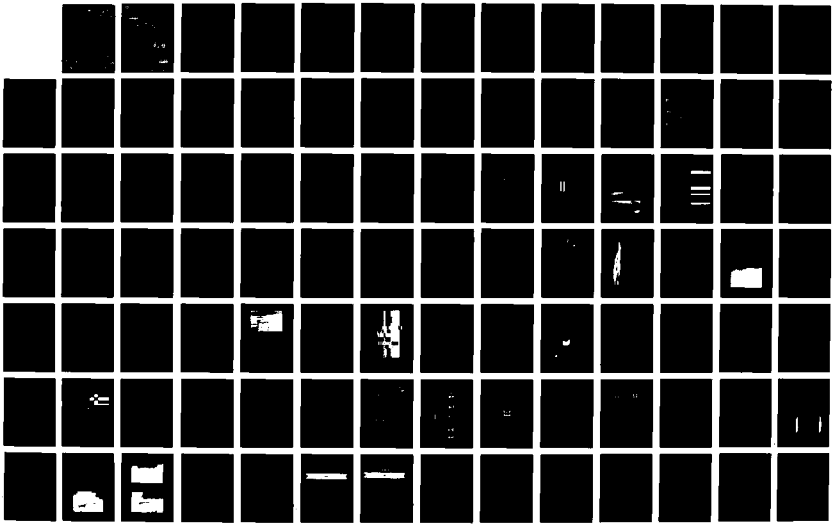
AD-A274 459 MAINTENANCE MANAGEMENT OF US ARMY RAILROAD NETWORKS - 1/2
THE RAILER SYSTEM:..(U) CONSTRUCTION ENGINEERING
RESEARCH LAB (ARMY) CHAMPAIGN IL.. D R UZARSKI ET AL.
UNCLASSIFIED OCT 93 CERL-TR-FM-94/01 XA-CECPW NL



USACERL Technical Report FM-94/01
October 1993
Railroad Engineered Management System

US Army Corps
of Engineers
Construction Engineering
Research Laboratories

Maintenance Management of U.S. Army Railroad Networks—the RAILER System: Detailed Track Inspection Manual

by
D. R. Uzarski
D. G. Brown
R. W. Harris
D. E. Plotkin

The Engineered Management System for railroad track (RAILER) is one of several such systems developed as decision-support tools for Army facility managers. RAILER is designed to help managers allocate scarce maintenance and repair funds in the best possible way while ensuring that Army trackage is maintained in a condition sufficient to sustain routine and mobilization operations at the lowest possible cost.

RAILER is a comprehensive system that combines sound railroad engineering and management practices within a microcomputer environment for speedy analysis. A component of the RAILER system is a complete, detailed inspection of tracks to identify and quantify defects in need of repair. Guidance is needed to ensure consistency and facilitate computer use in collecting and recording the appropriate data.

This report provides guidance on detailed inspection and recording procedures that can be used as part of a safety, network level, and/or project level management program. In addition, data collection forms have been developed and are provided to expedite and organize the inspection. Field-testing has validated the procedures. The procedures are most useful and applicable to the project level phase of the track management cycle.

USER EVALUATION OF REPORT

REFERENCE: USACERL Technical Report FM-94/01, *Maintenance Management of U.S. Army Railroad Networks—the RAILER System: Detailed Track Inspection Manual*

Please take a few minutes to answer the questions below, tear out this sheet, and return it to USACERL. As user of this report, your customer comments will provide USACERL with information essential for improving future reports.

1. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which report will be used.)

____

____

____

2. How, specifically, is the report being used? (Information source, design data or procedure, management procedure, source of ideas, etc.)

____

____

3. Has the information in this report led to any quantitative savings as far as manhours/contract dollars saved, operating costs avoided, efficiencies achieved, etc.? If so, please elaborate.

____

____

4. What is your evaluation of this report in the following areas?

a. Presentation: ____

b. Completeness: ____

c. Easy to Understand: ____

d. Easy to Implement: ____

e. Adequate Reference Material: ____

f. Relates to Area of Interest: ____

g. Did the report meet your expectations? ____

h. Does the report raise unanswered questions? ____

i. General Comments. (Indicate what you think should be changed to make this report and future reports of this type more responsive to your needs, more usable, improve readability, etc.)

____

____

____

____

____

5. If you would like to be contacted by the personnel who prepared this report to raise specific questions or discuss the topic, please fill in the following information.

Name: ____________________________

Telephone Number: ____________________________

Organization Address: ____________________________

____

____

6. Please mail the completed form to:

Department of the Army
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES
ATTN: CECER-IMT
P.O. Box 9005
Champaign, IL 61826-9005

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1993	Final

4. TITLE AND SUBTITLE
Maintenance Management of U.S. Army Railroad Networks—the RAILER System: Detailed Track Inspection Manual

5. FUNDING NUMBERS
4A162731
AT41
042

6. AUTHOR(S)
D.R. Uzarski, D.G. Brown, R.W. Harris, and D.E. Plotkin

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Construction Engineering Research Laboratories (USACERL)
P.O. Box 9005
Champaign, IL 61826-9005

8. PERFORMING ORGANIZATION REPORT NUMBER
TR FM-94/01

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Center for Public Works (USACPW)
ATTN: CECPW-FB-P
Bldg 358
Fort Belvoir, VA 22060-5516

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

Copies are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The Engineered Management System for railroad track (RAILER) is one of several such systems developed as decision-support tools for Army facility managers. RAILER is designed to help managers allocate scarce maintenance and repair funds in the best possible way while ensuring that Army trackage is maintained in a condition sufficient to sustain routine and mobilization operations at the lowest possible cost.

RAILER is a comprehensive system that combines sound railroad engineering and management practices within a microcomputer environment for speedy analysis. A component of the RAILER system is a complete, detailed inspection of tracks to identify and quantify defects in need of repair. Guidance is needed to ensure consistency and facilitate computer use in collecting and recording the appropriate data.

This report provides guidance on detailed inspection and recording procedures that can be used as part of a safety, network level, and/or project level management program. In addition, data collection forms have been developed and are provided to expedite and organize the inspection. Field-testing has validated the procedures. The procedures are most useful and applicable to the project level phase of the track management cycle.

14. SUBJECT TERMS
RAILER
railroad track
track inspection
maintenance
Engineered Management System (EMS)

15. NUMBER OF PAGES
110

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

FOREWORD

This research was conducted for the U.S. Army Center for Public Works (USACPW) under Project 4A162731AT41, "Military Facilities Engineering Technology"; Task C, "Operation, Management, and Repair"; Work Unit 042, "Railroad Maintenance Management System." The technical monitor was Mike Dean, CECPW-FB-P. His outstanding support is very much appreciated.

The work was performed by the Engineering and Materials Division (FM), Infrastructure Laboratory (FL), U.S. Army Construction Engineering Research Laboratories (USACERL). Dr. Paul Howdyshell is Chief, CECER-FM and Dr. Michael J. O'Connor is Chief, CECER-FL. The USACERL technical editor was Gloria J. Wienke, Information Management Office.

Dr. David G. Brown is a visiting Assistant Professor of Transportation and Logistics at the Naval Postgraduate School, Monterey, CA. The contributions, hospitality, and outstanding support provided by the following individuals during the field testing are greatly appreciated: J. Elton, D. Benson, "Put" Putham, and L. Wright from Tooele Army Depot, UT; T. Houston, D. Keifer, B. Wilkerson, and B. Benton from Fort Stewart, GA; A. Myles from Hunter Army Airfield, GA; and B. Griffis and N. Black from Fort Devens, MA. Support from the U.S. Navy Civil Engineering Laboratory, especially C. Inaba and M. Hironaka for the field work at Tooele, was indispensable and appreciated.

The authors thank the Consolidated Rail Corporation (CONRAIL) for cooperation in permitting the use of their Urbana, IL, yard in the research. The authors also wish to express their sincere thanks to Jim McKinstray and Donald Brucker of The Andersons Management Corporation for the use of their track network located at Champaign, IL, in support of this research.

A very special acknowledgment is given to Eric Hunsaker, USACERL, for his work in developing the computer software for these detailed inspection procedures. This effort is vital to the success of the RAILER system.

The contributions of S. Wagers, R. Pugh, G. Prose, B. Sparks, R. Parham, M. Pearson, M. Britton, M. Khan, J. Crowder, S. Kibler, B. Miller, J. Mahoney, J. Lavrich, and W. Murphy with special thanks to K. Coyle of USACERL and D. Coleman from the U.S. Army Waterways Experiment Station are gratefully acknowledged.

LTC David J. Rehbein is Commander of USACERL and Dr. L. R. Shaffer is Director.

