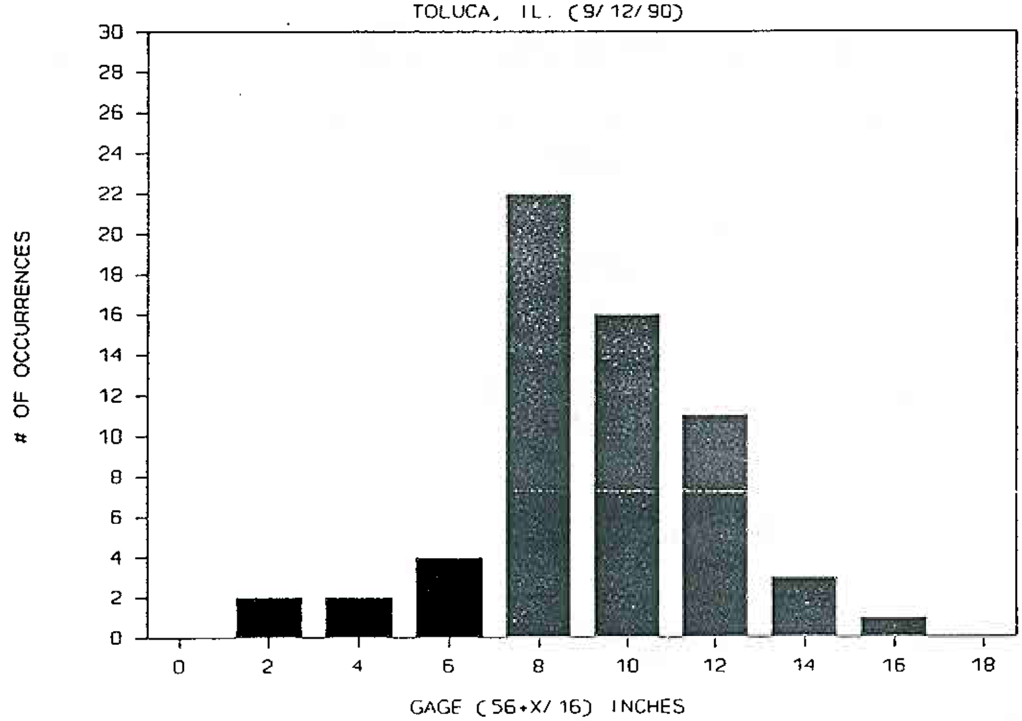
MOISTURE CONTENT (1ST, 2ND, & 3RD INCH)

TOLUCA, IL (9/13/90)



UNLOADED GAGE DISTRIBUTION

TOLUCA, IL. (9/12/90)



2.7 Cordele, GA (Phase II)

ALTERNATIVE TIE TREATMENT STATUS SHEET

SITE:	Cordele, GA.
PHASE:	II
RAILROAD:	Norfolk Southern, Coastal Division GS&F Line MP 59.6
TRAFFIC:	20 MGT
LOCATION:	US 41 N. from Cordele to Ridgewood Baptist church sign, turn right down dirt road to site. Second crossing south of MP 59.

INSTALLATION DATE:	12/20/88
MEASUREMENT DATE:	12/20/88, 9/26/89
PERSONNEL PRESENT:	K. J. Laine, D. D. Davis
MEASUREMENT SCHEDULE:	Initial and 1 year measurements

INSTALLATION METHODOLOGY: Four sections of 100 consecutive ties each,
Section #1 - Msu borate spray,
Section #2 - Pandrol borate rods,
Section #3 - Mooney water base cu. Napth. Spray,
Section #4 - Mooney oil base cu. Napth. Spray.

TAGGING SCHEME: Every tenth tie 1001-1100, 2001-2100, 3001-3100, 4001-4100.

TRACK SPECIFICATIONS: 131 RE, 132 RE, CWR, 14" tie plates, mixed hardwoods.

MEASUREMENTS TAKEN:

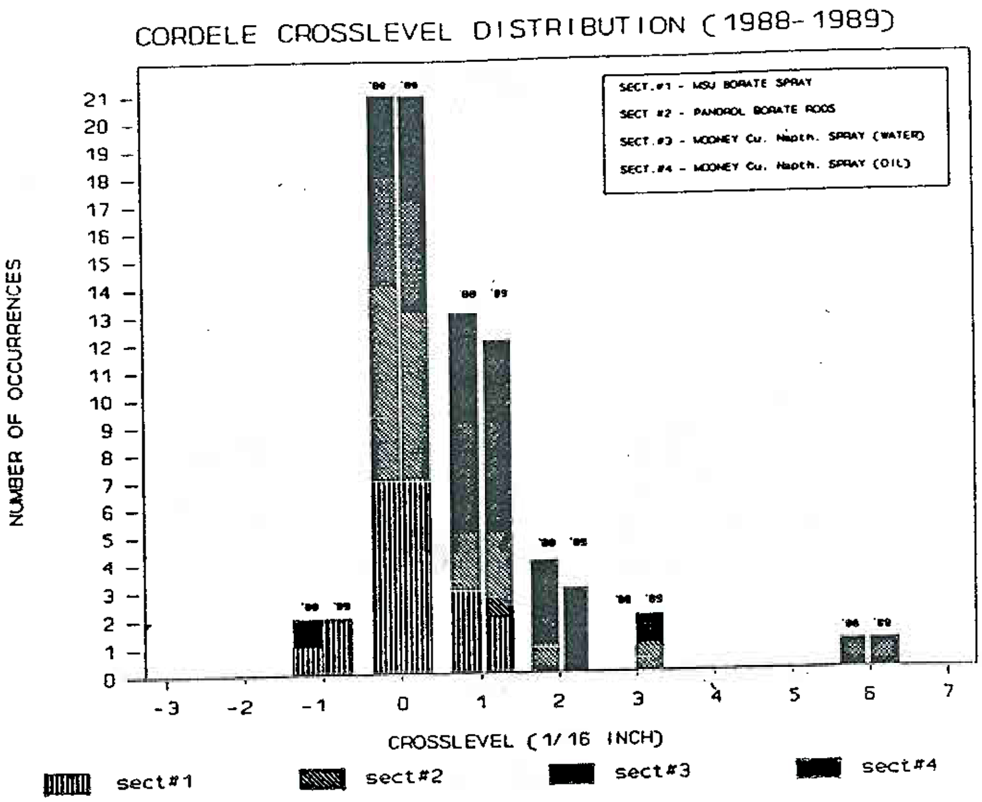
1988	1989
Unloaded Gage	Unloaded Gage
Crosslevel	Crosslevel
Plate Cutting	Plate Cutting
Spike Integrity	LTLF
Moisture Content	

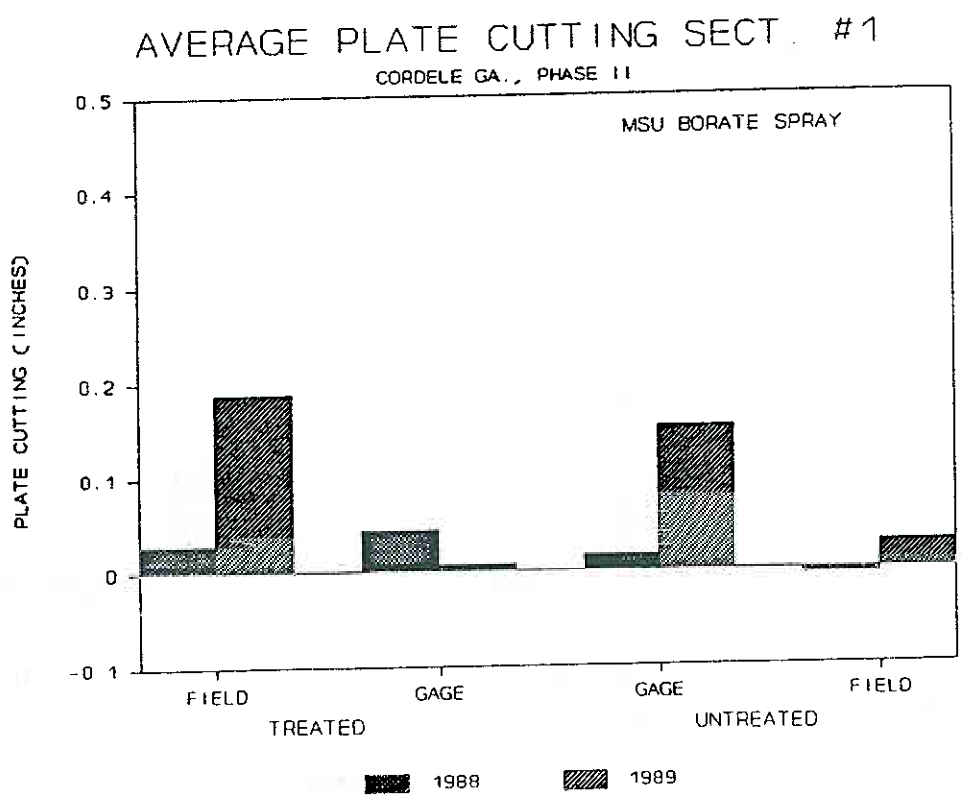
PROBLEMS ENCOUNTERED:

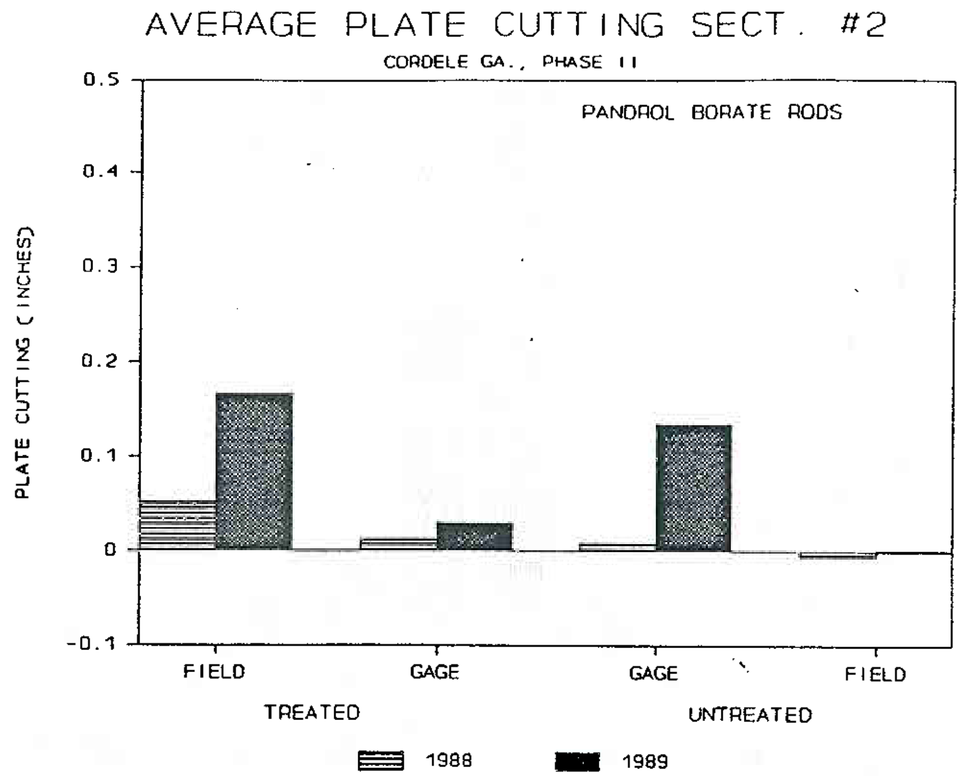
INTERMITTENT TRACK WORK:

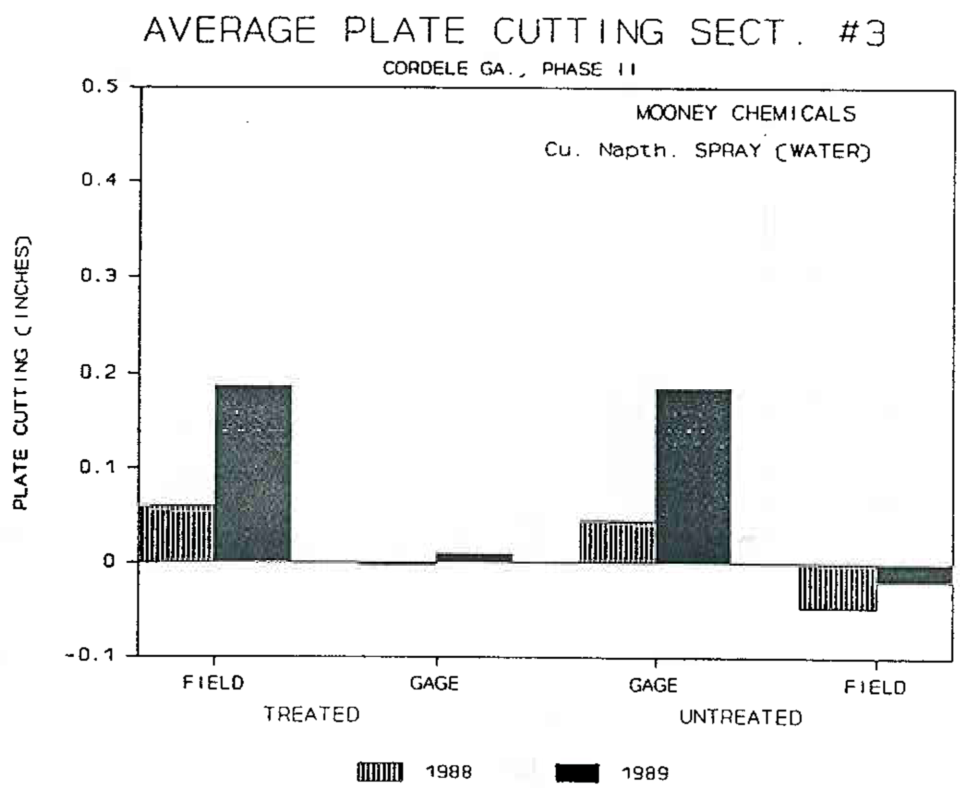
GRAPHS: One year comparisons of Gage, Crosslevel, and Plate Cutting, initial Spike Condition and Moisture Content graphs, and 1 year LTLF measurement.

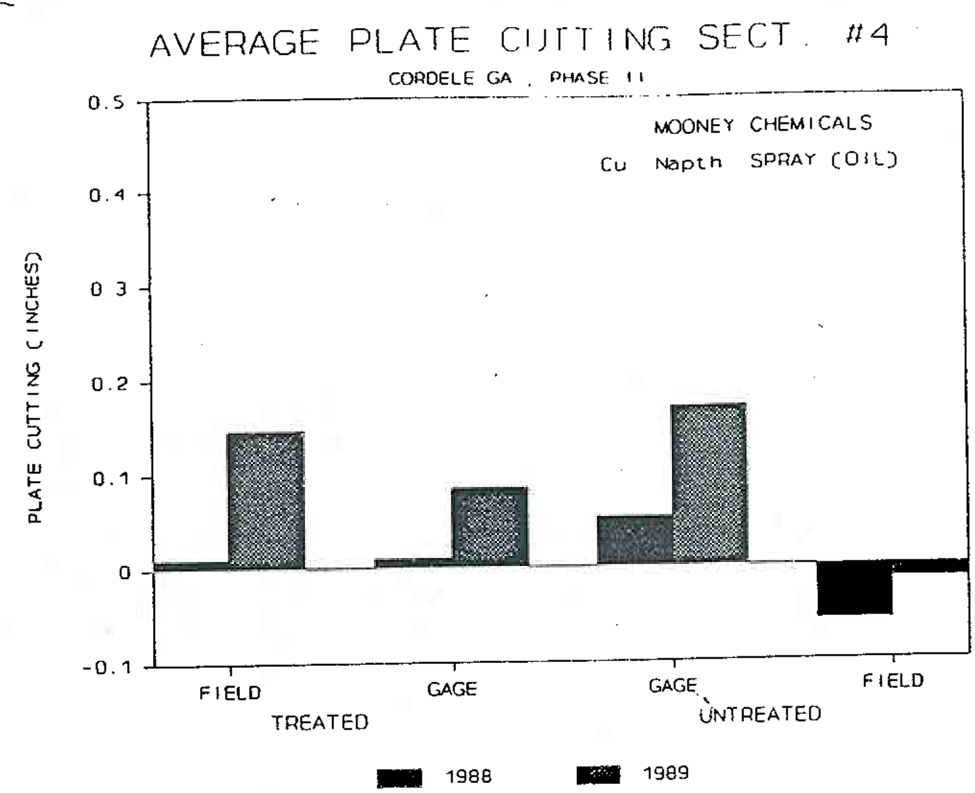
COMMENTS:

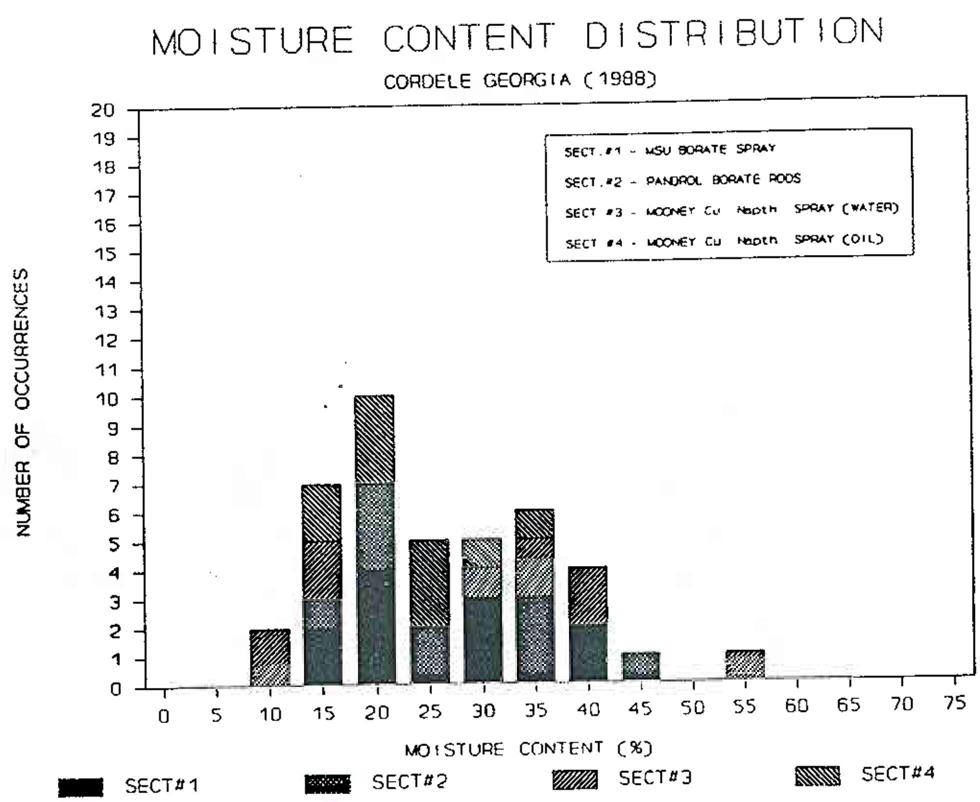

CORDELE CROSSLEVEL DISTRIBUTION (1988-1989)
SECT.#1 - MSU BORATE SPRAY
SECT #2 - PANDROL BORATE RODS
SECT.#3 - MOONEY Cu. Napth. SPRAY (WATER)
SECT.#4 - MOONEY Cu. Napth. SPRAY (OIL)
NUMBER OF OCCURRENCES
CROSSLEVEL (1/16 INCH)
sect#1
sect#2
sect#3
sect#4

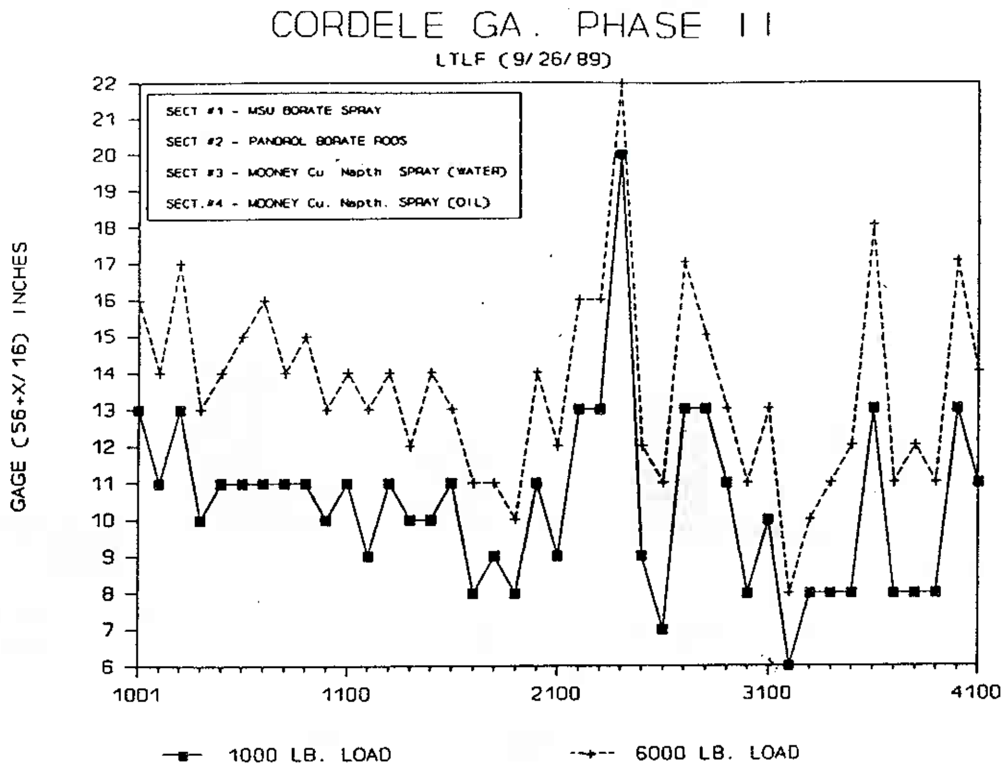

AVERAGE PLATE CUTTING SECT. #1
CORDELE GA., PHASE II
MSU BORATE SPRAY
PLATE CUTTING (INCHES)
FIELD
GAGE
GAGE
FIELD
TREATED
UNTREATED
1988
1989

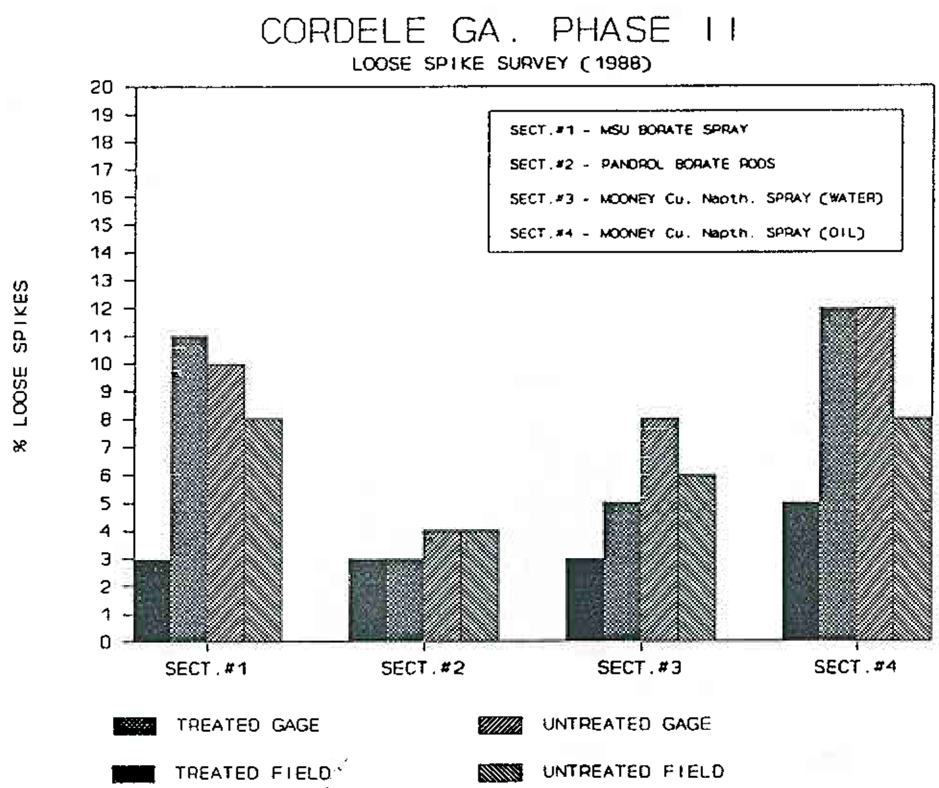

AVERAGE PLATE CUTTING SECT. #2
CORDELE GA., PHASE II
PANDROL BORATE RODS
PLATE CUTTING (INCHES)
0.5
0.4
0.3
0.2
0.1
0
-0.1
FIELD
GAGE
GAGE
FIELD
TREATED
UNTREATED
1988
1989

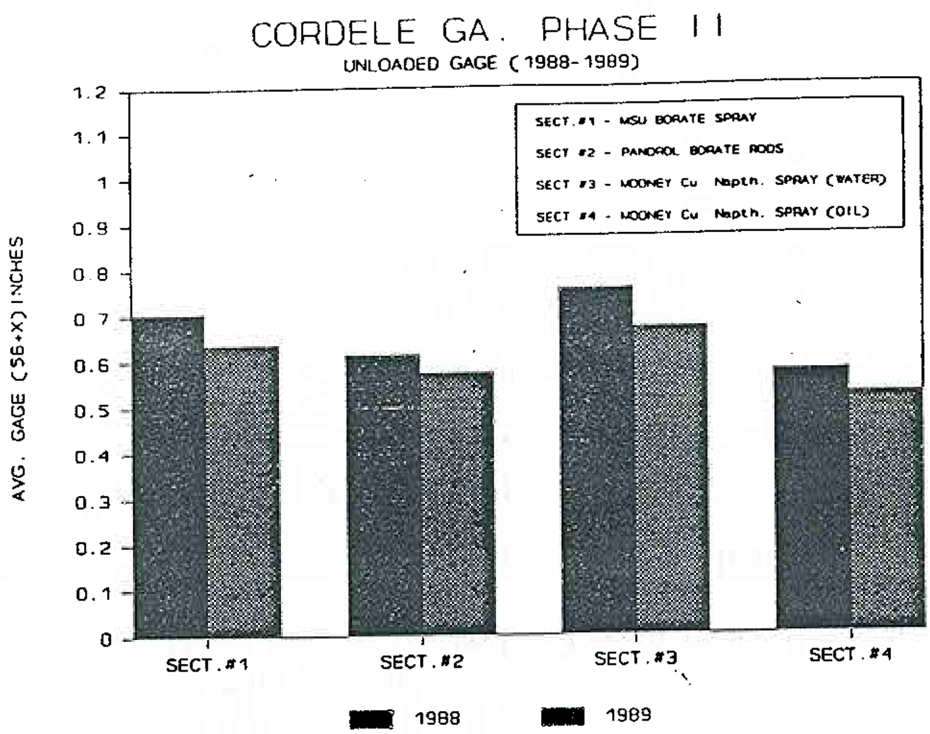

AVERAGE PLATE CUTTING SECT. #3
CORDELE GA., PHASE II
MOONEY CHEMICALS
Cu. Napth. SPRAY (WATER)
PLATE CUTTING (INCHES)
0.5
0.4
0.3
0.2
0.1
0
-0.1
FIELD
GAGE
GAGE
FIELD
TREATED
UNTREATED
1988
1989


AVERAGE PLATE CUTTING SECT. #4
CORDELE GA , PHASE II
MOONEY CHEMICALS
Cu Napth SPRAY (OIL)
PLATE CUTTING (INCHES)
0.5
0.4
0.3
0.2
0.1
0
-0.1
FIELD
GAGE
GAGE
FIELD
TREATED
UNTREATED
1988
1989


MOISTURE CONTENT DISTRIBUTION
CORDELE GEORGIA (1988)
SECT.#1 - MSU BORATE SPRAY
SECT.#2 - PANDROL BORATE RODS
SECT #3 - MOONEY Cu Napth SPRAY (WATER)
SECT #4 - MOONEY Cu Napth SPRAY (OIL)
NUMBER OF OCCURRENCES
MOISTURE CONTENT (%)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
SECT#1
SECT#2
SECT#3
SECT#4


CORDELE GA. PHASE II
LTLF (9/26/89)
SECT #1 - MSU BORATE SPRAY
SECT #2 - PANDROL BORATE RODS
SECT #3 - MOONEY Cu Napth SPRAY (WATER)
SECT.#4 - MOONEY Cu. Napth. SPRAY (OIL)
GAGE (56+X/16) INCHES
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
1001
1100
2100
3100
4100
1000 LB. LOAD
6000 LB. LOAD


CORDELE GA. PHASE II
LOOSE SPIKE SURVEY (1988)
SECT.#1 - MSU BORATE SPRAY
SECT.#2 - PANDROL BORATE RODS
SECT.#3 - MOONEY Cu. Napth. SPRAY (WATER)
SECT.#4 - MOONEY Cu. Napth. SPRAY (OIL)
% LOOSE SPIKES
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
SECT.#1
SECT.#2
SECT.#3
SECT.#4
TREATED GAGE
UNTREATED GAGE
TREATED FIELD
UNTREATED FIELD



* DISCREPANCY OF 3/16 INCH ON GAGE BAR (1989)

2.8 Somerville, TX (Phase II)

ALTERNATIVE TIE TREATMENT STATUS SHEET

SITE:	Somerville, Texas
PHASE:	II
RAILROAD:	AT&SF
TRAFFIC:	30 MGT, 100-Ton unit train traffic
LOCATION:	Texas 36N, tie plant road

INSTALLATION DATE:	1987 borate spray, 3/15/88 borate spray, and 5/22/89 CU. Napth. and borate rods
MEASUREMENT DATE:	5/22/89, 4/24/90
PERSONNEL PRESENT:	K. J. Laine, D. D. Davis, Jerry Waits (Track Supervisor)
MEASUREMENT SCHEDULE:	Initial and 1 year measurements ('89, '91, '93)

INSTALLATION METHODOLOGY: 1987 borate spray ties were installed consecutively (100 used for test measurements). 3/15/88 Borate Spray ties were installed and 100 were used for measurements. 5/22/89 The 2 Mooney Chemical (CU. Napth) and the Pandrol Borate Rod sections were installed (100 consecutive ties each).

TAGGING SCHEME:

TRACK SPECIFICATIONS: Tangent track, 136 RE, CWR, 7 3/4 x 14" tie plates, 7 x 8 x 8.5 mixed hardwoods.

MEASUREMENTS TAKEN:

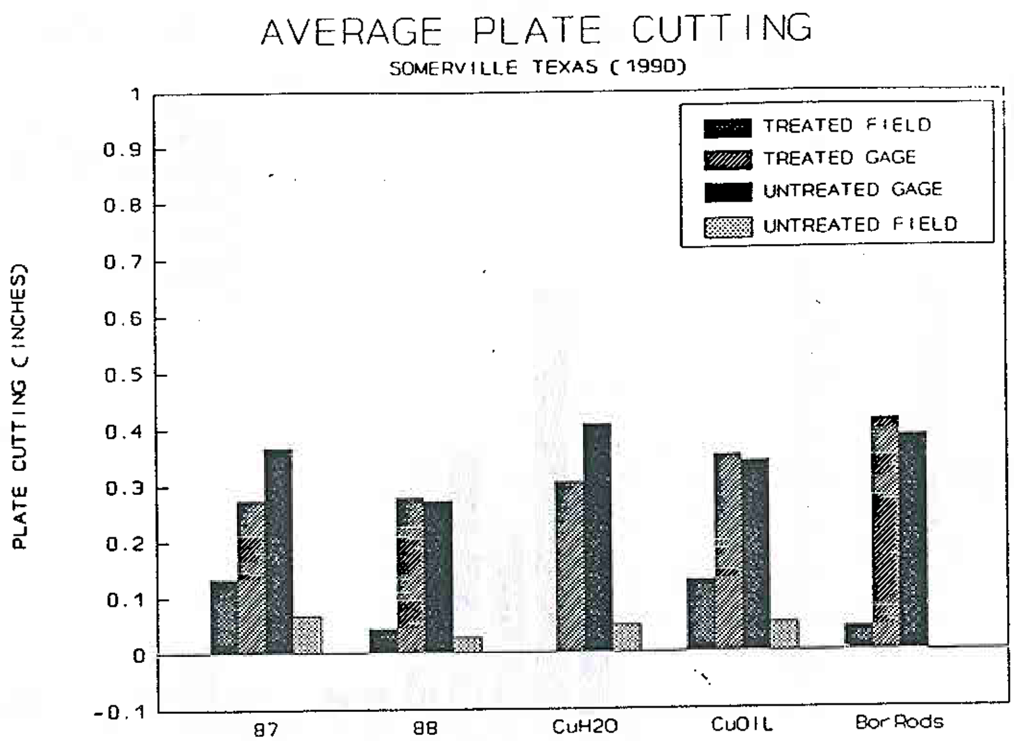
1988	1989	1990
Spike Integrity	Spike Integrity	
	Unloaded Gage	Unloaded Gage
	Crosslevel	Crosslevel
	Plate Cutting	Plate Cutting
	Moisture Content	Moisture Content

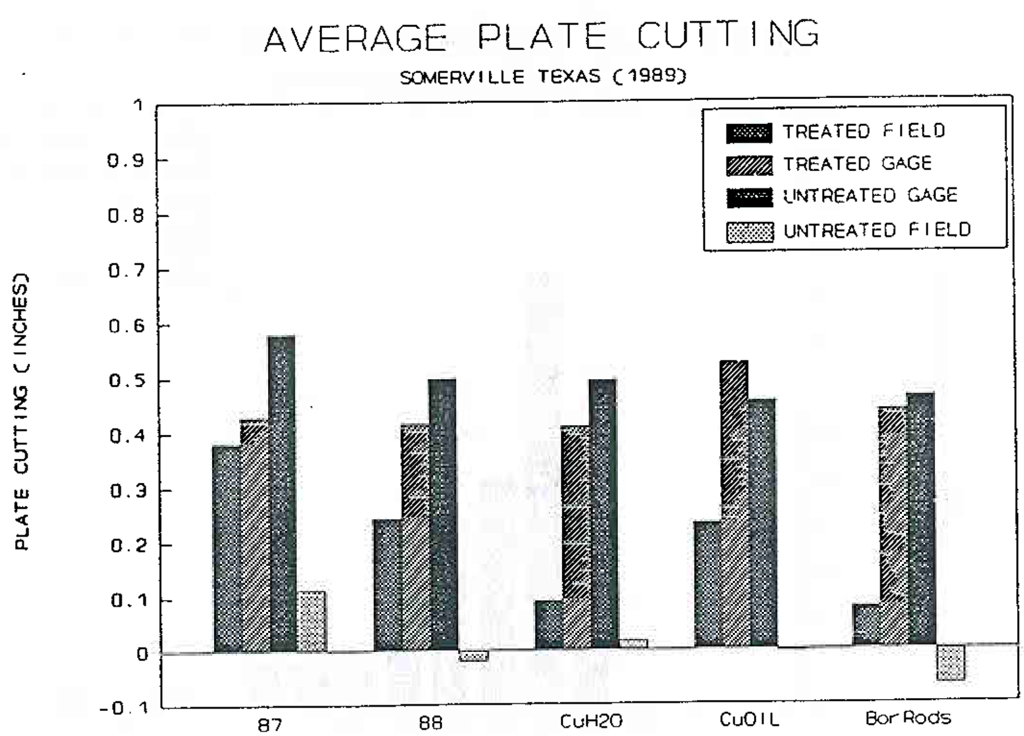
PROBLEMS ENCOUNTERED: Some test ties lost to 1989 tie gang, fire ants.

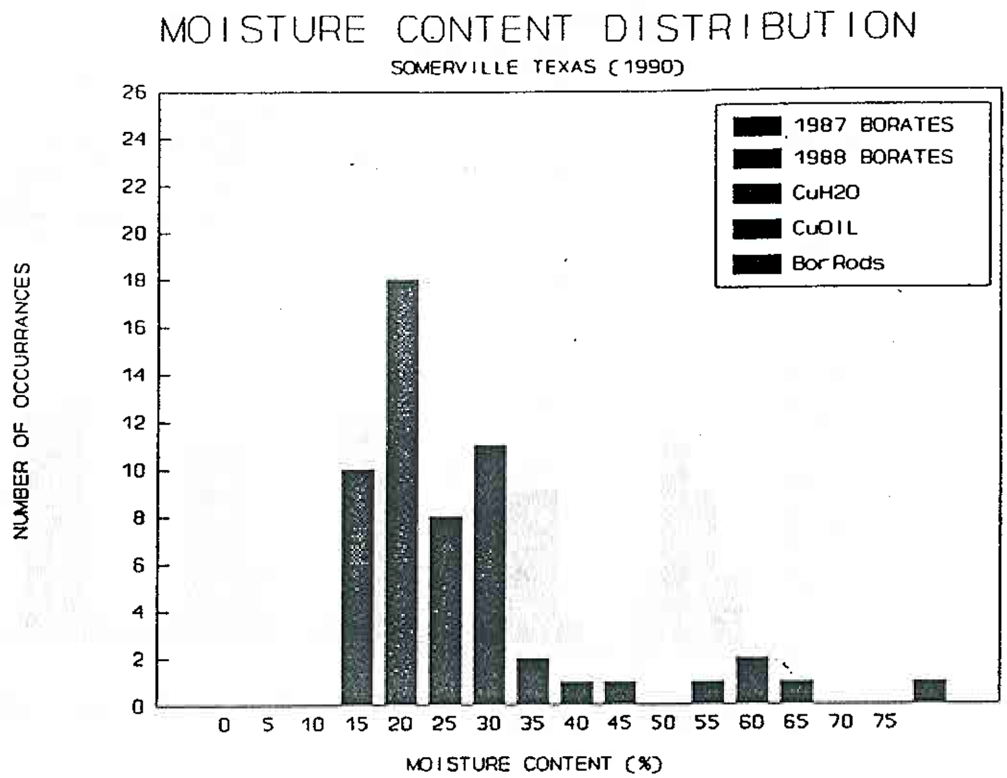
INTERMITTENT TRACK WORK: Tie gang between 1989 and 1990 measurements makes several comparisons difficult.