CONTENTS

CONTENTS (Cont'd)

FIGURES

FIGURES (Cont'd)

TABLES

TABLES (Cont'd)

MAINTENANCE MANAGEMENT OF U.S. ARMY RAILROAD NETWORKS— THE RAILER SYSTEM: DETAILED TRACK INSPECTION MANUAL

1 INTRODUCTION

Background

The RAILER Engineered Management System (EMS) has been developed to support Army installation Directorates of Engineering and Housing (DEHs) and Directorates of Public Works (DPWs) in managing maintenance and repair (M&R) of railroad track networks. RAILER is a decision support tool that can be used, in part, to assess condition levels, determine M&R needs and costs, establish budgets, and develop annual and long-range work plans.

Many of the decision-support tasks RAILER is designed to perform require an assessment of track conditions and a determination and quantification of M&R needs. The track conditions and M&R needs are determined by inspection. However, the different track management tasks that depend on inspection information do not necessarily require the same level of inspection detail. Three levels of inspection have been incorporated into RAILER. These levels are associated with safety, network level, and project level management which, together, make up a complete track management program.

Safety Management

Managing track safety is a critical part of a track management program. A safety program is generally required by the track standards applicable to the railroad (public or private). For example, U.S. Army trackage is governed by the safety and maintenance standards specified in TM 5-628 (1991). Private railroads, on the other hand, must meet the requirements as set forth by the Federal Railroad Administration (FRA) Office of Safety (1982). These standards, and others, specify a frequency for inspecting track segments for the primary purpose of detecting defects or other track problems that, if present, result in condition level classifications that have operating restrictions. These restrictions, generally in the form of imposed speed limits, remain in effect on the track segments until the defect or problem is corrected. This is done for the safety of both the train crews (including passengers, if applicable) and the general public. Several safety inspections may be performed on a given segment of track each year depending on operations, but the inspections are generally not very detailed since they are done relatively quickly. The exception is internal rail flaw detection surveys, conducted per the appropriate track standard, which are very detailed. These inspections result in unplanned work if raising the track condition to a higher operating level is desired. If lower operating speeds can be tolerated, correction of the safety deficiencies may be deferred for incorporation into a planned M&R program (discussed below).

Network Level Management

The inspections associated with network level management are more detailed than safety inspections, but may be performed less frequently. This inspection focuses on detecting those defects that would be corrected as part of a planned M&R program that may encompass several years (Uzarski, Plotkin, and Brown, September 1988; Uzarski 1993b). The planned M&R program could range from minor (spot work accomplished by a section gang) to major capital improvement (out-of-face work accomplished by production gangs). Planned M&R could also include correcting deferred safety defects that would result in an upgrade of operating condition level. The inspection results will also be used to determine track condition, predict future conditions, and determine required track M&R budget levels in future years.

Since the M&R planning and other tasks are primarily intended for condition assessment and determining future M&R and budget needs, this inspection need not be very detailed nor frequent; annual will suffice. A specific "Condition Survey Inspection" procedure has been developed to meet these needs and the procedures for conducting these are documented elsewhere (Uzarski 1993a and 1993b).

Project Level Management

Project level management inspections are the most detailed, but need not be performed very often. The project level phase of a track management program only occurs before executing a project. Thus, several years may pass between these inspections on a given track segment. The primary purpose is to gather detailed information from which work quantities are determined, M&R alternatives evaluated, and any plans, specifications, and designs finalized. The inspection may focus on a single component, such as cross ties, or a multitude of components depending on the nature of the project. These inspections need to be linked to appropriate track standards to ensure that completed projects result in desired track operating conditions.

Objective

The overall objective of the RAILER EMS research is to develop procedures for gathering inventory, inspection, traffic, and other pertinent information needed for proper maintenance management of U.S. Army railroad track networks. This information is used in a microcomputer environment as a decision-support tool to help the DEH and DPW develop annual and long-range work plans based on M&R needs and operational requirements.

The objective of this phase of RAILER development is to formalize the detailed inspection data collection procedures. To assist Army track managers, this report incorporates the defect criteria contained in the U.S. Army Track Standards. The defect criteria as set forth by the FRA and the U.S. Navy are also incorporated for nonmilitary users and the U.S. Navy, respectively.

Approach

Technical aspects of the U.S. Army Railroad Track Standards as well as those of the FRA and the U.S. Navy (MO-103.9 draft 1993) were incorporated into practical procedures for inspecting track. The procedures developed as part of this work provide a way to capture the defect information in a format that facilitates use within the RAILER system.

The procedures were based on the experience and expertise of military engineers, railroad engineers, facility managers, and others involved with railroad maintenance management in both military and civilian sectors. When practical, the procedures were designed to ensure compatibility with existing Army methods and terminology, including the Integrated Facilities System (IFS) and Military Traffic Management Command Transportation Engineering Agency (MTMCTEA) installation Transportation System Capability Studies (TSCS). The procedures have been field-tested extensively at several U.S. Army installations and on several private and industrial track networks.

The approach assumes that the track network has been divided into track segments as described in the RAILER inventory report (Uzarski, Plotkin, and Brown, August 1988).

Scope

RAILER is intended to be a program encompassing a wide range of railroad track maintenance management; this report covers one part of the program: detailed track inspection procedures.

More specifically, this report:

1. Describes procedures for visually inspecting track segments.
2. Describes the various inspection elements.
3. Explains a procedure to account for track portions that are "inspection-impaired."

These detailed inspection procedures were developed for primary use in project level management. However, since they are linked to track standards, they may also be used to conduct periodic safety and network level inspections at a frequency specified by those standards. The same procedures would apply; however, more inspection time would be required because of the detail involved. If these procedures are selected for use in safety inspections, the inspector should limit the range of defects to those that would impart operating restrictions below the level at which the track segment is currently rated.

The turnout inspection procedures described in this report should be used for all inspections.

Report Organization

Chapter 2 gives an overview of the track inspection concepts and procedures; it outlines the preparation steps for an inspection and describes, in general, how the inspection should progress in the field. Chapters 3 through 10 describe the detailed track inspection procedures for the various track components. These chapters define the component area, the defects and causes, and data collection and recording procedures. If the inspection is impaired (i.e., cannot be accomplished because some components are blocked from view), procedures are described in Chapters 3 and 4 for quantifying the impairment. Chapter 11 discusses the field testing.

Mode of Technology Transfer

Track managers can use the procedures described in this report for performing detailed track inspections. The procedures are intended to be used with the RAILER Railroad Engineered Management System developed by USACERL; however, they may also be used in stand-alone mode at locations where RAILER has not been implemented. The use of RAILER with these procedures will greatly reduce the inspection data analysis effort.

The RAILER technology is being transferred to Army and other Department of Defense installations through mechanisms such as a contract administered by the U.S. Army Center for Public Works (USACPW) and through a training program conducted jointly by USACPW and USACERL. The procedures described in this report are also intended for application, through RAILER, to civilian short-line, industrial, transit, and portions of larger civilian railroads. Thus, it is suggested that the information be disseminated among the Association of American Railroads (AAR), the American Short Line Railroad Association (ASLRA), and FRA for implementation in the civilian sectors.

USACPW currently sponsors a training course in track inspection that teaches inspectors how to identify the defects described in the standards and in this report. The data collection procedures described herein could easily be incorporated into that course.

2 DETAILED TRACK INSPECTION CONCEPTS AND PROCEDURES

Overview

RAILER detailed track inspection is designed to identify all track defects specified by the Army Railroad Track Standards (TM 5-628). With slight modifications, these detailed inspection procedures have been adapted for use with other track standards. The modifications required to support the FRA and Navy track standards can be determined by comparing the backs of the inspection worksheets in Appendix A.

For convenience, the inspection procedures are divided into seven track component areas:

1. Tie inspection,
2. Rail inspection,
3. Fastenings and other track material (F&OTM) inspection,
4. Ballast, subgrade, and roadway (BSR) inspection,
5. Drainage inspection,
6. Turnout inspection, and
7. Manual track geometry inspection.

The inspection procedures primarily consist of specific visual observations and manual measurements of the track structure, which may be augmented by automated data collection for both track geometry and rail defects. A complete regular manual inspection would include the first six component areas; manual track geometry inspection is usually conducted only when there are specific indications of potential problems. The seven component areas are discussed individually in Chapters 3 and 5 through 10; those detailed procedures shared by the Rail, F&OTM, BSR, and Drainage component areas are discussed in Chapter 4.

This chapter presents the larger conceptual and procedural aspects underlying the entire inspection process and describes those common to more than one component area. It begins by chronologically following the inspection routine, starting with a discussion of the RAILER-inventoried track network and the available inventory information, and continuing with preinspection activities and the actual inspection process, with a brief overview of the inspection worksheets. Two important underlying concepts for the entire inspection process (and all component areas) are then discussed; these are (1) impaired inspection and (2) defects requiring immediate attention. The chapter closes by briefly addressing the relationship between these inspection procedures and the computation of the Tie Condition Index (TCI), Rail and Joints Condition Index (RJCI), Ballast Subgrade Condition Index (BSCI), and Track Structure Condition Index (TSCI) (Uzarski 1993a).

Starting Point: An Inventoried Track Network

RAILER inspection is based on the RAILER track inventory procedures as specified in a previous USACERL Technical Report (Uzarski, Plotkin, and Brown, August 1988). The track stationing (location) and component identification procedures are particularly important. Other types of inventory information (e.g., rail length, tie spacing, etc.) are used when the inspection data are later processed in the computer. In the present report, it is therefore assumed that the inspector starts with an inventoried track network. It would be particularly difficult to approximate a detailed inspection without compatible track stationing and identified track segments.

A traditional engineering stationing procedure is used to locate components and track defects. The basic units are hundred-foot lengths (or stations) followed by a "+" and then the extra feet (less than 100) to the right of the "+". Thus, station 18+46 is 1846 ft* from the track origin. As alternatives, a milepost or metric stationing location reference approach may be used. The basic units are miles (or kilometers) and feet (or meters) separated with a "+". For example, station 1+1500 defines a location that is 1 mile plus 1500 feet from the origin. Each track on an installation is divided into one or more track segments. The track segment is the basic unit for track maintenance management within RAILER. In RAILER, each track segment is identified by a unique identification number. Station location and track segment number have important roles in the inspection procedures and are referenced repeatedly in this report; RAILER turnout and curve identification numbers are also used with the turnout and track geometry inspection component areas, respectively (see Chapters 9 and 10). (Refer to Uzarski, Plotkin, and Brown [August 1988] for a detailed explanation or to review these conventions.)

Preinspection Activities

Three actions must be completed before track inspection: (1) specify the inspection team(s) and define the general duties of each team member, (2) create an inspection plan to minimize wasted time and effort, and (3) obtain and distribute equipment. All three activities are clearly interrelated, as discussed below.

Inspection Teams

Detailed visual track inspection is performed by a track inspection team. Team members make specified measurements of components, note these measurements and other appropriate observations on track inspection forms, and sometimes mark items for repair, such as defective ties or rails.

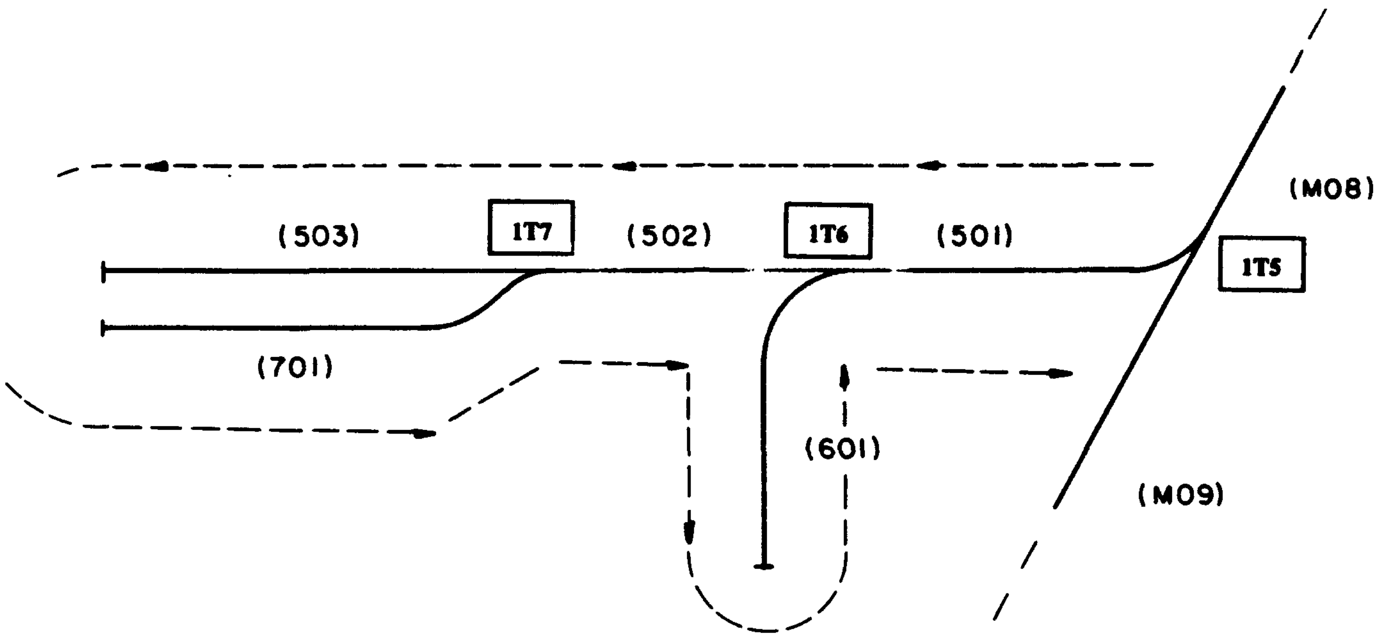
The size and organization of the inspection team will vary greatly, depending on the available labor, network size and layout, scope of inspection, general track quality, and other local conditions. Inspection can be accomplished by a single inspector but a crew size of two, in many cases, will greatly enhance productivity. If many defects are present, a single inspector will require at least three passes of a track segment for a complete regular inspection (one pass for ties, one for rail and F&OTM, and one for BSR and drainage). The second person can also increase the effectiveness of the inspection by providing an additional angle-of-view (one person on each side of the track) for some components when vision may be impaired, such as when there is rolling stock on the track. For manual inspection of track geometry, a second person is almost a necessity.

Inspection Plan

An inspection plan mainly indicates in what order component areas and track segments are to be inspected; Figure 1 is an example. Inspection routing will primarily be a function of the network layout. For example, with a single isolated loading track, it may be advantageous to inspect some components in one direction and others while walking back. However, with two parallel loading tracks, it may be better to inspect some or all components of one track in one direction and the same components of the other track while walking back. Generally, the inspection will progress more efficiently if the component areas of rail, F&OTM, and BSR are inspected in the direction of increasing station number. Ties, drainage, and turnouts can be inspected in either direction with equal efficiency. Inspection plans may also specify goals for the work day.

---

*A metric conversion table is on page 88.



Inspection Plan for Tracks 5, 6, and 7

Track Segments	Component Areas
501	Inspector 1: Rail and F&OTM
	Inspector 2: BSR and Drainage
502	Inspector 1: Rail and F&OTM
	Inspector 2: BSR and Drainage
503	Inspector 1: Rail and F&OTM
	Inspector 2: BSR and Drainage
503	Inspector 1: Ties
701	Inspector 1: Rail and F&OTM
	Inspector 2: BSR and Drainage
701	Inspector 1: Ties
502	Inspector 1: Ties
	Inspector 2: Turnout IT7
601	Inspector 1: Rail and F&OTM
	Inspector 2: BSR and Drainage
601	Inspector 1: Ties
501	Inspector 1: Ties
	Inspector 2: Turnout IT6

Note: Turnout IT5 would be inspected as part of segment M08.

Figure 1. Example Inspection Plan.

Inspection plans are informal (often not even written) and must be very flexible. This flexibility accommodates the common (and sometimes large) deviations between the expected and actual time required for inspecting individual track segments and component areas. Clearly, the preponderance of defects in one or more component areas will affect inspection time. The number of defects will also affect which and how many component areas an inspector can inspect on a single pass of the track segment. An inspection plan should also be developed with the knowledge of expected train movements to avoid both train movements and stationary rolling stock which could result in a safety hazard and/or delay the inspection.

Inspection Equipment

Inspection equipment can be divided into three groups. The first group is the equipment required for measurements and defect counting, including measuring tapes, hand counters, metal prod for tie inspection, and specialized devices for manual geometry measurements. The second group is the equipment needed to record the defects and measurements, including clipboards, pencils, and a sufficient supply of appropriate inspection forms. The third group includes all equipment used to field-mark appropriate track defects, such as paint cans and applicators for bad ties and paint pens or lumber crayons for other defects.

The appropriate equipment will depend on the scope of the inspection and the organization of the inspection team. The equipment needed for each component area is specified in Table 1. Field-marking equipment is generally optional. For example, it is not necessary to paint defective ties if there is no intent to replace them in the near future. A copy of the track standards should always be readily available as a reference guide.

Inspection Process and Worksheets

The inspection process is organized around the three inspection worksheets presented in Figures 2 through 6. Note that four component areas (Rail, F&OTM, BSR, and Drainage) are addressed together in the middle section of the Detail Inspection Worksheet (Figure 2). The component codes and defect codes used to indicate defects in this section are presented on the back of the Detail Inspection Worksheet (Figure 3). The measurements and common defects for Grade Crossings and Rail Crossings (two F&OTM items) are recorded in the bottom section of the worksheet and tie inspection data are recorded at the top of the worksheet. Figure 4 shows a completed Turnout Inspection Worksheet. Useful diagrams and other helpful information for a turnout inspection are presented on the back of the Turnout Inspection Worksheet (Figure 5). Manual Track Geometry data are recorded on the worksheet shown in Figure 6.