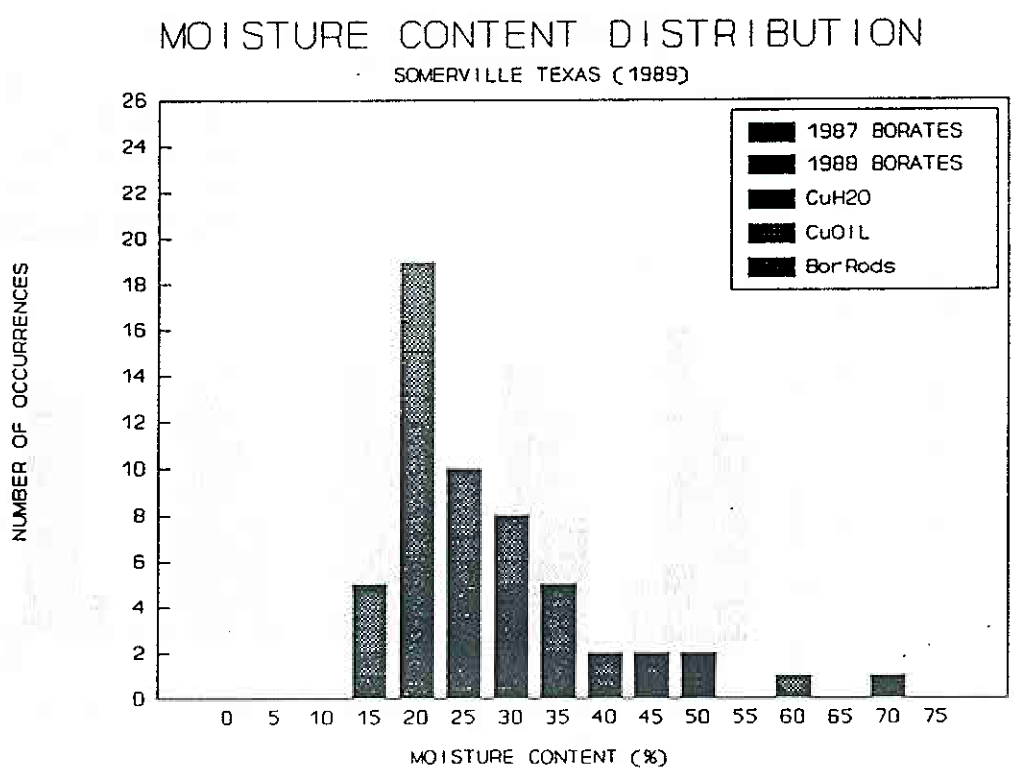
GRAPHS: 1989 and 1990 Gage, Crosslevel, and Moisture Content distributions. 1989 and 1990 average Plate Cutting measurements. 1988 and 1989 Spike Integrity measurements on the two 1987 and 1988 installed borate sprayed sections.

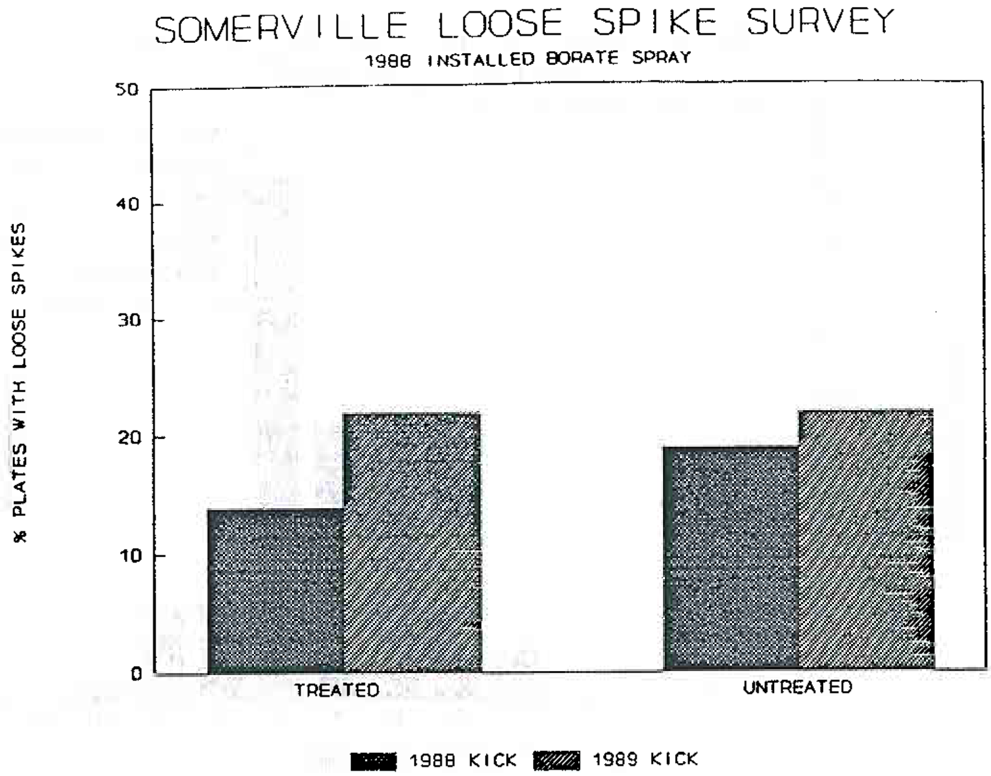
COMMENTS:

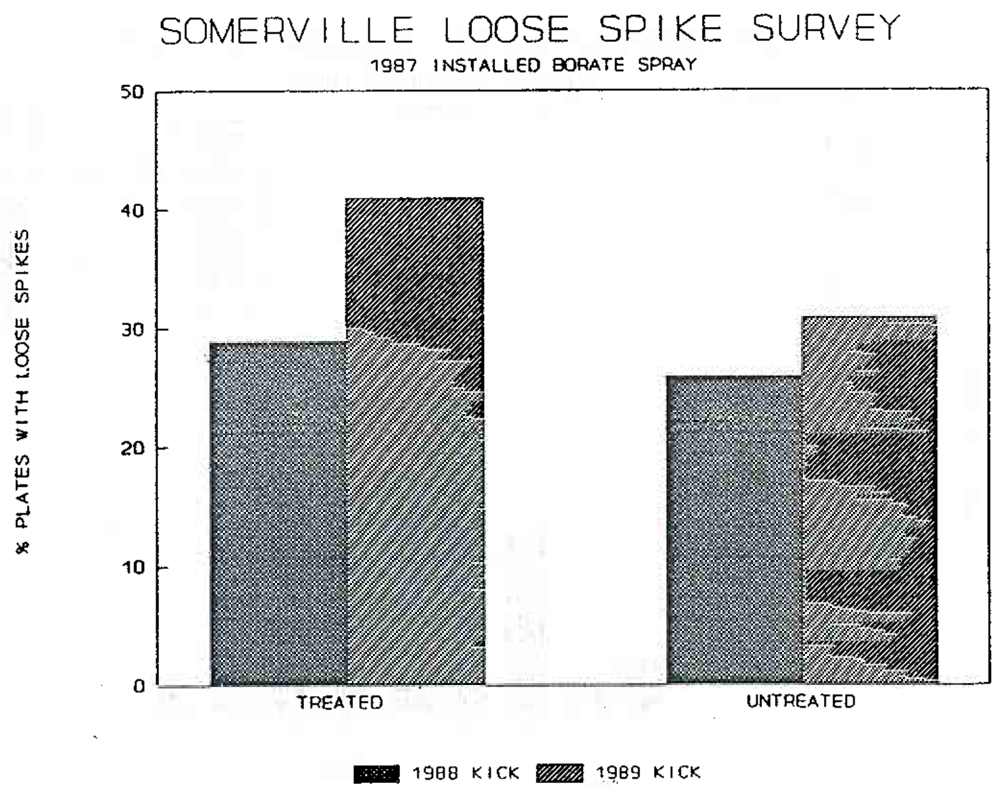

AVERAGE PLATE CUTTING
SOMERVILLE TEXAS (1990)
TREATED FIELD
TREATED GAGE
UNTREATED GAGE
UNTREATED FIELD
PLATE CUTTING (INCHES)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
87
88
CuH2O
CuOIL
Bor Rods

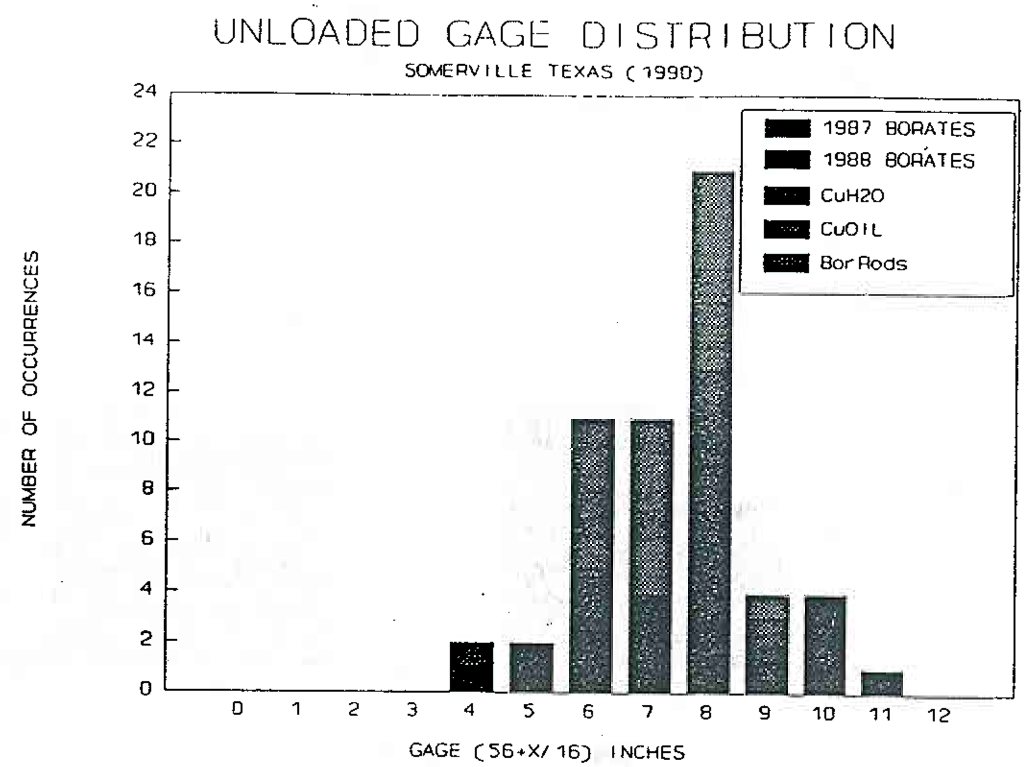

AVERAGE PLATE CUTTING
SOMERVILLE TEXAS (1989)
TREATED FIELD
TREATED GAGE
UNTREATED GAGE
UNTREATED FIELD
PLATE CUTTING (INCHES)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
87
88
CuH2O
CuOIL
Bor Rods

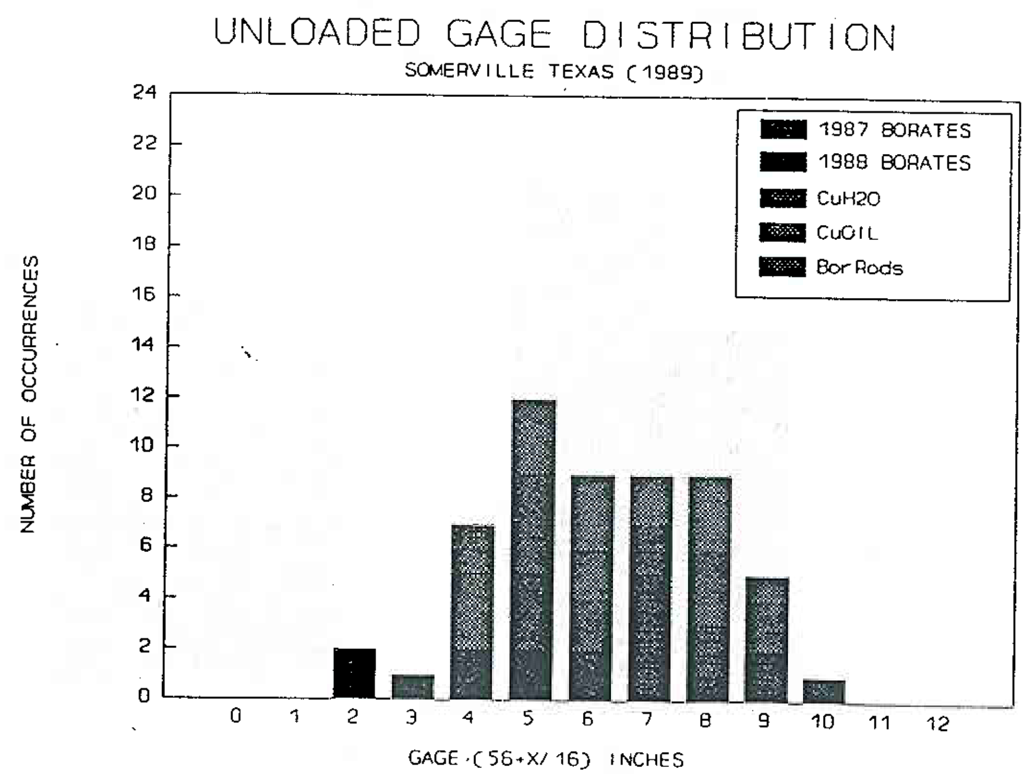

MOISTURE CONTENT DISTRIBUTION
SOMERVILLE TEXAS (1990)
1987 BORATES
1988 BORATES
CuH2O
CuOIL
Bor Rods
NUMBER OF OCCURRANCES
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
MOISTURE CONTENT (%)


MOISTURE CONTENT DISTRIBUTION
SOMERVILLE TEXAS (1989)
1987 BORATES
1988 BORATES
CuH2O
CuOIL
Bor Rods
NUMBER OF OCCURRENCES
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
MOISTURE CONTENT (%)


SOMERVILLE LOOSE SPIKE SURVEY
1988 INSTALLED BORATE SPRAY
% PLATES WITH LOOSE SPIKES
0
10
20
30
40
50
TREATED
UNTREATED
1988 KICK
1989 KICK


SOMERVILLE LOOSE SPIKE SURVEY
1987 INSTALLED BORATE SPRAY
% PLATES WITH LOOSE SPIKES
0
10
20
30
40
50
TREATED
UNTREATED
1988 KICK
1989 KICK


UNLOADED GAGE DISTRIBUTION
SOMERVILLE TEXAS (1990)
NUMBER OF OCCURRENCES
GAGE (56+X/16) INCHES
1987 BORATES
1988 BORATES
CuH2O
CuOIL
Bor Rods


UNLOADED GAGE DISTRIBUTION
SOMERVILLE TEXAS (1989)
NUMBER OF OCCURRENCES
GAGE (56+X/16) INCHES
1987 BORATES
1988 BORATES
CuH2O
CuOIL
Bor Rods

2.9 Jesup, GA (Phase III)

ALTERNATIVE TIE TREATMENT STATUS SHEET

SITE : Jesup, GA.
PHASE: III
RAILROAD: Norfolk Southern, MP 389 H south + east of Jesup towards Brunswick
TRAFFIC: 2-4 MGT, mixed traffic
LOCATION: GA.82, GA.DOT material yard

INSTALLATION DATE: 10/02/88
MEASUREMENT DATE: 09/28/89
PERSONNEL PRESENT: K. J. Laine, D. D. Davis, P. W. Cook (Roadmaster)

MEASUREMENT SCHEDULE: Initial Measurements

Total 1595 ties

INSTALLATION METHODOLOGY: 250 ties were supplied for each of 8 groups participating in the test (not all ties were used). See attached test layout summary.

TAGGING SCHEME: Sections 1000-1250 every tenth tie, 2000-2250 etc.

TRACK SPECIFICATIONS: Ties - 7 x 9 x 8.6" mixed hardwoods, tie plates - 10, 11, 12" plates, 100 lb cwr rail, georgia granite ballast.

MEASUREMENTS TAKEN:

1987

Unloaded Gage
Crosslevel
LTLF
Spike Integrity

PROBLEMS ENCOUNTERED:

Plate cutting measurement device did not fit plates. Wet conditions prohibited moisture content measurements.

INTERMITTENT TRACK WORK:

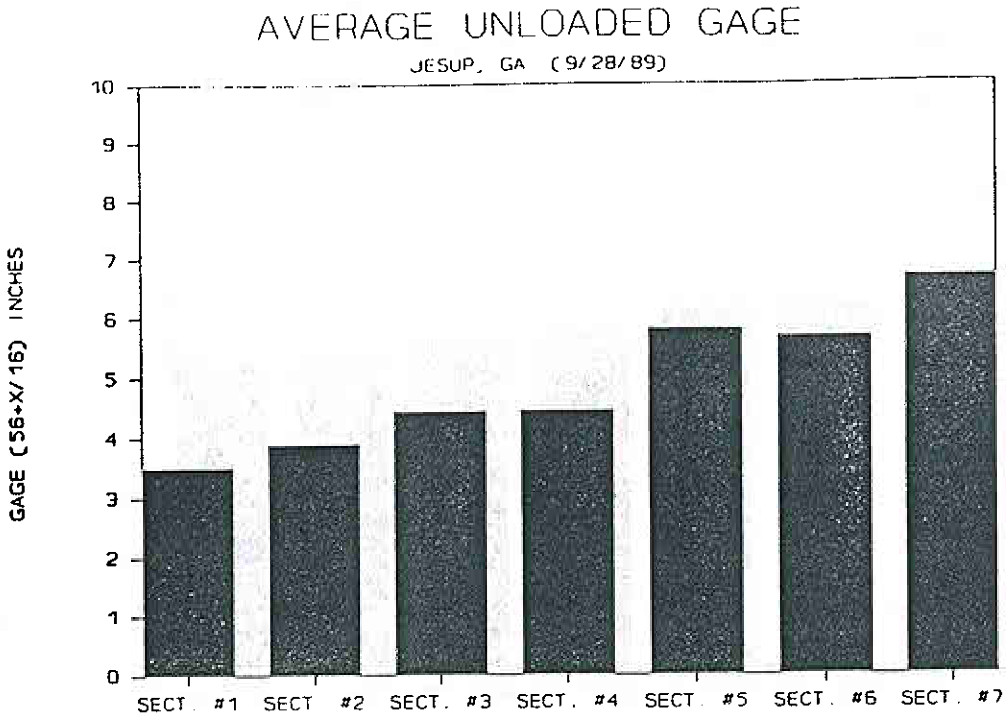
GRAPHS: Unloaded Gage averages for each section, average Crosslevel Error for each section, average Lateral Track Stiffness for each section.