Blank worksheets are provided in Appendix A and are intended to be used as masters for copying for field use. It should be noted that there are two different versions of the Detail Inspection Worksheet. One version is for Army users and the other is for users subject to the FRA or Navy standards. There is a slight difference in the tie portion of the worksheet to account for the differences between the standards. However, the main difference in application is in the defect list presented on the reverse of the form. The FRA and Navy have a more extensive list of defects from which to choose. The defect codes shown in Figure 3 comply with the Army track standards. The Turnout Inspection Worksheet and Manual Track Geometry Worksheet are identical for all users. If desired, any of these forms may also be modified by the user for any special network characteristics. For example, if the network has a lot of long segments or if large numbers of defects are expected in different component areas, it may be desirable to develop one page devoted to tie inspection, and another page for only Rail, F&OTM, BSR, and Drainage inspection. As users gain experience with these worksheets and RAILER, the need to tailor and the places to tailor will become evident.

Table 1

Inspection Equipment by Component Area

Equipment	**Component Areas**						
	Ties	**Rail**	**F&OTM**	**BSR**	**Drainage**	**Turnout**	**Manual Track Geometry**
Hand counter (optional)	X	X	X	X		X	
6-ft measuring tape	X					X	X
Measuring rule		X	X			X	
100-ft measuring tape (or 62-ft stringline)							X
Track level							X
Gauge bar (optional)						X	X
Metal Prod	X						
Clipboard(s)	X	X	X	X	X	X	X
Pencils	X	X	X	X	X	X	X
Worksheets	X	X	X	X	X	X	X
Track Standards	X	X	X	X	X	X	X
Inspection manual	X	X	X	X	X	X	X
Paint can(s) and applicator	X	X	X			X	
Paint pens and/or lumber crayons		X	X			X	

Detailed inspection procedures, including use of the worksheets, peculiar to the individual components areas are discussed in Chapters 3 and 5 through 10. In addition, Chapter 4 addresses the detailed procedures common to the Rail, F&OTM, BSR, and Drainage component areas. However, four general concepts that apply to multiple component areas deserve special mention: (1) comments, (2) the idea of "defect free," (3) inspection impairment, and (4) defects requiring immediate attention.

Comments

A track inspector will often want to indicate additional information that does not fit in with a standardized fill-in-the-blank approach. Examples include defect peculiarities and additional location information such as the distance to some landmark. The RAILER software facilitates the collection of this kind of information with comments. The user may provide comments with each inspection component area. However, only the Turnout and Track Geometry Worksheets include labeled comment areas. With the other component areas, the inspector should write appropriate comments in the margin or on the back of the worksheet, and indicate this to the person responsible for entering the data into the RAILER database.

RAILER DETAILED TRACK INSPECTION

TRACK SEGMENT #: 101	SEGMENT BEGINNING LOCATION: 0+87	INSPECTOR: DRU	DATE: 1/20/93

TIES	DEFECTIVE TIES: SINGLE OR TOTAL (TOTAL circled)	SINGLE AT JT	ALL AT JOINT: 1 Tie	ALL AT JOINT: 2 Ties	MISSING TIES: SINGLE OR TOTAL (SINGLE circled)	2 IN A ROW	3 IN A ROW	ALL AT JOINT: 1 Tie	ALL AT JOINT: 2 Ties
CHECK IF DEFECT FREE ☐	51	2		1	2	1			1

INSPECTION IMPAIRED: TF	%
5,5,1,1,5,2,2,1 22	

	ISOLATED CLUSTER	ISOLATED w/1 JOINT TIE	ADJACENT CLUSTER
2 IN A ROW	4	1	3
3 IN A ROW	3		2
4 IN A ROW			
5 IN A ROW			1

IMPROPERLY POSITIONED TIES: SKEWED, ROTATED, BUNCHED	CENTER - CENTER SPACING > 48": NOT AT JT	CENTER - CENTER SPACING > 48": AT JOINT
2	2	2

CHECK IF DEFECT FREE: RAIL ☐ FASTENINGS AND OTM ☐ BALLAST, SUBGRADE AND ROADWAY ☐ DRAINAGE ☒

COMP CODE	DEFECT CODE	RAIL (L,R,B)	LOCATION (STATION)	LENGTH (T F)	DENSITY (%)	QTY (#)	COMP CODE	DEFECT CODE	RAIL (L,R,B)	LOCATION (STATION)	LENGTH (T F)	DENSITY (%)	QTY (#)
GR	LOS		0+90			1	RL	FLK	R	5+50	250	75	
BS	DTY		1+00	100			JT	LBT	L	5+70			1
RL	(BRB)	L	1+40			1	RL	LIJ	R	5+80			2
SP	IMP	R	1+50	200	50		TP	IMP	B	6+00	200	50	
BS	VGB		1+50	400	75		JT	LBT	B	6+00	100	75	
RL	SHL	R	2+20			1	BS	CBT		6+00	40		4
RL	ENB	B	3+50	150		10	JT	(ABL)	L	6+40			1
SP	MIS	B	3+50			5	RL	ENB	L	6+50			2
BS	PCE		3+70			3	RL	(SHV)	L	6+50			1
RL	TCE	R	4+00			1	RL	(BHC)	L	6+50			1
BS	VII		4+10	30			GC	RFM		7+20			26
JT	(CCB)	R	5+20			1	RL	FLK	B	8+00	250	75	
BS	IBL		5+50	40									

FLANGEWAYS: COMP CODE	LOCATION: ROAD NAME	LOCATION: STATION	MIN DEPTH (IN)	MIN WIDTH (IN)	FOULED	LENGTH (FT)	INSPECTION IMPAIRED: 1/4 'S	LENGTH (LF)	LINE TOTAL (LF)	Q.L. (LF)	
(GC) RR	Infantry Rd	2+50	1.50	1.65	N (Y)	25	1	10	10	10	SUM OF Q.L. 114
(GC) RR	Parking Lot #5	4+50	1.75	1.75	(N) Y	50	2	9,5,4	18	36	TOTAL SUM OF Q.L./4
GC (RR)	Seg 107	5+90	2.0	2.0	(N) Y	-	3	7,5	12	36	28.5
(GC) RR	Bradley Rd	7+20	2.50	2.50	(N) Y	-	4	8	8	32	%

Minimum Full Compliance Values	Depth	Width
GC:	2" (2.0)	2 1/2" (2.5)
RR:	1 7/8" (1.875)	1 7/8" (1.875)

Figure 2. Completed Detail Inspection Worksheet (Army and Air Force).

COMPONENT AND DEFECT CODES (ARMY AND AF USERS)