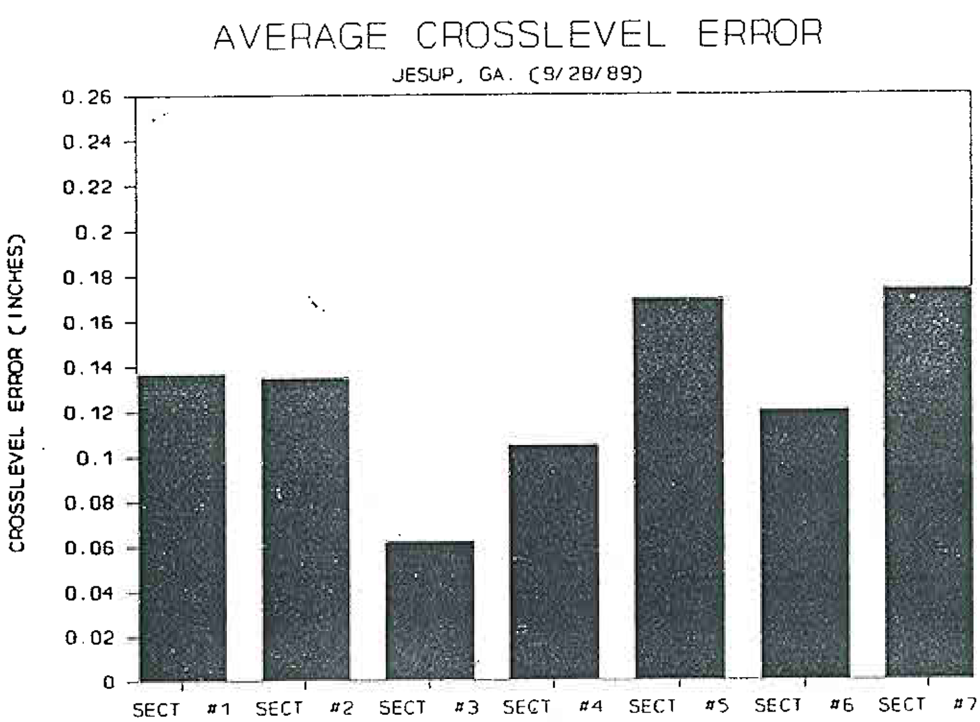
COMMENTS:

— *Phase III* In-Place Treatments
Jesup, Georgia

TEST SECTION	PARTICIPATING COMPANY	MATERIAL USED	NUMBER OF TEST TIES
ONE	OSMOSE	SODIUM FLUORIDE (RODS) SODIUM FLUORIDE (PADS)	30 220
TWO	PANDROL	TIMBER (RODS)	250
THREE	PANDROL	TIMBER (SPIKE HOLE RODS)	75
FOUR	MOONEY	OIL BASED COPPER NAPHTHANATE (SPRAY)	250
FIVE	MOONEY	WATER BASED COPPER NAPHTHANATE (SPRAY)	250
SIX	M.S.U.	TIMBER-CUNAPSOL (PADS)	250
SEVEN	M.S.U.	TIMBOR-CUNAPSOLE-CORROSION INHIBITOR (PADS)	220

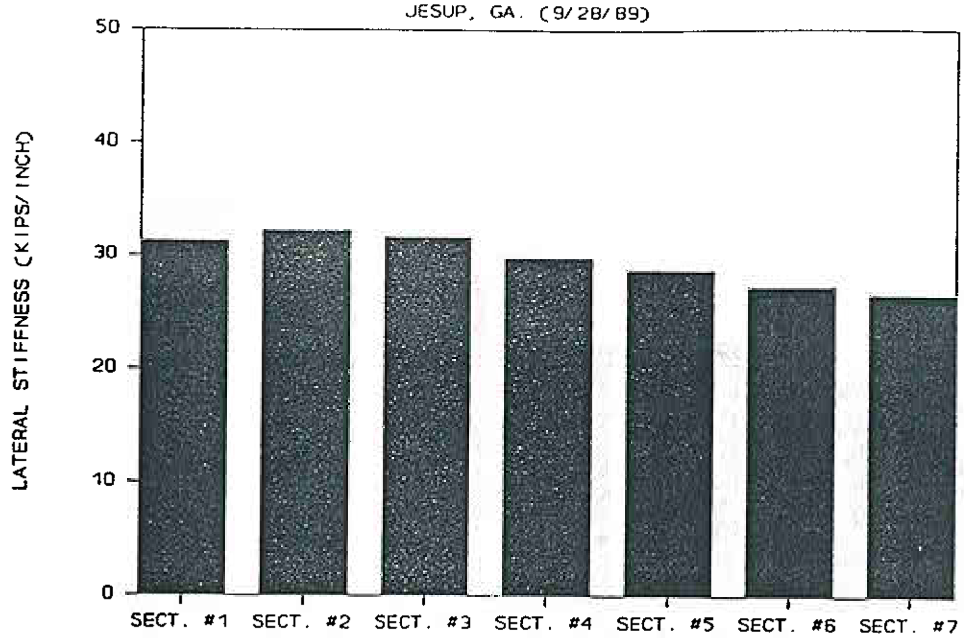
TOTAL = 1545


AVERAGE UNLOADED GAGE
JESUP, GA (9/28/89)
GAGE (56+X/16) INCHES
0
1
2
3
4
5
6
7
8
9
10
SECT. #1
SECT #2
SECT. #3
SECT. #4
SECT. #5
SECT. #6
SECT. #7


AVERAGE CROSSLEVEL ERROR
JESUP, GA. (9/28/89)
CROSSLEVEL ERROR (INCHES)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
0.22
0.24
0.26
SECT #1
SECT #2
SECT #3
SECT #4
SECT #5
SECT #6
SECT #7

AVERAGE LATERAL STIFFNESS (LTLF)

JESUP, GA. (9/28/89)



2.10 Lorenzo, IL (Phase III)

ALTERNATIVE TIE TREATMENT STATUS SHEET

SITE: Lorenzo, Illinois
PHASE: III
RAILROAD: AT&SF, MP 53, Illinois Division
TRAFFIC: 30 MGT, mixed traffic, high speed Intermodal
LOCATION: Lorenzo Rd, Wilmington, Illinois. I-55 south

INSTALLATION DATE: 9/87
MEASUREMENT DATE: 10/27/88, cores 12/7/89
PERSONNEL PRESENT: K. J. Laine, D. D. Davis
MEASUREMENT SCHEDULE: Initial Measurements

INSTALLATION METHODOLOGY: 8 sections; 3 Pandrol sections including Borate Rods (250 tie), Liquid Glycol (150 ties), and a combination of Borate Rods and liquid Glycol (100 ties) -
2 MSU sections including 'Timbor + Cunapsol + Corrosion Inhibitor' pads (167 ties) and a section of 'Timbor + Cunapsol' pads (139 ties) -
2 Mooney Chemicals sections including oil based (250 ties) and water based (225 ties) Copper Naphthenate Sprays -
1 section of Osmose Sodium Fluoride pads (250 ties), The west end of each tie has been treated.

TAGGING SCHEME: BR2 - BR250, GL1 -GL150, GPBR151 - 250, TCCI1 - TCCI81, TCCI82 - TCCI219, BC1 0 BC129, S1 - S250, W1 - W225, SF1 - SF250, Every tenth tie has been tagged.

TRACK SPECIFICATIONS: Tangent, 136 RE CWR, 14" tie plates, paved road crossing in section, turnout between Pandrol sections.

MEASUREMENTS TAKEN:

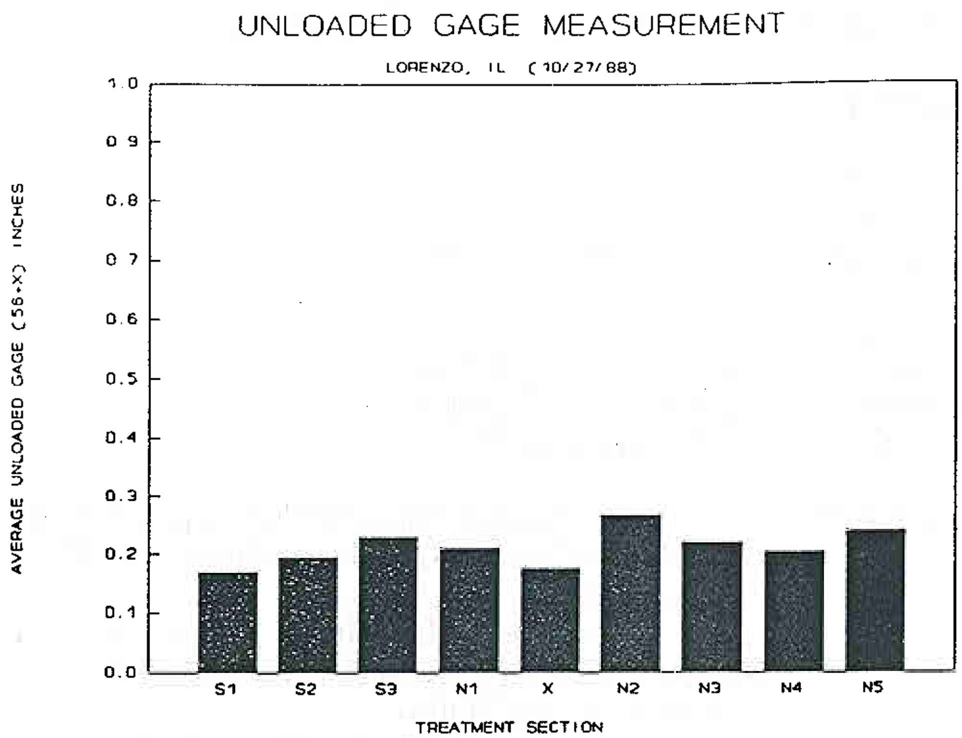
1988
Unloaded Gage
Crosslevel
Spike Integrity
Plate Cutting
LTLF

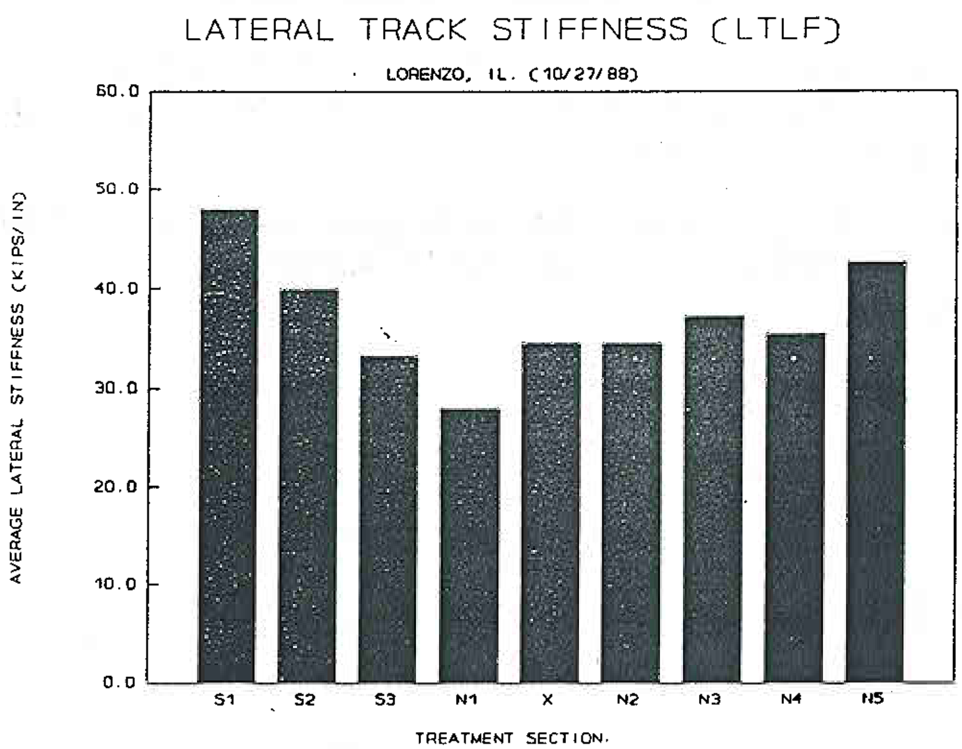
PROBLEMS ENCOUNTERED:

INTERMITTENT TRACK WORK:

GRAPHS: Unloaded Gage Crosslevel averages for each section, LTLF Track Stiffness averages for each section, and Average Plate Cutting for each section.

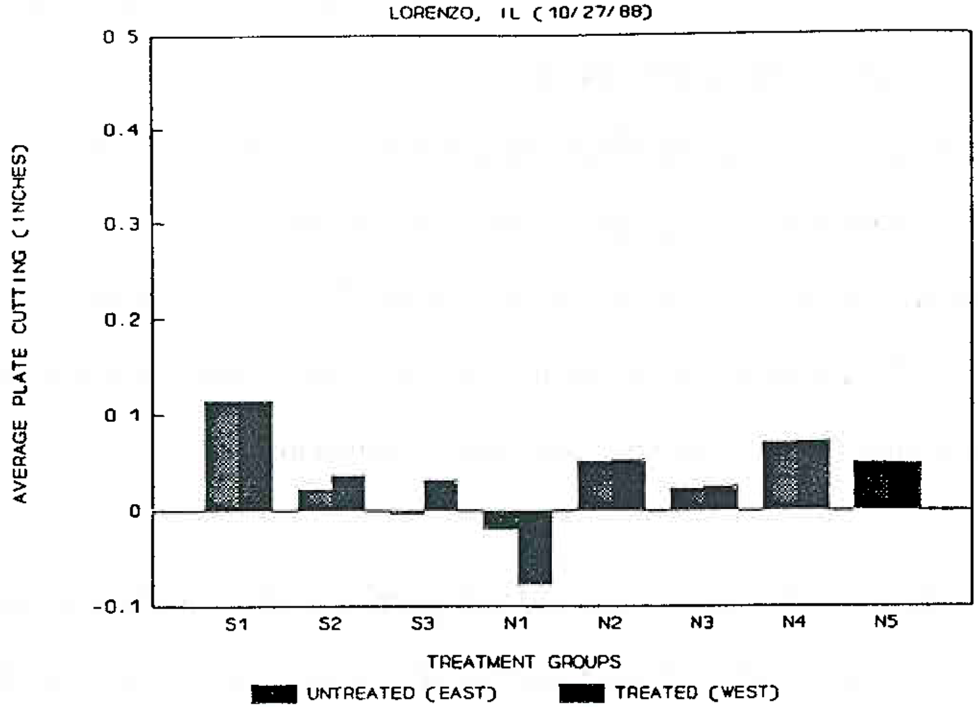
COMMENTS:


UNLOADED GAGE MEASUREMENT
LORENZO, IL (10/27/88)
AVERAGE UNLOADED GAGE (56+X) INCHES
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
S1
S2
S3
N1
X
N2
N3
N4
N5
TREATMENT SECTION


LATERAL TRACK STIFFNESS (LTLF)
LORENZO, IL. (10/27/88)
AVERAGE LATERAL STIFFNESS (KIPS/IN)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
S1
S2
S3
N1
X
N2
N3
N4
N5
TREATMENT SECTION.

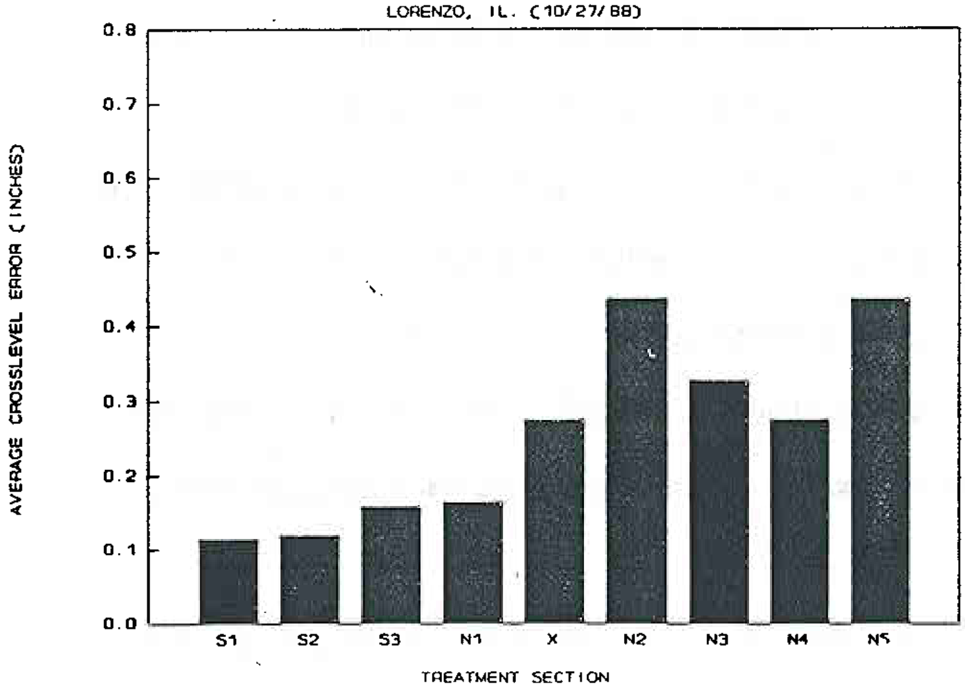
AVERAGE PLATE CUTTING

LORENZO, IL (10/27/88)



CROSSLEVEL MEASUREMENT

LORENZO, IL. (10/27/88)



3.0 TREATMENT RETENTION

The focus of the treatment retention tests is on the effectiveness and longevity of the various treatments. Core sample analysis of the ties at various time intervals provides an assessment of treatment effectiveness and treatment material loss rate. Both are essential for determining the applicability of alternative treatments.

The treatment materials employed in this test have been proven effective in laboratory trials. Their effectiveness in the railroad environment with the extremes of moisture, temperature, loading and drainage is being evaluated.

3.1 Methodology

The ties are sampled at one, three, and five years in track. Initial treatment concentrations were measured for Phase I dip treated ties upon completion of air drying.

Core samples were taken using a small diameter wood coring bit. Cores of .169 or .202 inches diameter and 3 to 4 inch length were obtained.

Exhibits 15-17 show the Santa Fe method of core sampling. The coring is done with a powered drill. The coring bit is held by a special bit holder. This holder allows the core to be removed without disassembling the drill-bit-holder combination. Cores were drilled at various locations on the tie surface. The standard location was in the gage side of the tie plate area. Generally, one sample was taken from each tie. The analysis method used is sensitive enough to determine treatment concentrations from the wood in one core. Upon removal of the core sample, the tie was plugged with an untreated hardwood plug.

The core samples were placed into individual containers and placed in water proof bags. The samples were divided into segments by depth. The top and second half inch segments were analyzed for treatment material concentration.

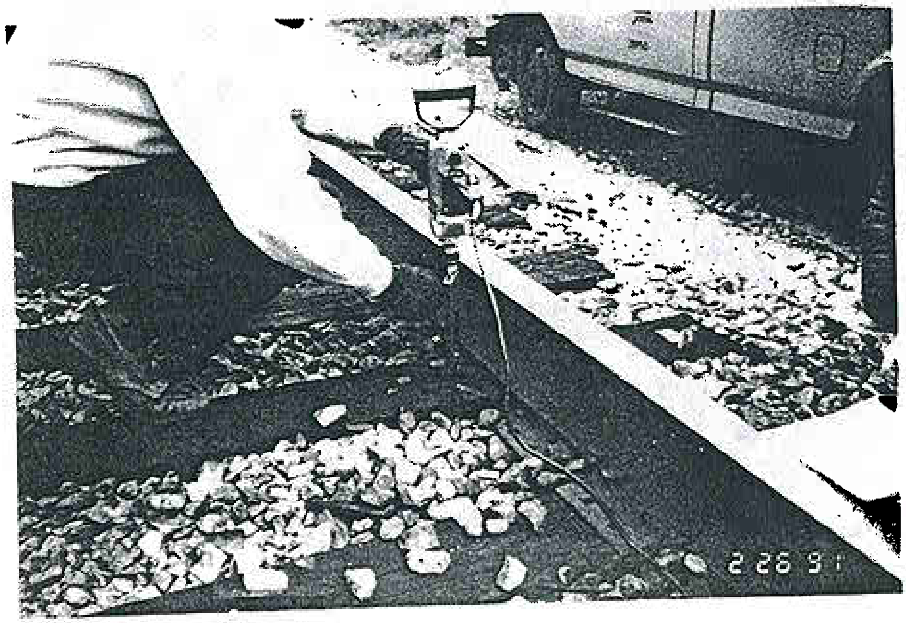


Exhibit 15. Santa Fe Coring Method.