Component Codes	Defect Codes	
RAIL RL = RAIL	BRL = BENT RAIL + BRS = BENT RAIL (SURFACE BENT) + BHC = BOLT HOLE CRACK BRC = BREAK (COMPLETE) - CLEAN AND SQUARE BRR = BREAK (COMPLETE) - ROUGH AND ANGLED BRB = BROKEN BASE CD1 = CHIP / DENT IN HEAD > .25" + CB1 = CORRODED BASE > .25" + CRR = CORRUGATION + CRH = CRUSHED HEAD ENB = END BATTER > .25" EB1 = ENGINE BURN > .25" + FCM = FISSURE (COMPOUND) FTL = FISSURE (TRANSVERSE) > 40% FTS = FISSURE (TRANSVERSE) <= 40% FLK = FLAKING + FDL = FRACTURE (DETAIL) > 40% FDS = FRACTURE (DETAIL) <= 40% FEL = FRACTURE (ENGINE BURN) > 40% FES = FRACTURE (ENGINE BURN) <= 40%	FJB = FRACTURE REPAIRED WITH JOINT BAR HCK = HEAD CHECKS (SURFACE CRACKS) + HWS = HEAD / WEB SEPARATION MDF = MILL DEFECTS + OVF = OVERFLOW + PPR = PIPED RAIL L13 = RAIL LENGTH < 13' RSD = RUNNING SURFACE DAMAGE (DEPTH >.25") + SHL = SHELLING + SLV = SLIVERS + SHH = SPLIT HEAD (HORIZONTAL) SHV = SPLIT HEAD (VERTICAL) SWB = SPLIT WEB SFL = SURFACE SPALLS + TCE = TORCH CUT END TCH = TORCH CUT HOLE WRS = WEAR (SIDE) — 0.375 for < 90lb WRV = WEAR(VERTICAL) — 0.5 for => 90lb WDD = WELD DEFECT
	+ If recurring in a given individual rail, only record once	
FASTENINGS AND OTHER TRACK MATERIALS JT = JOINT	ABL = ALL BOLTS IN JOINT LOOSE ABM = ALL BOLTS ON A RAIL END MISSING OR BROKEN BBB = BOTH BARS BROKEN BBM = BOTH BARS MISSING BCC = BOTH BARS CENTER CRACKED BCB = BROKEN OR CRACKED BAR (not through center) CCB = CENTER CRACKED OR CENTER BROKEN BAR CDB = CORRODED BAR IBP = IMPROPER BOLT PATTERN IBT = IMPROPER SIZE / TYPE BOLT IIB = IMPROPERLY INSTALLED JOINT BAR	ISB = IMPROPER SIZE / TYPE BAR LJB = LOOSE JOINT BAR(S) LBT = LOOSE JOINT BOLT MBT = MISSING/BENT/CRACKED OR BROKEN BOLT 1BT = ONLY 1 BOLT PER RAIL END RG1 = RAIL END GAP > 1" BUT <= 2" RG2 = RAIL END GAP > 2" RMS = RAIL END MISMATCH (HOR. OR VERT.) > 0.1875" BUT <= 0.25" RM2 = RAIL END MISMATCH (HOR. OR VERT.) > 0.25" SMB = SINGLE MISSING BAR TCB = TORCH CUT/ALT JOINT BAR
IC = INSULATION COMPONENT	IIV = INSUFFICIENT INSULATION VALUE	
GC = GRADE CROSSING	RFL = ROUGH (LOW SEV) RFM = ROUGH (MED SEV)	RFH = ROUGH (HIGH SEV)
CB = CAR BUMPER CS = CAR STOP DL = DERAIL GR = GAUGE ROD HD = HOLD-DOWN DEVICE RA = RAIL ANCHOR RR = RAIL CROSSING SH = SHIM S1 = SIGNAL S2 = SIGN SP = SPIKE TP = TIE PLATE	BRK = BROKEN (NOT FOR RA) COR = CORRODED CRB = CRACKED/BENT (NOT FOR RA) IMP = IMPROPER POSITION (NOT FOR RR)	IST = IMPROPER SIZE/TYPE (NOT FOR CB,CS,DL,RA OR RR) LOS = LOOSE MIS = MISSING (NOT FOR GR OR RR) NFL = NON-FUNCTIONAL (S1,S2 ONLY) WOR = WORN (RR ONLY)
BALLAST, SUBGRADE, AND ROADWAY BS = BALLAST, SUBGRADE, AND ROADWAY	CBT = CENTER BOUND TRACK (CROSS TIE) CBJ = CENTER BOUND TRACK (JOINT TIE) DTY = DIRTY (FOULED) EMB = EMBANKMENT EROSION ECS = EROSION (CRIB AND SHOULDER) ERM = EROSION (RESTICTED MOVEMENTS) ESS = EROSION (SINGLE SHOULDER) EWA = EROSION (WASHOUT) HTB = HANGING TIES AT BRIDGE APPROACH IBC = INSUFFICIENT BALLAST (CRIB)	IBL = INSUFFICIENT BALLAST (LEFT) IBR = INSUFFICIENT BALLAST (RIGHT) PBE = PUMPING TIES (BOTH ENDS) PJE = PUMPING TIES (JT TIE AT JT END) POE = PUMPING TIES (ONE END) UNS = UNSTABLE SLOPE VGB = VEGETATION GROWING IN BALLAST VII = VEGETATION INTERFERES WITH INSPECTION VIM = VEGETATION INTERFERES WITH TRAIN MOVEMENT VPM = VEGETATION PREVENTS TRAIN MOVEMENT
DRAINAGE CU = CULVERT DI = DITCH DR = DRAIN SS = STORM SEWER	COR = CORRODED (NOT FOR DI) ERO = EROSION (DI ONLY) IST = IMPROPER SIZE/TYPE (NOT FOR DI) RFL = RESTRICTED FLOW (DI ONLY)	RFM = RESTRICTED FLOW (MAJOR) (NOT FOR DI) RFP = RESTRICTED FLOW (PARTIAL) (NOT FOR DI) SCR = SCOUR (CU ONLY) STD = STRUCTURAL DETERIORATION

MEASUREMENT REFERENCE TABLE

1/16" = 0.0625"	5/16" = 0.3125"	9/16" = 0.5625"	13/16" = 0.8125"
1/8" = 0.125"	3/8" = 0.375"	5/8" = 0.625"	7/8" = 0.875"
3/16" = 0.1875"	7/16" = 0.4375"	11/16" = 0.6875"	15/16" = 0.9375"
1/4" = 0.25"	1/2" = 0.5"	3/4" = 0.75"	1" = 1.0"

Figure 3. Back of Detail Inspection Worksheet (Army and Air Force).

RAILER TURNOUT INSPECTION

TRACK SEGMENT #: 101	TURNOUT ID #: 1T5	INSPECTOR: DKLl	DATE: 4/3/93

GENERAL		
Switch Difficult to Operate	(No)	Yes
Rail Weight or Section Change	(No)	Yes
Debris in Crib Area	(No)	Yes
Surface and Alignment	(Good) Fair	Poor

TIES								
Defective Head Blocks	(0)	1	2	3				
Tie Size	9	10	11	12	13	14	15	16
Defective or Missing (circle clusters)		(11)	2	/ /				
Defective Joint Ties								
Improperly Positioned								

	Component	Not Applicable (NA)	Defect Free	Improper Size/Type	Loose/ Improper position	Damaged (chipped, etc.) or worn	Missing
SWITCH & STAND	Switch Stand	y	(y)	y	y	y	y
	Target	y	y	y	y	y	(y)
	Ground Throw Lever	y	(y)	y	y	y	y
	Point Locks/Lever Latches	y	y		/		
	Jam Nut	y	(y)	y	y	y	y
	Connecting Rod	y	(y)	y	y	y	y
	Switch Rods	y	(y)				
	Switch Clips	y	(y)				
	Connecting Rod Bolts	y	(y)				
	Switch Rod Bolts	y	y		2		
	Clip Bolts	y	y		3		
	Cotter Keys	y	y	////////////////////	////////////////////	////////////////////	12
	Insulation Filler	(y)	y		////////////////////		
	Switch Points	////////////////////	L (R)	////////////////////	////////////////////	(L) R	////////////////////
	Switch Point Protector	(L) (R)	L R	L R	L R	L R	L R
	Point Rails	L R	(L) (R)	L R	L R	L R	L R
	Gauge Plate	(y)	y				////////////////////
	Rail Braces (L) < 4*	y	y		/		
	Rail Braces (R) (< 4*)	y	y		5		
	Slide Plates	y	(y)				
	Turnout Plates	y	(y)				
	Twin Tie Plates	y	(y)				
	Heel Fillers	(L) (R)	L R	L R	L R	L R	L R
	Heel Bolts	L R	(L) (R)				
	Heel Joint Bars	L R	(L) (R)				
FROG	Frog	y	(y)	y	y	y	y
	Point	////////////////////	(y)	////////////////////	////////////////////	y	////////////////////
	Top Surface	////////////////////	(y)	////////////////////	////////////////////	y	////////////////////
	Guard Faces (SG only)	(L) (R)	L R	////////////////////	////////////////////	L R	////////////////////
	Hinged Wing Rail (SP only)	(y)	y	y	y	y	y
	Springs and Assemblies (SP only)	(y)	y	////////////////////			
	Movable Point (SWP only)	(y)	y	y	y	y	y
	Bolts	y	y				/
	Plates	y	(y)				
GUARD RAILS	Guard Rails	L R	(L) (R)	L R	L R	L R	L R
	Fillers	L R	(L) (R)				
	Bolts	L R	(L) (R)				
	Clamps	(L) (R)	L R				
	Guard Rail Plates	L R	(L) (R)				

MEASUREMENTS (in)

	COMPONENT	LEFT	RIGHT
POINTS & JOINTS	Switch Point Gap	0.0	0.0
	Gauge at Switch Points	56.5	
	Gauge at Joints in	1st: 56.75	
	Curved Closure Rail	2nd: –	

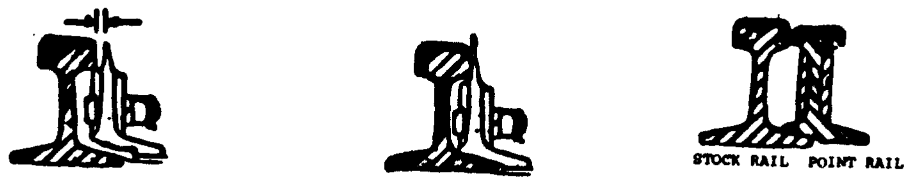
	COMPONENT	LEFT	RIGHT
FROG & GUARD RAILS	Gauge at Point	56.5	56.5
	Frog Flangeway Width	1.75	1.75
	Frog Flangeway Depth	1.75 Fouled+	1.75 Fouled+
	Guardrail Flangeway Width	1.875 Fouled+	2.00 Fouled+
	Guard Check Gauge	54.625	54.50
	Guard Face Gauge	52.875	52.75

Comments

* Circle if less than four braces are functional

\+ Circle if fouled

Figure 4. Completed Turnout Inspection Worksheet.