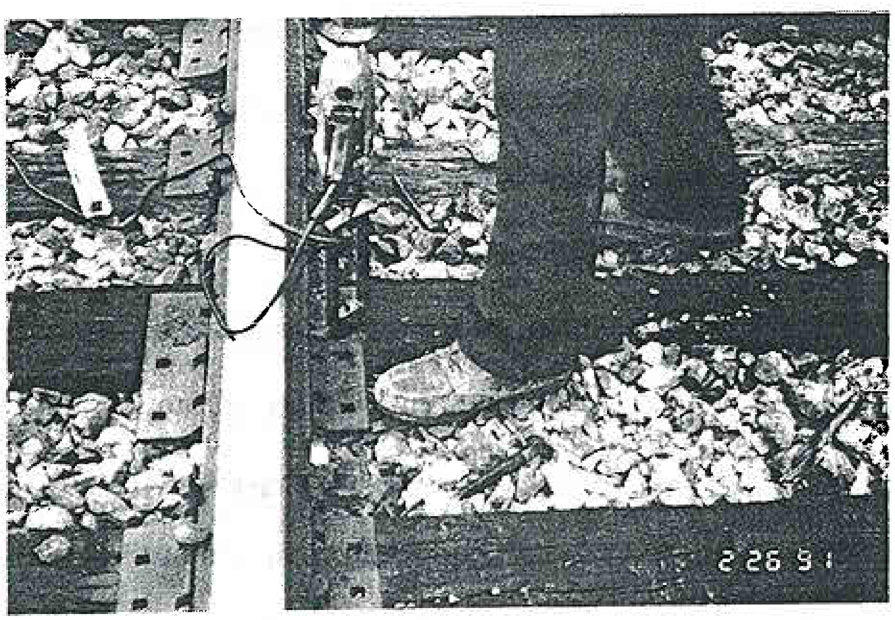


Exhibit 16. Santa Fe Coring Method.

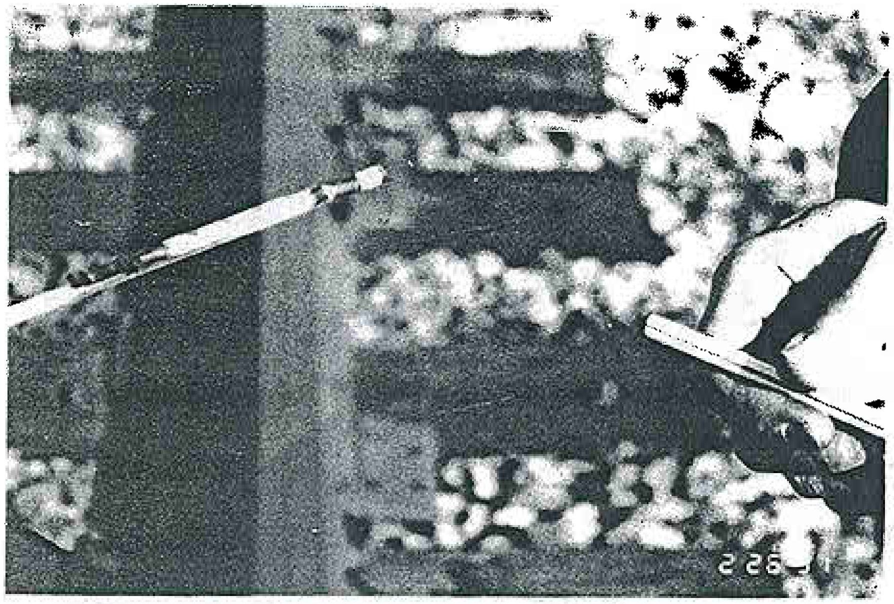


Exhibit 17. Santa Fe Coring Method.

Core analysis was conducted by the Topeka laboratories of the Santa Fe Railway. The analysis for copper and boron based materials was by Inductively Coupled Plasma (ICP) Spectroscopy (see Appendix 7.3 for a discussion of this method). The analysis of fluorine based materials was by American Wood Preservers Standard A2-88, Method 7, Analysis of Fluoride in Wood and Solutions.[3]

3.2 Core Analysis Results - Treatment and Seasoning

The core analysis results will be presented by test phase. The Phase I tests involve new ties. The results cover the entire life of the tie; from seasoning to the present. The Phase II and Phase III ties were treated in track after they had seen various levels of service. The core results cover only a portion of the lives of these ties. Also, the initial condition of these ties varied. However, all were considered to be serviceable at the start of the test.

The results from Phase I test sections consist of an initial post seasoning, pre-creosote treatment analysis, a post creosote treatment analysis, and the first year in service analysis. At this time, results from Cajon, CA and Toluca, IL for one year in track were not available.

The Phase I ties consist of three species of wood: red oak, white oak, and gum. There are also three seasoning methods: vapor drying, conventional air seasoning, and bulk stack air seasoning. In addition, there are five types of creosote treatment: NS standard mixed hardwood treatment with a "60-40"* creosote solution, NS "dip" treatment with a "60-40" creosote solution, no creosote treatment, Santa Fe standard oak treatment with a "30-70" creosote solution, and Santa Fe "dip" treatment with a "30-70" creosote solution.

These five treatments constitute four levels:

NS Standard mixed hardwood treatment - 10-15 pcf
ATSF Standard oak treatment - 7-10 pcf
NS and ATSF dip treatment - 0-2 pcf
No treatment - 0 pcf

3.2.1 Seasoning Methods

The effect of tie seasoning on borate concentration levels was examined in three separate tests. The first test examined the effect of tie "greenness" on borate retention levels. Green ties and air seasoned ties were treated with the standard borate dip treatment. The second test examined the effects of air seasoning and vapor drying on borate retention levels. All ties in this test were dip treated when "green." The third test involved tie stacking configurations during air drying. The effects of standard open tie stack drying vs. a covered bulk

* The proportions of creosote and petroleum are given as percentages.

stack drying were studied in this test.

The first seasoning test is designed to find out when in the seasoning process to borate dip treat ties. Since the borate treatment process is a water diffusion process, ties with high moisture contents are preferred. Thus, treatment when the tie is green will provide the best conditions for borate diffusion. However, if the borate treatment is used in conjunction with another treatment (such as creosote pressure), treatment after seasoning is preferred as this minimizes tie handling. Pressure treatments are most effective after the tie has been seasoned, because the creosote fills some of the space vacated by water.

This test involved two groups of ties; one dip treated after sawing (i.e. green), the other dip treated after air drying for creosote treatment (i.e. dried). Core samples from both groups were taken before creosote treatment. The green ties were bulk stacked for six weeks before being restacked in normal air dry configuration. The dried ties were bulk stacked for six weeks after dip treatment. They were then creosote treated.

Analysis of the cores for borate concentration revealed that both groups absorbed some borates. Exhibit 18 lists the concentration levels for the two groups. For each species tested (red oak and white oak), the green ties had a much higher concentration level. The green ties have concentrations of at least 200 percent of the dried ties.

Analysis of the treatment levels of all boron containing products was standardized by using the Boric Acid Equivalent (BAE) of each treatment. Since the various boron-containing treatments have different molecular structures, use of a BAE factor allows us to make relevant comparisons of the different materials from the core analysis results. Use of the BAE analysis allows us to compare the treatment effectiveness of each product, not the amount of boron in each tie.

While many have proposed treatment level thresholds or standards for borate-based preservatives, none are officially recognized. The American Wood Preservers Association (AWPA) does not have a standard for borate treatment of ties.[3] Mississippi State has proposed a threshold level of 0.35 BAE required to kill active decay already present in wood. This level is higher than that which is needed to prevent decay from occurring in wood.

The green ties had average concentration levels above the threshold value of 0.35 BAE over the entire one inch sampled. The dried ties, however, have average concentrations above the threshold only in the top half inch. The second half inch concentrations are well below the threshold level.

TIE SPECIES	TREATMENT STATUS	BORON CONCENTRATIONS (% BAE)				PERCENT SAMPLES >0.35 BAE	
		MEAN VALUE		STD. DEVIATION			
		TOP 1/2"	2ND 1/2"	TOP	2ND	TOP	2ND
WHITE OAK	GREEN	1.42	0.49	0.87	0.41	93	57
WHITE OAK	DRIED	0.47	0.09	0.24	0.07	80	0
RED OAK	GREEN	1.26	0.50	0.62	0.25	90	77
RED OAK	DRIED	0.55	0.18	0.24	0.12	80	0

Exhibit 18. Borate Concentrations for Various Dip Treatment States.

Summary: Dip treatment of dried ties is not sufficient for decay prevention. New tie treatment should be done with green ties. A 3 minute dip in heated borate solution, followed by bulk stack storage (6 weeks) and air stack seasoning, produces a tie with sufficient levels of treatment to kill decay.

The second seasoning test involved a comparison of air drying and creosote treatment vs. vapor drying and creosote treatment. The effect of each sequence on borate retention levels was analyzed. The purpose of this test is to assess the effects of artificial seasoning on borate retention levels.

In the vapor drying process, the green tie is boiled in a xylene solution. When sufficient water has been removed, the tie is then pressure treated with creosote without removal from the cylinder.

Red Oak, White Oak and Gum ties (20 each) were selected for this test. The ties from each species were divided into two groups. Both groups of ties were dip treated when green and bulk stacked for six weeks. The vapor dried ties were then vapor dried and creosote treated. The air dried ties were restacked for air drying. After creosote treatment, each group was core sampled. The results are given in Exhibit 19.

Creosote pressure treatment in conjunction with vapor drying results in some loss in borate concentration. This loss averages about 0.30 BAE in the top half inch and 0.24 BAE in the second half inch. The effect is much more significant on the second half inch. The concentration levels are decreased to less than half of the pre-creosote levels. The percentage of samples with concentrations above the threshold level decreased dramatically.

The vapor drying related losses are significant, but do not render the borate treatment useless. The ties produced still have average concentration levels well above the borate threshold in the top half inch. There is sufficient borate material for effective diffusion treatment of the interior of the tie.

WOOD SPECIES	BORING SECTION	% BORIC ACID EQUIVALENT (BAE) AVE (STD. DEV.)		PERCENT OF SAMPLE >0.35 BAE	
		BEFORE CREOSOTE TREATMENT	AFTER CREOSOTE TREATMENT	BEFORE CREOSOTE TREATMENT	AFTER CREOSOTE TREATMENT
WHITE OAK	TOP 1/2"	1.42 (0.87)	1.02 (0.50)	93.3	93.3
	2nd 1/2"	0.49 (0.41)	0.22 (0.21)	56.8	20.0
RED OAK	TOP 1/2"	1.26 (0.62)	1.13 (0.50)	90.0	100.0
	2nd 1/2"	0.50 (0.25)	0.19 (0.13)	76.7	26.7
GUM	TOP 1/2"	1.48 (0.82)	1.13 (0.69)	86.7	90.0
	2nd 1/2"	0.27 (0.35)	0.13 (0.20)	20.0	6.7

Exhibit 19. Effect of Vapor Drying on Borate Concentration.

The loss of borate from the vapor drying process can be explained by the removal of water from the ties. The vapor drying process rapidly removes water from the tie. The borates (in the heated solution) are removed as well, whereas, in the air drying process the relatively slow evaporation of water leaves the borates in the tie. It appears likely that the extent of borate loss will depend on the initial borate concentration, the initial moisture content, and the extent of drying.

The third seasoning test involved the use of a bulk stack storage method and the regular air-drying stack storage method. The purpose of this test is to determine the benefits of a bulk stack wet storage period (of six weeks) in increasing borate retention. The wet storage procedure allows the borate material loaded on the surface of the tie (by dipping) to diffuse into the wood. The high moisture content permits diffusion to occur at higher rates. After the six week bulk stack storage, the ties are re-arranged into a conventional air dry stack. The air dry stack is required for drying the ties before conventional creosote pressure treatment

For ties that are to be air dried, the bulk stacking operation adds an additional step (and its attendant costs) to the process. However, it may be necessary to achieve the required concentration levels. It appears likely that the need for bulk stacking is dependent on the initial moisture content of the ties and the drying conditions.

Exhibit 20 lists the borate concentrations of the standard air drying stacked ties and the bulk stacked ties. The results show a significant increase in borate concentrations with the bulk stack methods. The concentrations are significantly higher in both red oak and white oak species. Concentrations in the second half inch were at least double the air stack values.

Tie Species	Stack Configuration	Boron Concentrations Mean	Value	Std. Deviation		Percent Samples >0.35 BAE	
		Top 1/2 in.	2nd 1/2 in.	Top	2nd	Top	2nd
White Oak	Bulk	1.42	0.49	0.87	0.41	93	57
White Oak	Air	0.65	0.14	0.35	0.20	83	7
Red Oak	Bulk	1.26	0.50	0.62	0.25	90	77
Red Oak	Air	0.90	0.24	0.45	0.20	93	20

Exhibit 20. Borate Concentrations vs. Stacking Configuration (Dip Treated Green Ties).

3.2.2 Creosote Treatment Effects

The effect of creosote treatment on borate concentrations was examined. A small sample of oak ties were selected for analysis to determine the borate concentration loss during creosote pressure treatment.

The purpose of this test is to determine the compatibility of borate dip treatments and creosote pressure treatment. The borate treatment may be used as a supplement to creosote treatment. The borates will protect wood during seasoning (before creosote treatment). After creosote treatment the borates will diffuse into the center of the tie; protecting the material below the pressure treated layer. The creosote treatment should benefit the borates by reducing moisture flow through the tie. This may reduce leeching losses.

The test involved red and white oak species. Core analysis of borate concentrations were conducted just prior to and after creosote treatment. All ties were dip treated when green, and some were bulk stacked for six weeks before all were air dried. The creosote treatment process used was the Santa Fe oak treatment: "30-70" solution, 7-9 pcf retention.

The results (Exhibit 21) show that creosote pressure treatment has little effect on borate concentration levels. The pre-creosote treatment and post-creosote borate concentration levels are virtually the same. This result was expected. Properly seasoned ties do not lose much water during creosote treatment. Borates are not soluble in creosote solutions. Thus, the borate concentration should not be radically changed by creosote pressure treatment.

This result has great practical implications. An improved product may be had by use of a two phase treatment. A water diffusible treatment may be applied before seasoning green lumber and an oil based pressure treatment may be applied after seasoning. The compatible treatments may be applied to cover more of the tie over a longer (earlier) period of time.

WOOD SPECIES	STACK CONFIGURATION	PLASTIC COVERING	BORING SECTION	% BAE AVE (STD. DEV.)	
				BEFORE CREOSOTE TREATMENT	AFTER CREOSOTE TREATMENT
Red Oak	Open	No	Top 1/2"	0.48 (0.17)	0.50 (0.34)
			2nd 1/2"	0.17 (0.13)	0.22 (0.11)
	Open	Yes	Top 1/2"	0.75 (0.36)	0.72 (0.28)
			2nd 1/2"	0.48 (0.17)	0.43 (0.18)
	Bulk	Yes	Top 1/2"	0.85 (0.36)	0.86 (0.26)
			2nd 1/2"	0.52 (0.23)	0.49 (0.17)
White Oak	Open	No	Top 1/2"	0.39 (0.21)	0.43 (0.20)
			2nd 1/2"	0.17 (0.16)	0.18 (0.19)
	Open	Yes	Top 1/2"	0.50 (0.19)	0.61 (0.27)
			2nd 1/2"	0.37 (0.11)	0.39 (0.11)
	Bulk	Yes	Top 1/2"	0.80 (0.37)	0.84 (0.40)
			2nd 1/2"	0.42 (0.15)	0.41 (0.17)

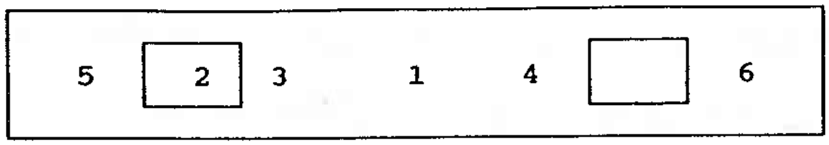
Exhibit 21. Effect of Creosote Treatment on Borate Concentration for Air Dried Ties.

Very little effect

3.2.3 Location in Tie Effects

In order to determine the distribution and movement of borate material in the tie, core samples were taken at several locations across the tie at two test sites. The sites are: Milano, Texas and Montgomery, Texas.

Core sampling from one, two, three and five locations on the tie were made. Exhibit 22 shows the locations and how they were labeled.



1 - Center

2 - Tie Plate Area

3 - Low Rail Gage Side

4 - High Rail Gage Side

5 - Low Rail Field Side

6 - High Rail Field Side

Exhibit 22. Core Sample Locations (plan view).

Statistical analysis of the data at the Milano site showed significant differences (95% confidence) between the population means of cores taken from (the top half inch) position 1, and cores taken from positions 5 and 6. This data was derived from cores taken from the same ties (i.e. cores were taken from position 1 and position 5 or position 6).

While the ties were evenly treated (dipped in a solution) initially, some uneven concentrations of borates have developed. The lower concentrations at the ends of the tie correspond with the lower moisture contents typically seen in the end of air dried ties.

Similar statistical tests of all positions show that the center locations (1, 3 and 4) are different from the outer ones (5, 6). The concentration of borates outside the rails is lower than the concentration inside the rails.

The analysis of the 2nd half inch revealed no statistically significant differences between any positions. The 2nd half inch average concentrations are considerably lower than the top half inch; while the variability is higher.

Due to the sampling scheme, no direct comparison between center (position 1) and plate area (position 2) samples on the same ties was possible. However, comparison of ties from the same treatment and seasoning groups was made. Results of these tests showed a difference in population means between position 1 and position 2 at both the top half inch and 2nd half inch. The tests show a population mean difference at 90 % confidence for the 36 samples.

The position one cores had higher concentrations in the top half inch, while the position two cores had higher concentrations in the second half inch. Exhibit 23 shows this.

POSITION NUMBER (S)	POSITION NAME	AVERAGE CONCENTRATION (BAE)		TOP 1.0 INCH
		TOP 0.5 INCH	2ND 0.5 INCH	
1	Center	.546	.273	.410
3 and 4	Gage	.582	.230	.406
2	Plate	.332	.393	.363
5 and 6	Field	.353	.353	.353

Exhibit 23. Borate Concentration by Sample Location.

The "pattern" is clear when one looks at total borate concentration in the first inch of material. The center has the highest concentration; with decreasing concentration towards the ends. The effect of the tie plate appears to provide a better local environment for diffusion. In effect, it is similar to the bulk stack storage conditions. Recent work[4] has shown that the tie plate area has a higher moisture content than the rest of the tie. This would result in the relatively low top half inch concentrations and the relatively high second half inch concentration.

3.2.4 Species Effects

The effect of tie species on borate concentrations from the dip treatments was relatively small. The results obtained from the dip treated and bulk stacked air dried ties were all within 20 % of the smallest average value. With the relatively small sample sizes and large variations of values, the true effect of species is not known. However, the data collected suggests that the effect is not major. This is expected since all species tested are hardwoods; with the same water transport structure.

Determining the effect of species on borate concentrations is further complicated by the variations in moisture content, both before and after seasoning. The test was conducted in a working treatment plant. No facilities were available to control the drying process. Thus, the green ties were received at their natural moisture contents and all were dried for the same period. This resulted in variations in moisture content at creosote treatment. Analysis of core samples revealed that the gum ties were the driest (average M. C. = 22.5), the red oaks were the wettest (average M. C. = 54.1) and the white oaks were in the middle (average M. C. = 34.0).

An "F" test of population means was conducted on samples from Milano Texas to compare the red oaks and white oaks. The boron concentrations (in BAE) from core analysis were used. The data consisted of 39 samples of red oak and 39 samples of white oak material.

The results are given in Exhibit 24. The results indicate that there is not a significant difference (90% confidence) between red oak and white oak samples in the top half inch of tie. However, there is a significant difference (95% confidence) between red oak and white oak samples in the second half inch of tie. The red oaks have a higher average value.

TOP HALF INCH	SPECIES	
"F" STATISTIC:	2.313840	samples: 39
POPULATIONS ARE DIFFERENT at confidence level (%): <90		means: (red) 0.526 (white) 0.419

2ND HALF INCH	SPECIES	
"F" STATISTIC:	6.636153	Samples: 39
POPULATIONS ARE DIFFERENT at confidence level (%): 95		means: (red) 0.349 (white) 0.233

Exhibit 24. Statistical Test Results - Species.

3.3 Core Analysis Results Field Tests

The field tests are designed to determine the viability and longevity of the treatments under a variety of typical railroad operating situations. The field trails also allowed test participants to gain first hand knowledge of the practical challenges of applying in-place treatments to ties under track maintenance conditions.

A five year program of sampling and treatment analysis is scheduled to evaluate the treatments performance. The following sections discuss the preliminary results from just one round of inspections. No firm conclusions can be drawn from the limited data collected to date.

3.3.1 Phase I Field Results

Exhibit 25 lists the borate test ties at each site. Several of the Phase I sites have been inspected. Core sample results have been obtained from the Cordele, GA; Milano, TX; and Montgomery, TX sites.

The results of core analysis are given in Exhibit 26. The three sites were cored after 12-13 months in track. The results show that the ties generally still have higher borate concentrations in the top 0.5 inches.

The lower concentrations in the gum ties are due, in part, to the longer period of time that they have been in track. Climate may also be playing a significant role. It should be remembered that all of the ties were borate treated at the same time (February, 1987). The differences in dates of installation and dates of sampling result in the different ages listed.

From Exhibit 26 one can see that the variability in the ties borate concentrations is quite large. The standard deviations of the samples are from 30 to 100 percent of the mean values. The result indicates a need to increase the sample size in future inspections. Exhibit 27 further emphasizes this point. The table shows the mean concentration change from before installation to the first field inspection. The annualized "loss rate" is also given and some of the concentration changes are positive.

TEST SITE	PROG. PHASE	TEST SECTION	COMPANY	PROD TYPE	ANALYSIS MATERIAL	NUMBER OF TIES	DATE INSTALLED
MILANO	TX	RBA	ATSF	DIP	BORON	10	6/88
MILANO	TX	RBB	ATSF	DIP	BORON	10	6/88
MILANO	TX	RBC	ATSF	DIP	BORON	10	6/88
MILANO	TX	WBA	ATSF	DIP	BORON	10	6/88
MILANO	TX	WBB	ATSF	DIP	BORON	10	6/88
MILANO	TX	WBC	ATSF	DIP	BORON	10	6/88
MONTGOM	TX	RBA	ATSF	DIP	BORON	10	6/88
MONTGOM	TX	RBB	ATSF	DIP	BORON	10	6/88
MONTGOM	TX	RBC	ATSF	DIP	BORON	10	6/88
MONTGOM	TX	WBA	ATSF	DIP	BORON	10	6/88
MONTGOM	TX	WBB	ATSF	DIP	BORON	10	6/88
MONTGOM	TX	WBC	ATSF	DIP	BORON	10	6/88
CORDELE	GA	GB	NS	DIP	BORON	100	2/88
CORDELE	GA	GBC	NS	DIP	BORON	100	2/88
CORDELE	GA	GBN	NS	DIP	BORON	200	2/88
CORDELE	GA	GBS	NS	DIP	BORON	50	2/88
AIKMAN	KS	RBA	ATSF	DIP	BORON	10	6/88
AIKMAN	KS	RBB	ATSF	DIP	BORON	10	6/88
AIKMAN	KS	RBC	ATSF	DIP	BORON	10	6/88
AIKMAN	KS	WBA	ATSF	DIP	BORON	10	6/88
AIKMAN	KS	WBB	ATSF	DIP	BORON	10	6/88
AIKMAN	KS	WBC	ATSF	DIP	BORON	10	6/88

Exhibit 25. Phase I Alternative Tie Treatment Summary.

TEST SITE	PROG. PHASE	TEST SECTION	COMPANY	PROD TYPE	ANALYSIS MATERIAL	NUMBER OF TIES	DATE INSTALLED
TOLUCA	IL	RBA	ATSF	DIP	BORON	60	6/88
TOLUCA	IL	RBB	ATSF	DIP	BORON	60	6/88
TOLUCA	IL	RBC	ATSF	DIP	BORON	60	6/88
TOLUCA	IL	WBA	ATSF	DIP	BORON	60	6/88
TOLUCA	IL	WBB	ATSF	DIP	BORON	60	6/88
TOLUCA	IL	WBC	ATSF	DIP	BORON	60	6/88
TOLUCA	IL	GBV	ATSF	DIP	BORON	10	6/88
TOLUCA	IL	RBV	ATSF	DIP	BORON	10	6/88
TOLUCA	IL	WBV	ATSF	DIP	BORON	10	6/88
CAJON	CA	RBA	ATSF	DIP	BORON	10	8/88
CAJON	CA	RBB	ATSF	DIP	BORON	10	8/88
CAJON	CA	RBC	ATSF	DIP	BORON	10	8/88
CAJON	CA	WBA	ATSF	DIP	BORON	10	8/88
CAJON	CA	WBB	ATSF	DIP	BORON	10	8/88
CAJON	CA	WBC	ATSF	DIP	BORON	10	8/88

Exhibit 25. Phase I Alternative Tie Treatment Summary.

SITE	GROUP	AGE MTS	NUMBER CORES	POSITION	AVG. BAE		STD. DEV.		% >0.35 BAE	
					TOP	2ND	TOP	2ND	TOP	2ND
MILANO	RBA	11	13	ALL	0.342	0.250	0.152	0.077	53.9	15.4
MILANO	RBB	11	13	ALL	0.482	0.255	0.179	0.129	69.2	23.1
MILANO	RBC	11	13	ALL	0.734	0.535	0.324	0.306	92.3	76.9
MILANO	WBA	11	13	ALL	0.187	0.135	0.172	0.141	15.4	7.7
MILANO	WBB	11	13	ALL	0.587	0.284	0.238	0.105	76.9	30.8
MILANO	WBC	11	13	ALL	0.450	0.272	0.414	0.179	61.5	38.5
MONTGOMERY	RBA	11	12	ALL	0.539	0.287	0.238	0.074	75.0	16.7
MONTGOMERY	RBB	11	12	ALL	0.738	0.414	0.235	0.170	00.0	66.7
MONTGOMERY	RBC	11	13	ALL	0.751	0.478	0.372	0.309	00.0	66.7
MONTGOMERY	WBA	11	13	ALL	0.474	0.235	0.189	0.149	58.3	25.0
MONTGOMERY	WBB	11	12	ALL	0.711	0.400	0.229	0.139	100.0	50.0
MONTGOMERY	WBC	11	12	ALL	0.408	0.293	0.214	0.168	50.0	33.3
CORDELE	GB	20	12	2	0.095	0.089	0.081	0.041	0.0	0.0
CORDELE	GBC	20	12	2	0.156	0.181	0.085	0.167	0.0	16.7
CORDELE	GBN	20	12	2	0.191	0.143	0.143	0.151	16.7	16.7
CORDELE	GBS	20	12	2	0.312	0.300	0.154	0.144	41.7	50.0
AIKMAN	RBA	24	5	1	0.212	0.236	0.161	0.166	40.0	20.0
AIKMAN	RBB	24	5	1	0.266	0.356	0.247	0.348	20.0	40.0
AIKMAN	RBC	24	5	1	0.427	0.385	0.570	0.316	20.0	20.0
AIKMAN	WBA	24	5	1	0.350	0.300	0.175	0.203	20.0	20.0
AIKMAN	WBB	24	5	1	0.562	0.703	0.080	0.506	100.0	100.0
AIKMAN	WBC	24	5	1	0.466	0.619	0.086	0.323	80.0	80.0

Exhibit 26. Phase I Field Results.

The increased concentration does not seem likely for the top half inch in the ties environment. It suggests a migration of borates toward the surface of the tie. This would not occur unless the ties were getting wetter on the surface. We have no evidence of this. The moisture content data suggests that the ties are dryer on the surface.

SITE	GROUP	AGE	TREATMENT LOSS				COMBINED ANNUAL RATE (BAE/YR)
			(BAE)		(PERCENT)		
			TOP 0.5 IN	2ND 0.5 IN	TOP 0.5 IN	2ND 0.5 IN	
MILANO	RBA	11	0.158	-0.03	31.6	-13.6	0.070
MILANO	RBB	11	0.378	0.235	44.0	48.0	0.334
MILANO	RBC	11	-0.014	-0.105	-1.9	24.4	-0.065
MILANO	WBA	11	0.243	0.045	56.5	25.0	0.157
MILANO	WBB	11	0.253	0.126	30.1	30.7	0.207
MILANO	WBC	11	0.016	0.118	26.2	30.3	0.152
MONTGOMERY	RBA	11	-0.039	-0.067	-7.8	-30.5	-0.058
MONTGOMERY	RBB	11	0.122	0.076	14.2	15.5	0.108
MONTGOMERY	RBC	11	0.031	0.048	-4.3	11.2	-0.043
MONTGOMERY	WBA	11	-0.044	-0.055	-10.2	-30.6	-0.054
MONTGOMERY	WBB	11	0.129	0.01	15.4	2.4	0.076
MONTGOMERY	WBC	11	0.202	0.097	33.1	24.9	0.163
CORDELE	GB	20	0.755	0.421	88.8	82.5	0.353
CORDELE	GBC	20	0.534	0.139	77.4	43.4	0.202
CORDELE	GBN	20	0.599	0.327	75.8	69.6	0.278
CORDELE	GBS	20	NA	NA	NA	NA	NA
AIKMAN	RBA	24	0.288	-0.016	57.6	-7.3	0.068
AIKMAN	RBB	24	0.594	0.133	69.1	27.1	0.182
AIKMAN	RBC	24	0.293	0.045	40.7	10.5	0.084
AIKMAN	WBA	24	0.080	-0.120	18.6	-66.7	0.010
AIKMAN	WBA	24	0.278	-0.293	33.1	-71.5	0.004
AIKMAN	WBC	24	0.144	-0.229	23.6	-58.7	0.021

Exhibit 27. Phase I Treatment Concentration Changes.

A more plausible explanation is the variability in the ties. A small sample of ties were cored for analysis after creosote treatment. This analysis established the baseline concentration level for field analysis. The field sample may have come from different ties than the baseline analysis. The relatively small sample size and large variability seen, may result in larger mean values from field samples than the baseline analysis, i.e. the differences seen may be due to "sampling error."

When one considers the borate concentration in the two samples combined (top and 2nd 0.5 inches) the results are more reasonable. Migration of the material in the sample area toward the center of the tie makes estimations of borate loss rates from the tie surface meaningless for the entire tie.

A reasonable borate loss rate estimate for the entire tie would require a full depth sample analysis. The current method is overly conservative. It assumes that all treatment material that migrates deeper into the tie is lost. Wrong! NaF still there at 3" depth. 9/92

The data collected is insufficient to establish borate loss rates. We are able to estimate a borate migration rate for the first inch of tie. This data is presented in Exhibit 27.

3.3.1.1 Effect of Climate

At this point, there is insufficient data to determine the effect of climate on borate concentration. The data collected to date is from the most severe decay environments. Exhibit 28 lists the decay hazard Climate Index [5] and relevant traffic information for all Phase I sites.

Exhibit 29 shows the combined effects of climate, species and traffic on borate concentrations. Climate is considered to be the main factor.

TEST SITE	LOCATION	PROGRAM PHASE	DATE INSTALLED	CLIMATE INDEX	TONNAGE RATE	CURVATURE (DEGREES)
LORENZO	IL	3	09/87	45	30	0
JESUP	GA	3	10/88	85	4	0
CORDELE	GA	2	12/88	70	20	0
SOMERVILLE	TX	2	05/89	60	30	0
MILANO	TX	1	06/88	60	30	3°7'
MONTGOMERY	TX	1	06/88	60	15	3°20'
CORDELE	GA	1	02/88	70	20	0
TOLUCA	IL	1	06/88	43	30	0
AIKMAN	KS	1	06/88	45	60	2°
CAJON	CA	1	08/88	5	30	6°20

Exhibit 28. Phase I Test Site Information.

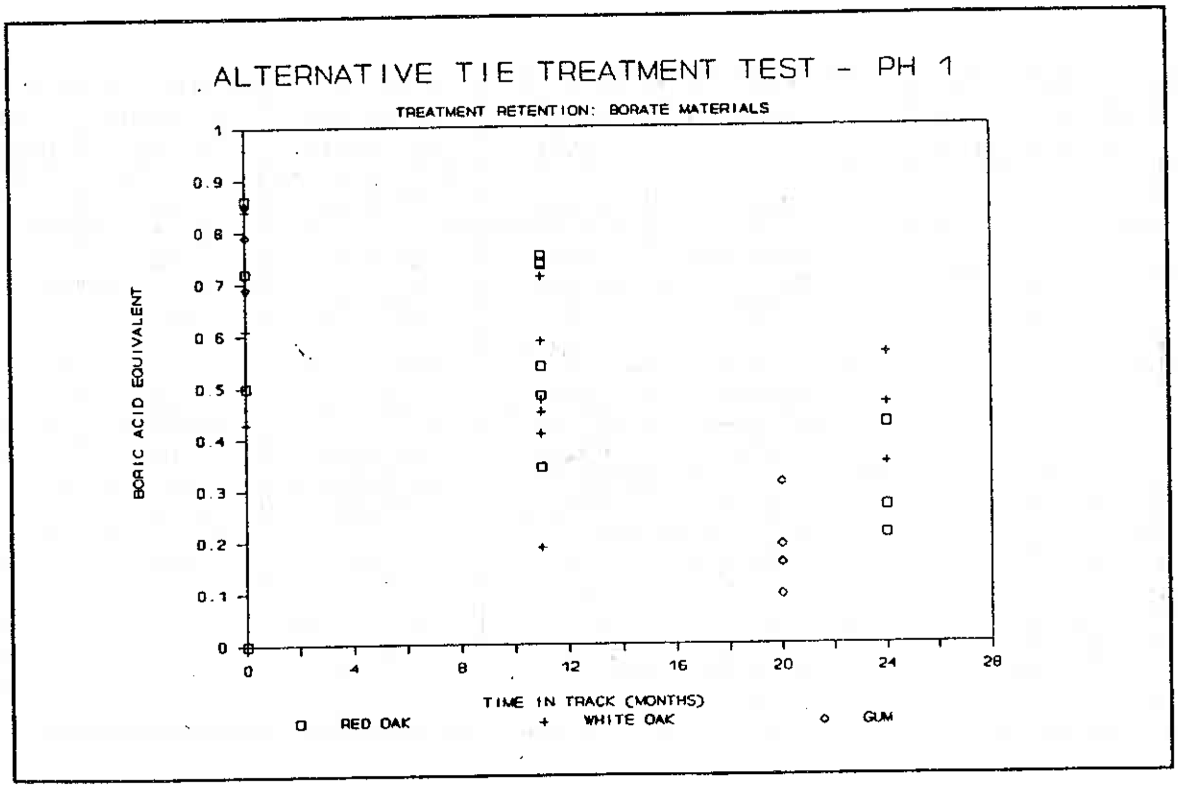


Exhibit 29. Phase I Borate Concentrations vs. Exposure.

3.3.1.2 Effect of Traffic

The effect of traffic has been minimal. The ties have been in track for one to two years. This is insufficient time to develop mechanical failures on new ties.

3.3.2 Phase II Results

The Phase II sites are "in-place" treatment sites. They consist of materials applied to one half of each tie in a given section of track. The ties are of various ages and conditions. Materials were applied to the tie surface. No plate area access (i.e., rail and plate removal) was permitted.

Products in test in Phase II consist of borate and copper based materials. A total of four products are under test in nine sections. Exhibit 30 lists the products. Sprays were mostly used in this phase. One solid product was also used.

TEST SITE	PROG. PHASE	TEST SECTION	COMPANY	PROD. TYPE	ANALYSIS MATERIAL	NUMBER OF TIES	DATE INSTALLED
CORDELE	2	1	M.S.U.	SPRAY	BORON	100	12/88
CORDELE	2	2	PANDROL	RODS	BORON	100	12/88
CORDELE	2	3	MOONEY	W. SPRAY	COPPER	100	12/88
CORDELE	2	4	MOONEY	O. SPRAY	COPPER	100	12/88
SOMERVI	2	1	ATSF	SPRAY	BORON	100	6/87
SOMERVI	2	2	M.S.U.	SPRAY	BORON	100	2/88
SOMERVI	2	3	MOONEY	W. SPRAY	COPPER	100	5/89
SOMERVI	2	4	MOONEY	O. SPRAY	COPPER	100	5/89
SOMERVI	2	5	PANDROL	RODS	BORON	121	5/89

Exhibit 30. Phase II Tie Treatment Summary.

The Phase II results consist of one set of samples from each site. The Cordele, GA site was sampled 13 months after treatment. The Somerville, TX site was sampled in stages; as it was constructed in stages. Most sections were sampled after 12 months in track.

Differences between the two Phase II sites include: Tonnage rates, climate (including temperature, moisture, sunlight), tie species, tie treatment (creosote) and railroad (i.e., train operations, track maintenance, etc.).

The Cordele, GA site was inspected 10 months after installation. Twenty cores were taken from each test section. The cores were removed from the tie plate areas of the treated side of each tie. Twelve cores from each section were analyzed. Exhibit 31 shows the results of the analysis. The products were analyzed for treatment materials in the top half inch and second half inch of material.

The results show the relatively low concentration levels that this method of application is able to achieve. The borate concentrations are considerably lower, with either the spray or solid rod application than the Phase I green tie dip treatments produced.

The topical spray method of application also produces a shallow treatment. This is especially true for the copper napthenate products; where concentrations greatly decrease in the second half inch. The borate spray had more equal concentrations in the top and second half inch. This is due to the water diffusibility of the material. It may also be due to the quantity of material applied. The borate rods, applied by drilling a hole into the tie, achieved a much deeper penetration. The second half inch concentration is higher than the top half inch. The second half inch is closer to the actual rod location than the first half inch. The actual rod location, which varies with hole depth, is usually about an inch below the tie surface.

The differences in borate concentrations with depth between the two application methods may diminish with time as the materials diffuse more.

Exhibit 31 also lists the results for the Somerville, Texas site. The same four products are in test here, with the addition of a second borate spray section installed by Santa Fe in 1987. The second borate spray section is similar to the first with the exception that it was applied one year prior to the other sections.

The variability in borate concentrations of the sprayed ties can be seen in Exhibit 32. The variability may be attributed, in part, to the condition of the ties. Newer ties with a well creosoted, smooth surface may not absorb much spray. Older ties with a roughened, creosote depleted surface may absorb a considerable amount of spray.

The same effect is seen with the copper napthenate sprays in Exhibit 33. The consistency of these sprays was somewhat thicker. This may allow the material to adhere to the tie instead of running off; thus improving the chances of absorption.

The variability in borate concentrations in the borate rod ties is also dependent on tie condition. The moisture content of the tie and moisture flow through the rod area are major factors in the sample borate concentration. A more detailed discussion of this factor is given in section 3.3.3.1.

TEST SITE	TEST SECTION	PRODUCT SPONSOR	PROD. TYPE	ANALYSIS MATERIAL	"AGE" (MO.)	NO. CORES	POSITION	CONCENTRATION (BAE OR PCF)			
								AVERAGE		STD. DEVIATION	
								0-0.5 INCH	0.5-1.0 INCH	0-0.5 INCH	0.5-1.0 INCH
CORDELE	1	M.S.U.	SPRAY	BORON	10	12	2	0.076	0.076	0.049	0.048
CORDELE	2	PANDROL	RODS	BORON	10	12	2	0.077 *	0.116 *	0.171	0.289
CORDELE	3	MOONEY	W. SPRAY	COPPER	10	12	2	0.015	0.004	0.018	0.004
CORDELE	4	MOONEY	O. SPRAY	COPPER	10	12	2	0.007	0.001	0.005	0.001
SOMERVI	1	ATSF	SPRAY	BORON	24	10	1	0.040	0.032	0.048	0.064
SOMERVI	2	M.S.U.	SPRAY	BORON	12	10	1	0.022	0.064	0.034	0.096
SOMERVI	3	MOONEY	W. SPRAY	COPPER	11	10	2	.0078	.0028	.0093	.0039
SOMERVI	4	MOONEY	O. SPRAY	COPPER	11	10	2	.0134	.0043	.0135	.0068
SOMERVI	5	PANDROL	RODS	BORON	11	10	2	.203 *	.315 *	.141	.236

Exhibit 31. Phase II Tie Treatment Test Results.