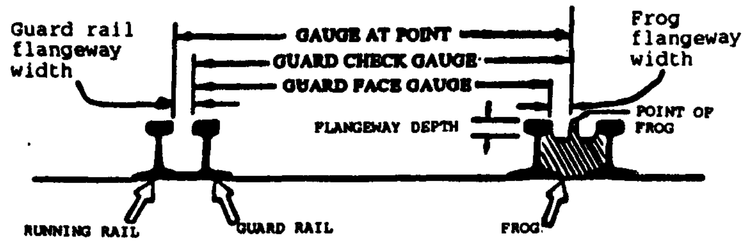


Gap greater than 1/8 in. between switch point and stock rail when switch is thrown and locked

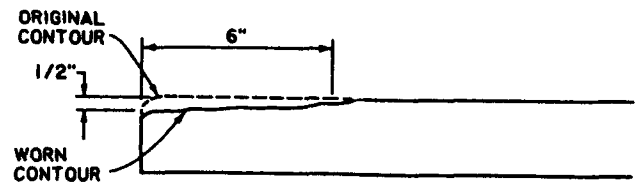
Point of switch higher than stock rail

Point rail (beyond taper) lower than stock rail

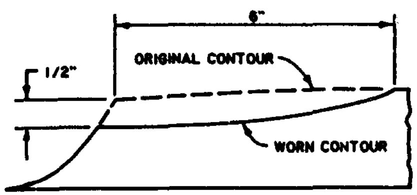
TYPES OF IMPROPER POINT RAIL POSITION



MEASUREMENTS AT FROG AND GUARD RAILS

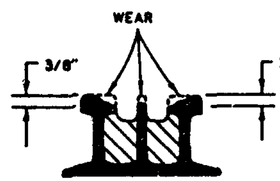


SWITCH POINT WEAR



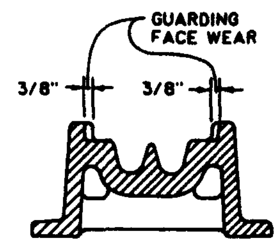
DETAIL OF FROG POINT ELEVATION

FROG POINT WEAR



SECTION THROUGH 1/2" POINT SHOWING SURFACE WEAR

WEAR FOR TOP SURFACE OF FROG



WEAR FOR GUARDING FACE OF SELF-GUARDED FROG

FRACTIONS/DECIMAL CONVERSION TABLE

1/16	0.0625	5/16	0.3125	9/16	0.5625	13/16	0.8125
1/8	0.125	3/8	0.375	5/8	0.625	7/8	0.875
3/16	0.1875	7/16	0.4375	11/16	0.6875	15/16	0.9375
1/4	0.25	1/2	0.5	3/4	0.75	1	1.0

Figure 5. Back of Turnout Inspection Worksheet.

RAILER MANUAL TRACK GEOMETRY INSPECTION

INSPECTORS: DRU							DATE: 1/20/93
TRACK SEGMENT NUMBER	LOCATION (STATION)	CURVE ID NUMBER	MEASUREMENT TYPE (OR CODE)	RAIL* (L or R)	MEASUREMENT VALUE (in.)	AFFECTED LENGTH (ft.)	COMMENTS
101	5+50		GA		57.50	30	
101	7+00		AL	L	4.25	50	
101	7+00		PR	L	3.00	32	
102	12+20	1C1	RD		0.25	75	
102	15+75		CL	L	2.25	55	

MEASUREMENT TYPES AND CODES:

GA: Gauge
RD: Rail Displacement
CL: Cross Level
AL: Alignment
PR: Profile

*RAIL is the reference rail for Cross Level measurements, or the measurement rail for Alignment and Profile measurements

Figure 6. Completed Manual Track Geometry Inspection Worksheet.

Defect Free

A track segment is "defect free" with respect to a given component area if there are no defects, and in the case of Ties, Rail, and F&OTM, if the segment is not inspection-impaired. It is probable that while inspecting a track segment with respect to one or more component areas, an inspector will not find any defects for some of the areas. This information must be recorded and entered into the database or RAILER will assume that a previous inspection (in which defects were found) is the most current inspection. Therefore, "defect free" boxes have been provided on the Detail Inspection Worksheet for each of the five component areas. The Turnout Inspection Worksheet contains a column to indicate "defect free" for several turnout subcomponent areas. If the component or subcomponent area is indeed defect free, it is important that this be indicated in the box or column. The manual track geometry and remaining turnout inspection information is not based on defect occurrences. Instead, it consists of measurements and similar data that do not require the inspector to explicitly log defect occurrences.

Impaired Inspection

Quite often vegetation, excessive ballast, and other nontrack materials will interfere with the inspection of several component areas. In addition to these undesirable materials, grade crossings may obscure (usually totally) the underlying track structure. If not documented properly, large segments of inspection-impaired track could cause profound overestimation of general track quality and consequent underestimation of necessary repair materials. Furthermore, even a few linear feet of foreign material may hide serious defects.

Inspection-impaired track is documented separately within the RAILER detailed track inspection procedures for two groups of component areas: (1) ties, and (2) Rail and F&OTM (the inspection-impaired concept does not usually apply to the remaining four component areas). These two groups are separated for two reasons. First, foreign material that obscures one component might not impair the inspection of another component. For example, rail can often be inspected easily even though the ties are covered by ballast or soil. Second, the nature and extent of obscuring foreign material may change between the inspection of two component areas. For example, during the time between a tie inspection and an inspection of Rail and F&OTM (which may be more than a month), gravel may have been accidentally spilled on the track, obscuring tie plates and spikes.

For each of the two component area groups, obscuring material is accounted for in terms of equivalent linear track feet and percentage of track length. These values are calculated within the RAILER computer software based on data collected in the field during track inspection, and can also be calculated manually if RAILER has not been implemented. The field procedures and manual calculations are discussed in detail in Chapter 3 for ties and Chapter 4 for Rail and F&OTM.

Grade crossings also obscure track inspection, but the effects are treated differently within RAILER. Grade crossing length is a RAILER inventory data element and is used within RAILER to account for the effect of grade crossings on track inspection. For this reason, the inspection impairment associated with grade crossings is not recorded during the track inspection.

Defects Requiring Immediate Attention

This report covers track inspection to locate defects; it does not address repair of those defects. However, some defects require action immediately (or very soon) after discovery and consequently demand special attention during the inspection process. Two groups of these defects are discussed here: (1) those posing an immediate hazard because of possible derailment, and (2) those causing excessive deflection or rail movement. These and other defects that require immediate attention (in the inspector's judgment) should be noted by circling the defect on the worksheet and bringing it to the attention of the appropriate authority. These defects are those that could certainly be discovered during a safety inspection.

Defects Causing High Probability of Derailment. Defects that, if present, would with high probability cause derailments are immediate hazards. For example, a washout that has removed several inches of support ballast for a significant length of track may cause a derailment. The track should be taken out of service immediately until the defect is repaired.

Defects Causing Excessive Deflection or Rail Movement. When excessive rail movement occurs, two events happen that are very detrimental to operational safety. First, rail movement translates into car movement, and this can cause the cars to move to the extent that they derail. Second, the rail bends and twists in ways and degrees for which it is not designed. This action induces fatigue many times higher than normal and, in particular, can cause undetectable small flaws to grow and produce rail failure in a very short time. For example, when the rail is able to twist without proper restraint, a small base flaw, which is very difficult to detect even with ultrasonic equipment, could cause a rail failure after only a few train movements. Since joints often are problem areas, it should also be expected that excessive movements of the joints could cause failure in a short time. Once a joint or rail fails completely (e.g., breaks or pulls apart), any train movement over the defect could easily cause a derailment.

These failures must be prevented whenever possible by immediate repair of defects that permit excessive rail movement. These defects are not limited to rail and joint defects; certain tie and other F&OTM and BSM defects can also cause excessive rail movement.

Relationship Between Detailed Track Inspection and Condition Indexes

The development of various track condition indexes and a simplified condition survey inspection procedure for determining the indexes are addressed in USACERL Technical Reports FM-93/13 and FM-93/14, respectively. The simplification of the condition survey is accomplished primarily through the use of sampling techniques and a less detailed inspection procedure.

There is a direct relationship between the "Distress Types" and "Severity Levels" used for the condition survey inspection and the track defects used for a detailed track inspection, which is the focus of this report. Appendix B displays the RAILER "Master Defect List" and shows this relationship. The "TSCI Indices" column lists the corresponding distress type and severity level associated with specific track defects, where applicable.

This direct relationship between distress types and severity levels and the detailed track defects permits the various track condition indexes to be computed from the detailed inspections. Thus, the power and value of the condition indexes can be fully utilized in track management decisionmaking regardless of the inspection procedure used.

3 TIE INSPECTION

Description

Ties, more formally called "crossties," are structural track components attached underneath and perpendicular to the rails. The three primary purposes of ties are to: hold the rails together at gauge, transmit axle loads to the ballast, and anchor the track in the ballast (Hay 1982). On domestic Army installations, ties are almost always wooden, but may also be reinforced concrete or steel. The tie component area does not include ties within the limits of a turnout; they are examined during turnout inspection (see Chapter 9).

Defects and Causes

There are three categories of tie defects: defective (i.e., deteriorated) ties, missing ties, and improperly positioned ties.

Defective Ties

Both RAILER and the U.S. Army *Railroad Track Standards* (TM 5-628, AFR 91-44, April 1991) reserve the term "defective tie" for ties that can no longer perform their function adequately in the track structure, usually because of deterioration. The criteria for determining if a tie is defective are specified in the *Railroad Track Standards*. However, the quality of many ties may be borderline, thus requiring subjective evaluation. Therefore, it is important that this evaluation process be consistent on a tie-by-tie basis.