Boron + Cu Nap sprays + rods are almost all gone after only 10-12 months.

* Cordele much wetter than Somerville ∴ lower concentrat

3.3.3 Phase III Results

The Phase II sites are also "in-place" treatment sites. Ties already in track were treated in the field with test materials. The difference between Phase II and Phase III is that the plate area of the tie is exposed in Phase III. It is adzed by a rail relay gang adzer as part of a typical rail relay just prior to treatment. Products were applied to the plate area. As part of a production gang process, the application had to be quick and simple.

There are two Phase III test sites: one in Jesup, GA and the other in Lorenzo, IL. Core samples were obtained at 11 months and 27 months respectively. There are ten products in test in 17 sections among the two test sites. Exhibit 34 lists the products in test for each Phase III site.

The Jesup, GA site was inspected approximately 12 months after installation. Twenty cores per section were taken. Exhibit 35 contains a listing of the results of the core analysis for each of the eight products in test. None of the borate products in this phase produced concentrations as high as the Phase I dip treatment. The borate rods (applied to a drilled cavity) performed best. The M.S.U. pads were next. These pads are unique in that they contain both boron and copper-based treatments.

The borate "spike hole rods performed the worst. These rods are approximately 3/8" in diameter and 3 inches in length. They were designed to fit into the pre-drilled spike holes found in some ties. The low concentrations found in ties with these rods are probably due to the following factors:

toxicity threshold.

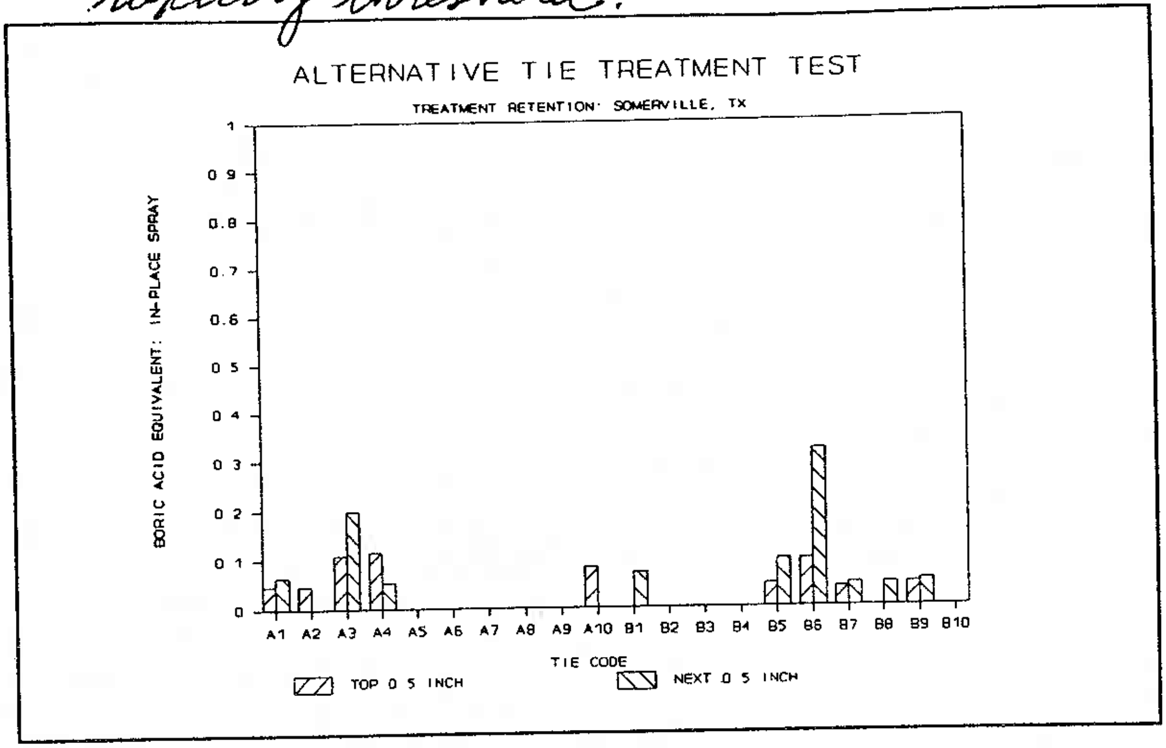


Exhibit 32. Phase II Treatment Variability - Borate Spray.

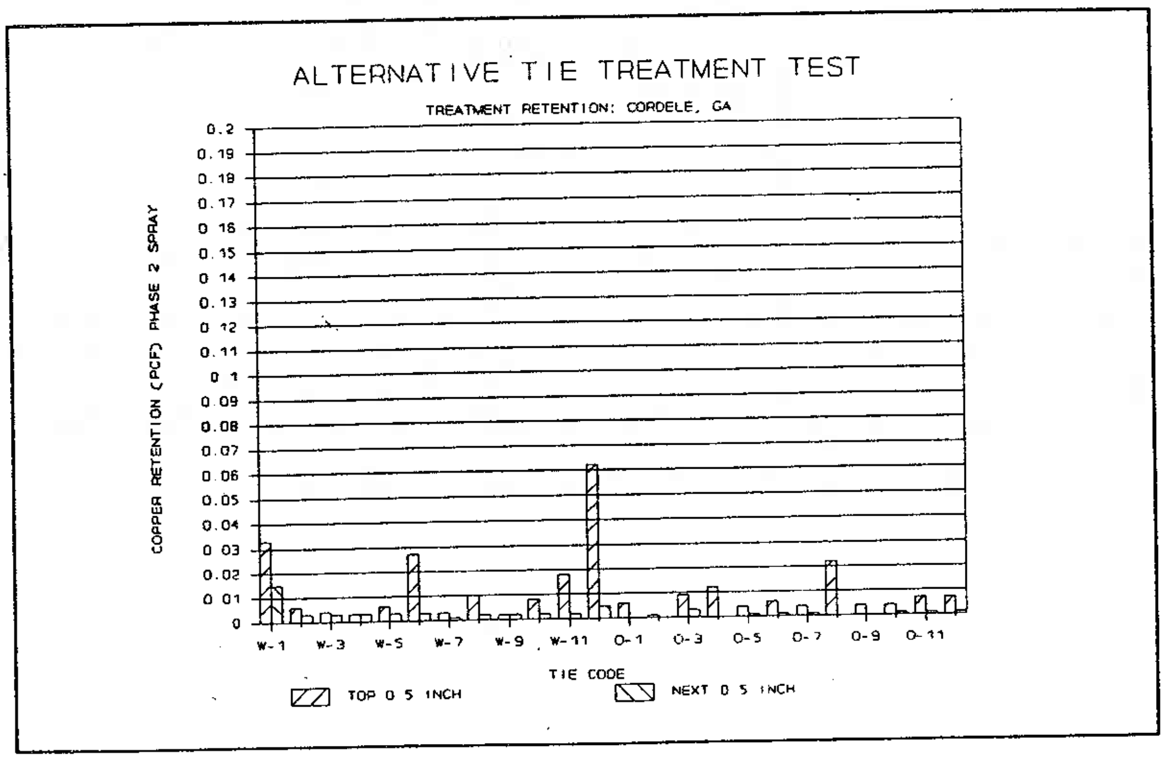


Exhibit 33. Phase II Treatment Variability - Copper Napthenate.

TEST SITE	PROG. PHASE	TEST SECTION	COMPANY	PROD. TYPE	ANALYSIS MATERIAL	NUMBER OF TIES	DATE INSTALLED
LORENZO	3	S1	M.S.U.	PADS	BOR, CU	250	9/87
LORENZO	3	S2	M.S.U.	PADS	BOR, CU	139	9/87
LORENZO	3	S3	MOONEY	O. SPRAY	COPPER	250	9/87
LORENZO	3	S4	MOONEY	W. SPRAY	COPPER	225	9/87
LORENZO	3	S4	UNTREATED	NONE	NA	25	9/87
LORENZO	3	S5	OSMOSE	PADS	FLUORIDE	250	9/87
LORENZO	3	N1	PANDROL	RODS	BORON	250	9/87
LORENZO	3	N2	PANDROL	PASTE	BORON	150	9/87
LORENZO	3	N3	PANDROL	BOTH	BORON	100	9/87
JESUP	3	1	OSMOSE	PADS	FLUORIDE	250	10/88
JESUP	3	1A	OSMOSE	RODS	FLUORIDE	30	10/88
JESUP	3	2	PANDROL	RODS	BORON	230	10/88
JESUP	3	3	PANDROL	S. RODS	BORON	250	10/88
JESUP	3	4	MOONEY	W. SPRAY	COPPER	250	10/88
JESUP	3	5	MOONEY	O. SPRAY	COPPER	250	10/88
JESUP	3	6	M.S.U.	PADS	BOR, CU	250	10/88
JESUP	3	7	M.S.U.	PADS	BOR, CU	117	10/88

Exhibit 34. Phase III Tie Treatment Summary.

- no hole bottom: this allows water to run through the tie. The rod rests on the bottom of the tie (i.e. the ballast) away from the cored area.

- no hole cover: this allows water to run through the tie, flushing the borates out.

Typical of the rod products installed, the concentrations are larger in the second half inch.

The copper products consisted of the M.S.U. pastes and two copper napthenate sprays. Concentration levels from the sprays were similar to the concentrations found in Phase II. The pads had higher concentrations; on the order of twice as high (or more) as the sprays. This is attributed to the amount of material used in the pads and the paste's ability to stay in the tie plate area. The paste lasts for at least several months and during this time is available to treat the tie.

TEST SITE	TEST SECTION	PRODUCT SPONSOR	PROD. TYPE	ANALYSIS MATERIAL	"AGE" (MO.)	NO. CORES	POSI TION	CONCENTRATION (BAE OR PCF)			
								AVERAGE		STD. DEVIATION	
								0-0.5 INCH	0.5-1.0 INCH	0-0.5 INCH	0.5-1.0 INCH
LORENZO	S1	M.S.U.	PADS	BORON	27	11	2	0.082	0.067	0.042	0.052
LORENZO	S1	M.S.U.	PADS	COPPER	27	11	2	0.022	0.012	0.035	0.021
LORENZO	S2	M.S.U.	PADS	BORON	27	0					
LORENZO	S2	M.S.U.	PADS	COPPER	27	0					
LORENZO	S3	MOONEY	O. SPRAY	COPPER	27	11	2	0.006	0.003	0.003	0.003
LORENZO	S4	MOONEY	W. SPRAY	COPPER	27	11	2	0.012	0.004	0.009	0.004
LORENZO •	S5	OSMOSE	PADS	FLUORIDE	27	11	2	#1 0.425	0.124	N/A	N/A
LORENZO	N1	PANDROL	RODS	BORON	27	11	2	0.129	0.148	0.191	0.204
LORENZO	N2	PANDROL	PASTE	BORON	27	21	2	0.092	0.092	0.085	0.084
JESUP	N3	PANDROL	BOTH	BORON	27	21	2	0.249	0.359	0.356	0.745
JESUP •	1	OSMOSE	PADS	FLUORIDE	12	12	2	#1 0.255 *	0.065 *	N/A	N/A
JESUP	1A	OSMOSE	RODS	FLUORIDE	12	12	2	0.165 *	0.188 *	N/A	N/A
JESUP	2	PANDROL	RODS	BORON	12	12	2	0.211	0.223	0.242	0.353
JESUP	3	PANDROL	RODS	BORON	12	12	2	0.079	0.104	0.129	0.160
JESUP	4	MOONEY	W. SPRAY	COPPER	12	12	2	0.008	0.007	0.006	0.012
JESUP	5	MOONEY	O. SPRAY	COPPER	12	12	2	0.006	0.002	0.004	0.004
JESUP	6	M.S.U	PADS	BORON	12	12	2	0.139	0.119	0.074	0.062
JESUP	6	M.S.U.	PADS	COPPER	12	12	2	0.020	0.004	0.018	0.004
JESUP	7	M.S.U.	PADS	BORON	12	12	2	0.206	0.169	0.254	0.226
JESUP	7	M.S.U.	PADS	COPPER	12	12	2	0.064	0.024	0.044	0.049

Exhibit 35. Phase III Tie Treatment Results.

* corrected from draft by Ostby and Davis 11/94.

3.3.3.1 Borate Rod Survey

The borate rods (disodium octaborate) applied to the in-place sites are unique among the test materials. As a solid material which dissolves, their progress can be monitored visually. The rods were placed into drilled cavities (i.e. a hole with a bottom) in the tie and covered with a plastic cap. The cap is removable, thus providing easy access to a visual observation of the material.

A small sample of ties in three test sections have been surveyed. A rating scale was developed by AAR engineers to evaluate the condition of the rod and indirectly determine the amount of material released. The survey method included removing the plastic cap and probing the hole with a metal rod. The following ratings were applied to each of the (two) holes in each tie:

0 = no visible residue

1 = some residue/partial rod

2 = full (solid) rod

The rating of each of two holes was added to obtain a tie rating. The Lorenzo and Somerville sites were examined in this manner. Exhibit 36 contains a table of the results. Exhibit 37 shows the rating distribution for each section.

TEST SITE	PROGRAM PHASE	TONNAGE RATE	CLIMATE INDEX	AGE (MONTHS)	RATING AVERAGE	RATING STD. DEV.
LORENZO S1	3	30	45	13	1.40	1.02
LORENZO S3	3	30	45	13	1.35	1.25
SOMERVILLE 5	2	30	60	11	1.30	1.31

Exhibit 36. Borate Rod Survey Results.

TIE NUMBER	CODE	NUMBER	SAMPLE POSITION	TOP 0.5" B.A.E.	2ND 0.5" B.A.E.	MOISTURE CONTENT PERCENT
1	RBB	399	2	0.4713	0.3461	30.0
2	RBB	399	1	0.9131	0.3976	30.0
3	RBC	421	2	1.2114	1.0273	30.0
4	RBC	421	1	0.9279	0.4087	30.0
5	RBA	269	2	0.2356	0.1251	29.0
6	WBA	702	1	0.6773	0.4760	22.0
7	WBA	702	2	0.5686	0.4824	22.0
8	WBC	866	5	0.3354	0.1182	18.0
9	WBC	866	4	0.2651	0.1853	18.0
10	WBC	866	3	0.2332	0.1565	18.0
11	WBC	866	1	0.4249	0.1980	18.0
12	WBC	866	6	0.5431	0.2651	18.0
13	WBC	878	1	0.8466	0.5910	16.0
14	WBC	878	2	0.5974	0.5399	16.0
15	WBB	842	2	0.4568	0.3833	14.0
16	WBB	842	1	0.5111	0.2811	14.0
17	RBB	322	1	0.0648	0.2798	21.0
18	RBC	440	1	0.4713	0.3424	22.0
19	RBC	440	2	0.2761	0.5118	22.0
20	RBC	444	1	1.2777	0.8395	23.0
21	WBB	841	1	0.7603	0.3035	21.0
22	WBC	876	1	0.4025	0.1821	36.0

Exhibit 39. Treatment Concentrations and Moisture Content.

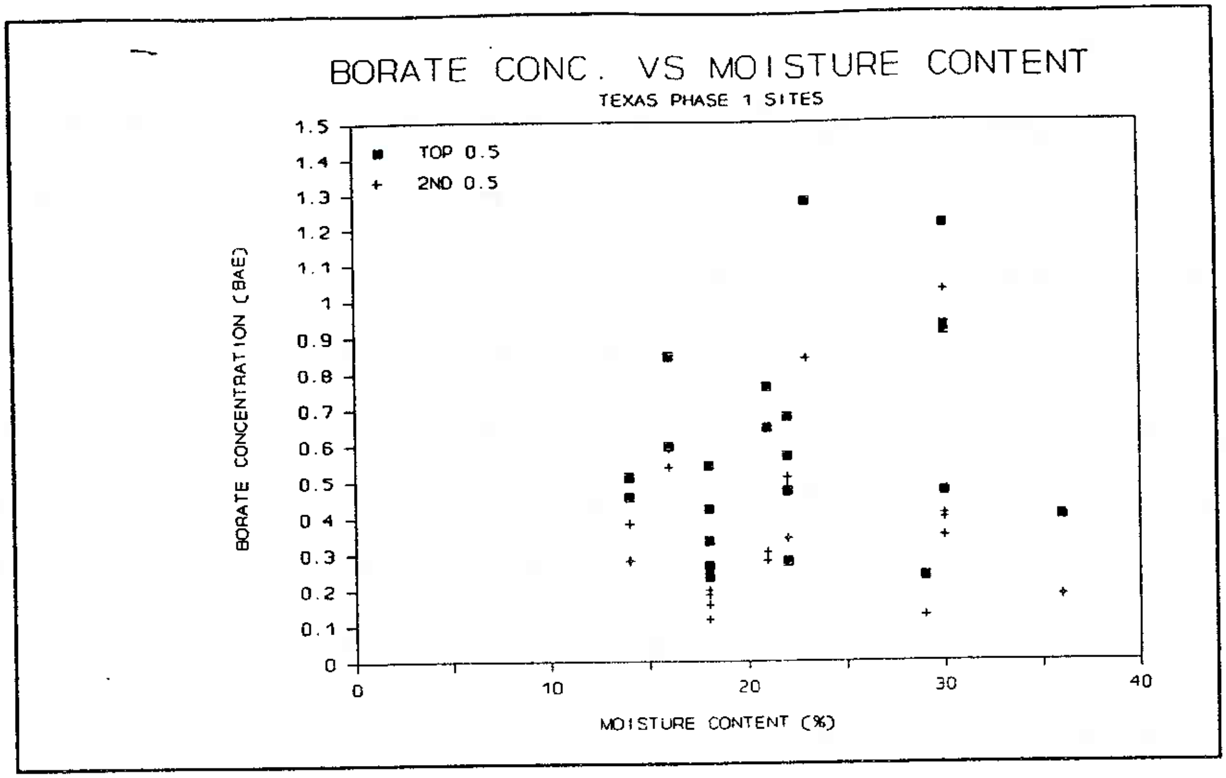


Exhibit 40. Treatment Concentration vs. Moisture Content.

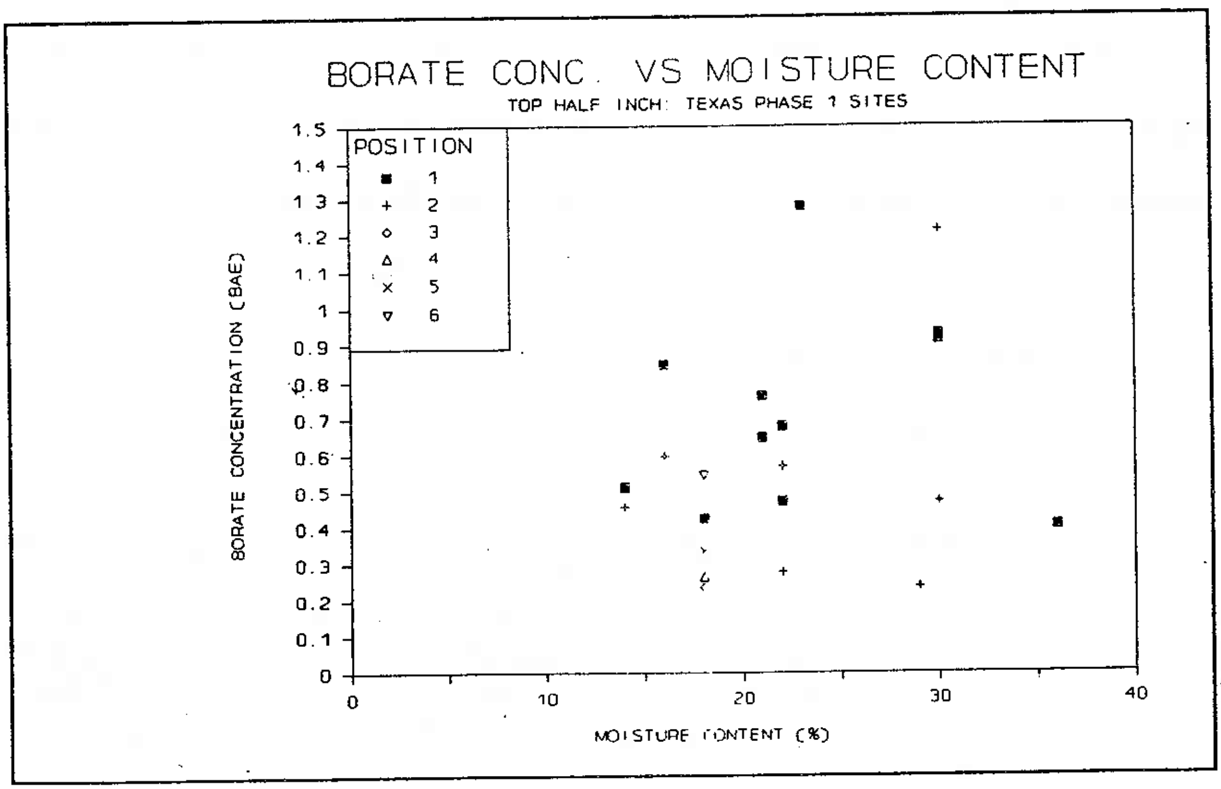


Exhibit 41. The Effect of Sample Location on Treatment Concentration, Moisture Content.

4.0 SUMMARY

The performance measurements are meant to provide a measure of the current condition of the track structure as well as a tool to determine the deterioration rate of the track properties which are being measured.

The majority of the sites involved in this study have only received one round of performance measurements. However, two of the sites, Somerville, Texas (Phase II), and Cordele, Georgia (Phase II), have had two measurement cycles. An examination of the data collected from these two sites does show some deterioration of the track performance properties. Namely, both the tie plate cutting and loose spike counts have increased as would be expected. It is too early at this time and with this limited amount of data to speculate on the differences between the various treatment groups and the control ties.

The data from the treatment analyses provide an early insight into the likely performance of alternative treatments. While the data on in-place treatments is too scant to draw firm conclusions, some conclusions about green tie dip treatment methods can be made.

These conclusions include:

- Bulk stack storage of ties for six weeks after treatment significantly increases borate retention.

- Artificial seasoning of ties (by vapor drying) reduces borate concentrations.

- Creosote pressure treatment and borate dip treatment are compatible. Creosote pressure treatment had virtually no effect on borate concentration levels in air seasoned ties. Analysis of borate levels in ties immediately before and after creosote pressure treatment showed no significant differences.

- Treatment concentration levels are still highest near the surface of the tie. Material is present at one inch depths. Along the long axis of the tie, treatment concentrations follow moisture content values: higher in the center and lower near the ends. Middle of tie gets protected too.

- The effect of species on treatment concentrations is minimal. The effects of moisture content and surface condition at the time of treatment are considered to be more important than species.

After one field inspection of each site, the following observations were made:

- Phase I tie treatment concentration levels found after one year in track, indicate a loss of treatment in the top inch of tie. Whether the majority of this is from inward migration (deeper into the tie), or outward migration (out of the tie) is unknown. (no NaF tested)

- Phase II borate treatment levels (rods and sprays) are well below the treatment levels in Phase I ties. The treatment levels of all products are quite variable; due to the various tie conditions encountered. (no NaF tested)

- Phase III borate treatment levels are higher than Phase II levels, but lower than Phase I levels. Access to the adzed plate area wood probably accounts for the higher treatment levels. (NaF did best of all)

- The effectiveness and long term viability of the treatments under study cannot be determined from one or two years in track. All sites will be monitored for at least five years.

- The tie plate area offers the best environment for water diffusible treatments. The moisture content in the plate area is generally higher near the tie surface than elsewhere on the tie. This will aid absorption of surface applied treatments.

5.0 RECOMMENDATIONS FOR FUTURE WORK

- Treatment Analysis: Deeper core analysis. The data suggests that the treatment material has penetrated well below one inch of depth. Assay to three inch depth is required to determine accurately the concentration and depth of treatment.

- Moisture Content: Most of the treatment products in this test are water diffusible. They require moisture to treat and protect the tie. In conjunction with deeper core analysis, deeper moisture content measurements are required. Measurements at one, two and three inches will be taken for each cored tie. Comparison between concentration levels and moisture content will be made. In order to interpret the treatment concentration results, one must also have the moisture contents.

- Core sample selection: Whenever practical, core samples will be taken from previously sampled ties. This will allow time series analysis of selected ties.

6.0 GLOSSARY OF TERMS

Air Drying Stack -	Ties are stacked in an open configuration to maximize air circulation and tie drying.
Air Seasoning -	Wood drying by exposure to air.
Borates -	Chemical products of boron; generally the salts of boric acid.
Boric Acid Equivalent -	A method of equating boron, borates, salts of boron. Items with the same BAE are equally effective as wood preservatives.
Bulk Stack -	A diffusion storage technique; ties are piled close together and covered with a plastic tarp. This keeps the moisture content high to facilitate diffusion.
Copper Naphthanate -	A wood preservative that is generally not considered to be water diffusible. It is applied as a liquid or paste in this test.
Dip Treatment (Borates) -	Tie immersion in a heated (130^0F) disodium octaborate solution for 3 minutes.
DiSodium Octaborate -	A wood preservative that is considered to be water diffusible. It is applied as a solid (rod, pads) and a liquid (spray) in this test.
"Green" Ties -	Freshly sawn ties. The moisture content is quite high (~ 100%).
Incising -	Puncturing the longitudinal surface of ties to assure penetration by a preservative and to release surface tension as an aid in the control of checking.
Moisture Content -	The amount of water in a tie. It is expressed (in percentage) as the ratio of weight of water vs. weight of solids.
Sodium Fluoride -	A wood preservative that is considered to be water diffusible. It is applied as a solid (rods and pads) in this test.
Vapor Drying -	Wood drying by artificial (Chemical) methods.

7.0 REFERENCES

1. McCarthy, W. T., Use of Under Plate Treatment in Place for Ties, American Railway Engineering Association, Vol. 90, No. 721, May 1989.

2. Davis, D. D. and Chrismer, S. M., Tie Performance - A Progress Report of the Des Plaines Test Site, Report Number R-746, Association of American Railroads, April 1990.

3. American Wood-Preserver's Association, Book of Standards, Stevensville, MD, 1989.

4. AAR Track Research Committee, Tie Working Group Minutes, 6/27/87.

5. Scheffer, T. D., A Climate Index for Estimating Potential for Decay in Wood Structures Above Ground, Forest Products Journal, Vol. 21, No. 10, 1970.

6. Davis, D. D. and Chow, P., Wooden Crosstie Weathering, Report Number R-7XX, (to be published), Association of American Railroads.

APPENDIX A

Alternative Tie Treatments Site Inspection Procedure

The purpose of this paper is to familiarize all participants in the AAR/RTA Alternative Tie Treatments project with the site inspection methods used. These guidelines will insure that comparable samples and measurements will be taken at each site regardless of who does the inspections. This is considered to be a critical factor in the success of this multi-year, multi-site project.

Being a three phase test, there are several items unique to each phase such as age and condition of test ties, treatments applied, treated areas and number of ties per treatment. Despite this variation in test sites, the basic track measurements and core sampling techniques will remain the same.

There are two levels of inspection to be discussed. The cursory inspection to be performed in even numbered years is the simpler of the two. No core samples are taken; no tie plates are removed.

The following tasks must be accomplished:

Walk the Test Site - note missing tie tags/missing ties, any track maintenance such as rail or tie replacements.

Visual Condition Evaluation - Overall tie condition; note any ties which are considered failed: broken, split, plate cut (> 3 inches) or decayed.
Spike Looseness Survey - Perform the kick test on all test tie line spikes. Record by tie number and spike position.

Gage and Crosslevel - Measure unloaded track gage and crosslevel throughout the test site. Every 10th tie will be measured.

A detailed inspection will be performed in odd numbered years. The detailed inspection consists of the items in the cursory inspection plus the following measurements and sampling:

Plate Cutting - Using the AAR plate cutting measurement device, every 10th tie will measured (both plates).

Moisture Content - Using a probe-type moisture meter, every 10th tie will be measured. Measuring location shall be adjacent to the tie plate (within one foot) on the gage side, treated half. This test may be omitted if weather conditions warrant.

LTLF - Measurements will be taken on every 10th tie. The device is placed in the crib after the test tie. Loads at 0, 1000, 4000, 6000 and 10,000 pounds, if warranted. This test must follow gage, spike looseness, and plate cutting measurements, but must precede core sampling.

Core Sampling - Samples must be at least 3 inches long. At least 5 per treatment are required. They must be individually wrapped and labeled, indicating: top surface, tie number, and location in tie. Samples must be stored in an airtight container. Samples must be collected from the tie plate area.

APPENDIX B

Mechanical Properties Evaluation - Somerville Ties

The 1989 tie replacement at the Somerville, Texas Phase II site afforded an (unexpectedly) early opportunity to evaluate the mechanical strength of in-place treatment ties. With the cooperation of the Santa Fe, five ties from each of the five product test sections were "saved" for mechanical testing. An additional 25 ties from areas adjacent to the test section were also "saved" for testing. All ties from the test section were marked for replacement by the Santa Fe tie inspector. The ties from adjacent sections were representative samples. All 50 specimens were selected (from those marked) by the following criterion:

- Whole, solid 1-piece ties
- Intact, relatively undamaged top surfaces

Dr. Poo Chow of the University of Illinois at Urbana performed the test on the Somerville ties. Each tie was identified by species and treatment group. Density was determined from tie weight and dimensions prior to testing. The moisture content was also determined at this time. A hand held probe was used to measure near the middle of the top surface at a depth of one inch.

The table shown in Exhibit B1 list the properties discussed above for each tie. In addition the results of a three point bending test of each specimen are listed. The test used a 60 inch span. Details are discussed in report AAR-R-7XX.[6]

Comparison of the bending values to new red oak tie values are made. The data is presented in several ways, grouped by treatment and species. The bending values are typical of failed ties seen elsewhere. Strength losses of 40-60% have been seen in aged (but not failed) ties taken from track. The bending modulus values of 130,000 psi to

200,000 psi are only 15 to 22% of the nominal new red oak value of 920,000 psi. The treated ties were lower in strength than the non-treated ties. It is doubtful that this can be attributed to the treatment; applied just months before testing. The differences are most likely due to differences in species, age, wood density and moisture content between the two groups.

There appears to be a difference in density and bending strength of hardwood and softwood ties. While this is a well documented phenomenon, our sample of softwoods is too small to determine a statistically significant difference. The differences may also be due to age differences in the samples. Local personnel suggested that the softwoods were likely to be older ties.

FIELD TEST OE: AT&SF TIES
SOMERVILLE, TEXAS
APRIL, 1989

TAG NUMBER	MOISTURE CONTENT (PERCENT)	WOOD SPECIES	HARDWOOD/ SOFTWOOD (1/2)	DENSITY (PCF)	BENDING M.O.E. (LBS/IN/IN)	PERCENT NEW OAK VALUE
1-1	16	W. OAK	1	60.6	341853	7.2
1-2	27	GUM	1	53.6	275475	29.9
1-3	15	GUM	1	45.6	65702	7.1
1-4	15	ELM	1	54.6	222852	24.2
1-5	16	FIR	2	45.6	46106	5.0
2-1	18	D. F.	2	39.6	211500	23.0
2-2	45	R. OAK	1	57.6	70746	7.7
2-3	19	R. OAK	1	51.6	289984	31.5
2-4	18	R. OAK	1	51.6	253446	27.5
2-5	28	R. OAK	1	49.5	138105	15.0
3-1	29	R. OAK	1	57.6	129702	14.1
3-2	26	R. OAK	1	59.6	135281	14.7
3-3	65	GUM	1	42.6	110325	12.0
3-4	27	R. OAK	1	55.6	145227	15.8
3-5	28	R. OAK	1	58.6	209872	22.8
4-1	39	R. OAK	1	59.6	55369	6.0
4-2	14	R. OAK	1	55.6	126736	13.8
4-3	25	W. OAK	1	53.5	171897	18.7
4-4	28	R. OAK	1	60.6	225057	24.5
4-5	38	W. OAK	1	59.9	111481	12.1
5-1	27	D. F.	1	49.4	119078	12.9
5-2	27	D. F.	2	43.5	168620	18.3
5-3	18	R. OAK	2	44.7	78413	8.5
5-4	18	GUM	1	46.9	158653	17.2
5-5	18	W. OAK	2	64.7	148334	16.1

Exhibit B1. MECHANICAL PROPERTIES TESTS.

FIELD TEST OF: AT&SF TIES
SOMERVILLE, TEXAS
APRIL, 1989

TAG NUMBER	MOISTURE CONTENT (PERCENT)	WOOD SPECIES	HARDWOOD/ SOFTWOOD (1/2)	DENSITY (PCF)	BENDING M.O.E. (LBS/IN/IN)	PERCENT NEW OAK VALUE
25-1	28	SPRUCE	1	47.1	159956	17.4
25-2	29	R. OAK	1	61.6	113710	12.4
25-3	15	HICKOR	1	57.6	244683	26.6
25-4	28	SPRUCE	2	44.8	162707	17.7
25-5	26	R. OAK	1	58.4	264672	28.8
25-6	15	R. OAK	1	66.4	222610	24.2
25-7	14	W. OAK	1	68.9	270040	29.3
25-8	24	GUM	1	49.1	169749	18.4
25-9	28	SPRUCE	2	48.1	121295	13.2
25-10	18	W. OAK	1	63.2	208944	22.7
25-11	25	R. OAK	1	59.8	235008	25.5
25-12	31	GUM	1	58	187424	20.4
25-13	14	R. OAK	1	56.1	185698	20.2
25-14	19	BEECH	1	57.4	278962	30.3
25-15	15	R. OAK	1	57.4	61931	6.7
25-16	17	HICKOR	1	54.2	337997	36.7
25-17	16	R. OAK	1	64.8	254081	27.6
25-18	13	W. OAK	1	67.2	241004	26.2
25-19	16	R. OAK	1	58.1	148568	16.1
25-20	21	R. OAK	1	54.2	202672	22.0
25-21	10	R. OAK	1	60.9	183031	19.9
25-22	15	SPRUCE	2	38,5	102987	11.2
25-23	19	R. OAK	1	60.7	280681	30.5
25-24	15	W. OAK	1	71.5	255647	27.8

Exhibit B1. MECHANICAL PROPERTIES TESTS. (Continued)

AVERAGE VALUES BY GROUP:	NUMBER OF TIES	MOISTURE CONTENT (PERCENT)	HARDWOOD/ SOFTWOOD (1/2)	DENSITY (PCF)	BENDING M.O.E. (LBS. IN/IN)	PERCENT NEW OAK VALUE
1	5	17.8	1.20	51.9	190398	20.7
2	5	25.6	1.20	50.1	192756	20.9
3	5	35.0	1.00	54.6	146081	15.9
4	5	28.8	1.00	57.8	138108	15.0
5	5	21.6	1.40	49.8	134620	14.6
TREATED (1-5)	25	25.8	1.16	52.8	160393	17.4
NON-TREATED	24	19.6	1.17	57.7	203919	22.2
HARDWOOD	41	22.6	1.0	57.3	190527	20.7
SOFTWOOD	8	23.4	2.0	44.6	136531	14.8

Exhibit B1. MECHANICAL PROPERTIES TESTS. (Continued)

APPENDIX C

TREATMENT CORE ANALYSIS METHODS FOR COPPER AND BORON

The Atchison, Topeka and Santa Fe Railway Company

Motive Power Building
1001 N.E. Atchison
Topeka, Kansas 66616

October 25, 1989

File: 96-06.61

Mr. Dave Davis
Research and Test Department - Technical Center
Association of American Railroads
3140 South Federal Street
Chicago, IL 60616

Dear Mr. Davis:

Attached are results of borings taken at Milano on September 12, 1989, and those from the topographical applications at Somerville in 1987 and 1988. Following is a short summary of the boring and analysis schemes:

1. BORING LOCATION

Milano: Six (6) ties of each species/treatment (RBA, RBB, RBC, WBA, WBB, WBC) were bored. Five borings were taken from one tie of each species/treatment, two borings from three of the ties, and a single boring from the other two ties. When a single boring was taken from a tie, it was from the middle of the tie between the rails (position 1). When two borings were taken from a tie, the first boring was from the middle (position 1) and the second was from under the tie plate (position 2). When five borings were taken from a tie, the first was from the middle of the tie (position 1), the second was inside the rail and plate on the low side of the curve (position 3), the third was inside the rail and plate on the high side of the curve (position 4), the fourth was outside the rail and plate on the outside of the low side of the curve (position 5), and the fifth was outside the rail and plate on the outside of the high side of the curve (position 6).

Somerville: A total of ten ties were sampled (species unidentified) from both the 1987 and 1988 applications. A single boring was taken at the middle between the rails (position 1).

2. ANALYSIS AND CALCULATION

The amount of borate in the top half inch (designated T) and second half (designated N) of each boring was determined by digestion of each section in mixed acid, dilution to 100 ml, and analysis by Inductively Coupled Plasma (ICP) Spectroscopy. The method of calculating the lbs. of boric acid (H_3BO_3) and % Boric Acid Equivalent (BAE) are shown as an attachment.

Results for each of the ties are shown in the attached tables. Should you have any questions, please call Glenn Bowen at (913) 295-5677.

Yours truly,

N. C. Marsh

N. C. Marsh
Director
Technical Research and Development

attachments

0528C/GWB/csl

Topeka, October 23, 1989

File: 96-06.61

CALCULATIONS FOR AAR BORATE TREATMENT TESTS

1. Lb. of boric acid in the plug = lbs.

   - 1/2" (length) X 0.202 (diameter) plug digested and extracted with acid, then diluted to 100 ml.
   - analysis for boron
   - M.W. of Boron = 10.81
   - M.W. of Boric Acid (H_3BO_3) = 61.81
   - conversion factor = 0.002205 lbs/gram
     lb. = mg/liter x 1 liter/1000mg x 1g/1000ml x 100ml x 0.002205 lbs/gram x 61.81/10.81

2. Volume of sample in cubic feet = V

   V = (length x 3.14 d^2/4)/1728 where 1728 is the conversion factor for in^3/ft^3
   V = (.5 x 3.14 x 0.202 x 0.202/4)/1728
   V = 0.0000093 ft^3

3. Lbs. of boric acid/cubic ft. = lb/V

4. Conversion factor for BAE (% Boric Acid equivalent)

$$\%BAE = \frac{lb/ft^3}{A(g/ml) \times 62.42621} \times 100\%$$

where
* A = 0.52 for sweetgum
0.59 for red oak
0.68 for white oak
62.42621 = conversion factor for g/ml to lb/ft^3

*For the Somerville topographical studies where tie species was not identified, a value of 0.60 for A was used.

0520C/GWB/csl