Ties generally deteriorate because of some combination of wear (loading) and environment. In addition, ties may be damaged during installation, in derailments, or by spike-kill (due to respiking the same tie several times).

Several distinct defect types associated with defective ties are distinguished by the following criteria:

1. Single versus tie cluster.

   The first criterion is the number of consecutive defective ties. If a single defective tie has neighboring ties that are not defective (i.e., the tie on both sides of the defective tie are not defective), then that tie is called a single defective tie. If there are two or more defective ties in a row, that group of ties is termed a defective tie cluster.

2. Single joint tie.

   Typical tie spacing will position one or two ties at rail joints. Depending on the track standard, to qualify as a joint tie, a crosstie must be placed with it's center within 18 or 24 inches of the rail ends. For the Army, the distance is 18 inches; a tie within this distance is a joint tie. A single defective joint tie where another nondefective joint tie is also present qualifies for this designation.

3. All joint ties defective.

   This is a case where all of the joint ties at a given joint are defective. This may be one or two ties depending on the tie spacing and positioning. If any defective tie cluster contains all of the joint ties at a given joint, then those ties are not considered part of the cluster. Instead, they constitute one occurrence of the defect type "defective ties -- all at joint." These occurrences are accounted for separately from other clusters.

4. Number of ties in a cluster.

Clusters are distinguished by the number of ties they contain: 2, 3, 4, or 5. If there are more than five consecutive defective ties, then they are treated as a combination of clusters -- the multiples of five and any remainder are all counted as separate defect occurrences. Note that the remainder may be a single defective tie. For example, if there are 7 defective ties in a row, then it counts as one cluster of 5 and one cluster of 2. Similarly, 11 consecutive defective ties counts as two clusters of 5 and one single defective tie.

5. Isolated versus adjacent clusters.

Clusters are further distinguished by how close they are to each other. If there is no more than one nondefective tie separating two clusters, they are then considered "adjacent" clusters. If a cluster is not adjacent, it is called "isolated." A cluster cannot be termed adjacent because of its proximity to a single defective tie. However, since two defective joint ties constitute a special kind of defective tie cluster (see #3 above), a regular cluster is considered adjacent if it is within one tie of such a joint tie cluster.

6. Isolated cluster with one joint tie.

Isolated clusters are also distinguished by whether or not they include a single defective joint tie.

These criteria imply the 16 defective tie defect types listed in Table 2.

Missing Ties

In the Army *Railroad Track Standards*, missing ties are not treated explicitly differently than defective ties. However, they are generally regarded as more serious because most defective ties still provide at least limited support to the track structure. Defective and missing ties are treated separately in RAILER in order to facilitate flexibility in M&R planning, the computation of the tie condition index (TCI) as reported by Uzarski (draft 1993a, 1993b), and other track standards.

Missing ties either were never originally placed or they were removed and never replaced.

Missing tie occurrences are determined relative to the existing tie spacing pattern. As illustrated in Figure 7, there are two common missing tie situations: (1) when a tie is simply missing and the tie spacing is otherwise unaffected (i.e., uniform), and (2) when one or both neighboring ties have been moved together to partially fill the gap.

There are five missing tie defect types:

1. Single missing tie (not part of a missing tie cluster),
2. Cluster of two missing ties,
3. Cluster of three missing ties,
4. All joint ties missing at a joint (one tie), and
5. All joint ties missing at a joint (two ties).

Table 2

Tie Defect Types

1. Single defective tie not at a joint
2. Single defective tie at a joint
3. All (one tie, as determined by spacing and positioning) joint ties defective (at a given joint)
4. All (two ties, as determined by spacing and positioning) joint ties, defective (at a given joint)
5. Isolated cluster without any joint ties–2 ties in a row
6. Isolated cluster without any joint ties–3 ties in a row
7. Isolated cluster without any joint ties–4 ties in a row
8. Isolated cluster without any joint ties–5 ties in a row
9. Isolated cluster with one joint tie–2 ties in a row
10. Isolated cluster with one joint tie–3 ties in a row
11. Isolated cluster with one joint tie–4 ties in a row
12. Isolated cluster with one joint tie–5 ties in a row
13. Adjacent cluster–2 ties in a row
14. Adjacent cluster–3 ties in a row
15. Adjacent cluster–4 ties in a row
16. Adjacent cluster–5 ties in a row

Note that no distinction is made between isolated and adjacent clusters of missing ties. If there are more than three consecutive missing ties, they are treated as a combination of clusters; the multiples of three and any remainder are counted as separate missing tie defect occurrences.

Tie Position Defects

Three types of tie defects are concerned with the position of the tie(s) relative to the rest of the track structure, including other ties. These are:

1. Improperly positioned (skewed, rotated, or bunched),
2. Tie center-to-center distance along either rail greater than 48 inches -- not at joint, and
3. Tie center-to-center distance along either rail greater than 48 inches -- at joint.

The first tie position defect type is evident when ties are shifted from their required normal position as illustrated in Figure 8. This defect is noted on a "per tie" basis. The other two defect types are concerned with the wide space between individual ties as measured along the rails, and is noted on a "per occurrence" basis. As indicated in Figure 9, wide spacing defects can occur because of several combinations of skewed, bunched, or missing ties. The only distinction between the wide spacing defect types is their location in relation to the joint (see types 2 and 3 above).

Causes of tie position defects include improper installation and handling during maintenance. Also, insufficient or poor quality ballast around the ties, coupled with train operations causing rail creep and vibrations, can result in tie movement.

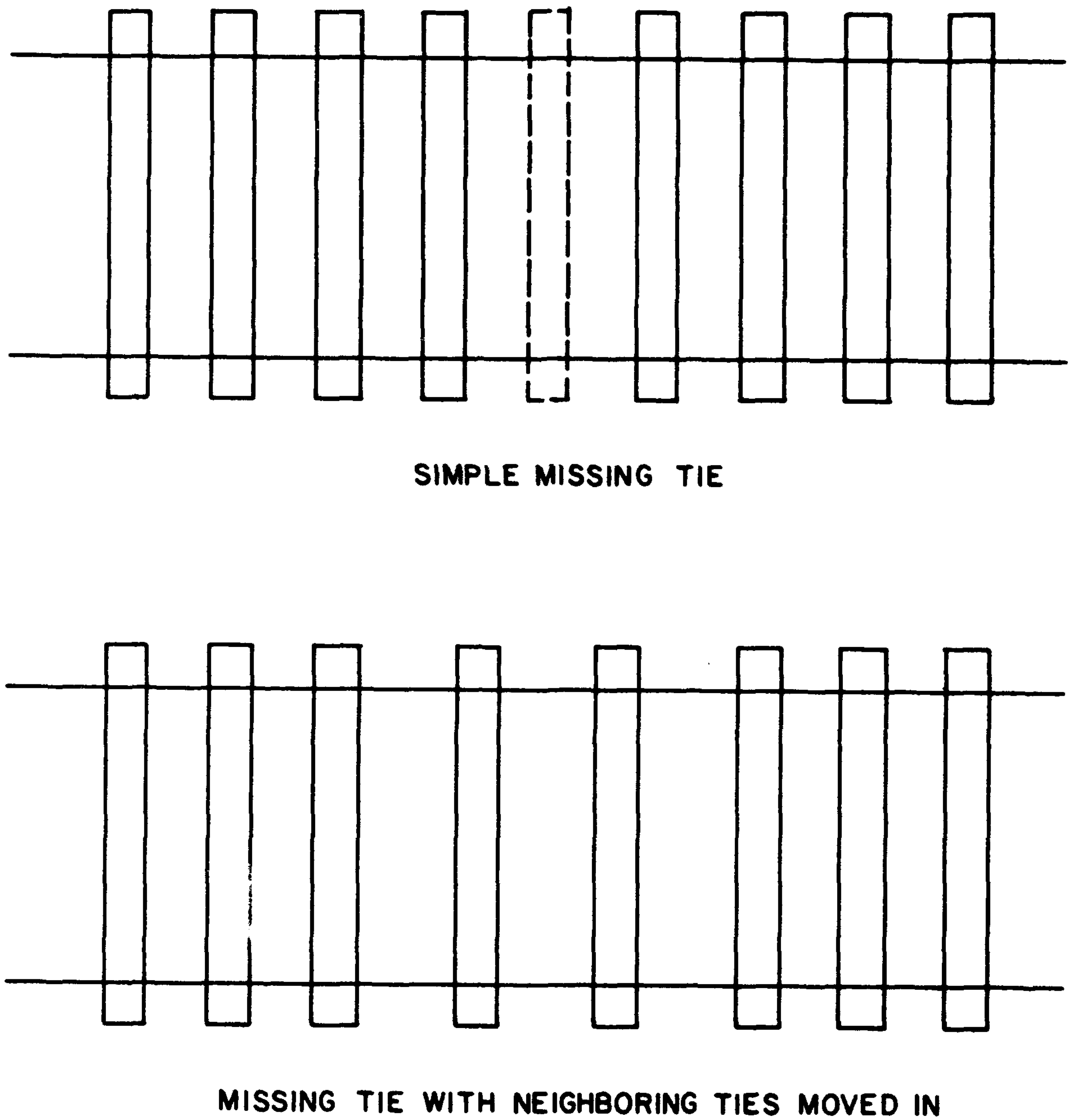
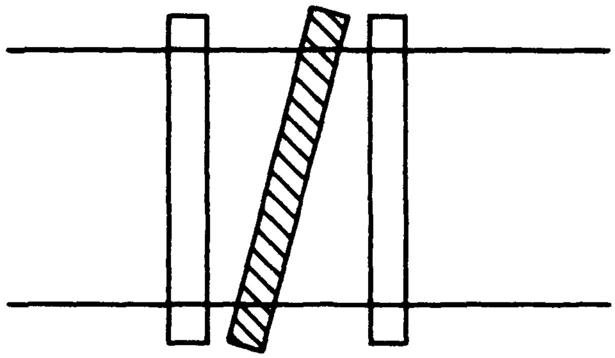
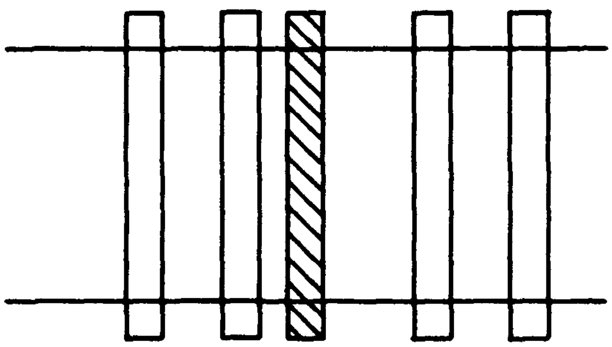


Figure 7. Missing Ties.



SKEWED TIE

ROTATED TIE (PROFILE VIEW)



BUNCHED TIE

Figure 8. Improperly Positioned Ties.

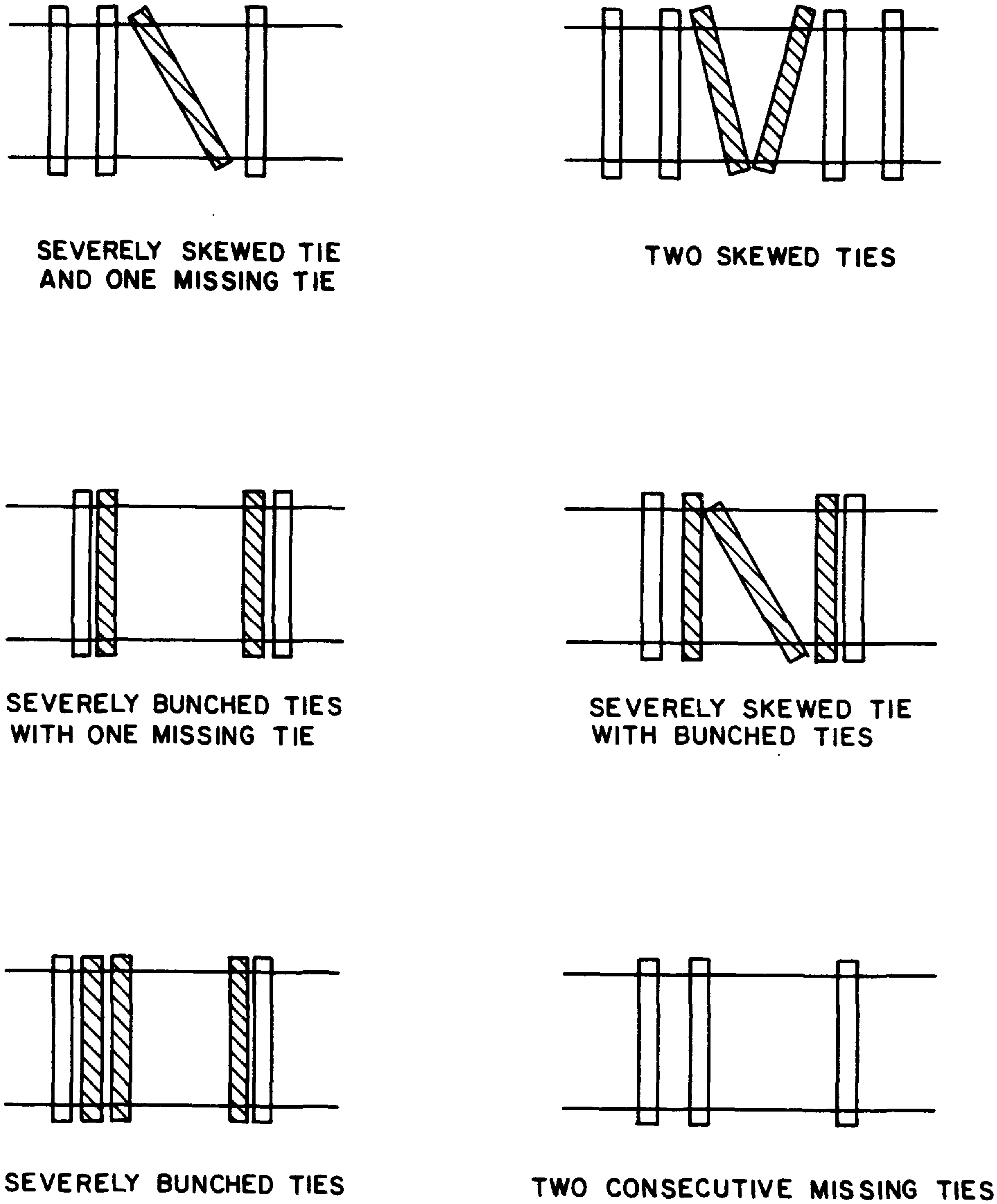


Figure 9. Some Potential Causes of Serious Separation Between Adjacent Ties.

Data Collection and Recording

Tie inspection data (for a single track segment) is recorded in the upper part of the Detail Inspection Worksheet (Figure 2); an enlargement of this portion of the worksheet is presented in Figure 10. Note that a box area is reserved for each of the 24 defect types discussed above (16 defective tie, 5 missing tie, and 3 tie position defect types). In each of these boxes, tie defect occurrences may be noted with tally marks while inspecting the segment, leaving room afterwards to enter the numerical value of the tally.

There are two alternative methods for keeping a count of single defective nonjoint ties and total number of defective ties. Single defective nonjoint ties may be tallied (using a tally counter, if convenient) as a group like the other tie defect types, or a total of all defective ties may be kept. Whichever counting approach is used, RAILER is able to calculate the other by either adding the count for the 16 defective tie types or subtracting the other 15 defective types while the total defective tie count may be determined by adding up the 16 defective types. For example, based on the data in Figure 10, the number of single defective nonjoint ties is:

$$11 = 51 - \{2+2+(4+1+3)(2)+(3+0+2)(3)+(0+0+0)(4)+(0+0+1)(5)\}$$

As in Figure 10, it is very important that the inspector circle either "single" or "total" above the data entry box to indicate the counting method used. Because single defective nonjoint ties are the most common defect type, a hand held "tally" counter is recommended for keeping count. The use of a counter will be especially helpful if the total defective ties option is used. The number from the counter is then simply entered on the worksheet (note that there are no tally marks in this box in Figure 10).

The same two alternatives are also available for determining the number of single missing ties. Again, it is very important to circle either "single" or "total" above the first missing ties data entry box. In Figure 10, the single missing tie option was used.

Usually, one tie defect is noted at a given location. If a defective tie is also skewed, rotated, or bunched, the tie position defect type is not noted. Also, when there are multiple tie position defects at the same location, only the most severe is counted, since the others are contributing to the one that is counted. For example, two defective ties under a joint followed by a missing tie and a bunched tie as depicted in Figure 11 imply one occurrence each of the three defect types indicated. The missing tie and 48-in. spacing problem are both counted. However, the bunched tie is a part of the spacing problem and is therefore not counted a defect occurrence. A 48-in. spacing problem is not recorded if the spacing is due to two or more missing ties; the "problem" is not spacing, but rather missing ties. RAILER will recognize that a distance of greater than 48 inches of unsupported rail length exists based on the number of consecutive missing ties.

The tie defects data collection process is illustrated with the tie defects track diagram presented in Figure 12 and the corresponding list of defect occurrences presented in Table 3. The completed tie inspection section (Figure 10) is based on this mock field data. In this case, all defective ties were counted so that the number of single defective nonjoint ties would be calculated in the computer as discussed above. This defective tie count is indicated along the bottom of the track in Figure 12; the tie positions along the top provide useful reference numbers for Table 3. The commentary in Table 3 indicates the logic that should be used in choosing the appropriate defect types in complicated situations.

RAILER DETAILED TRACK INSPECTION

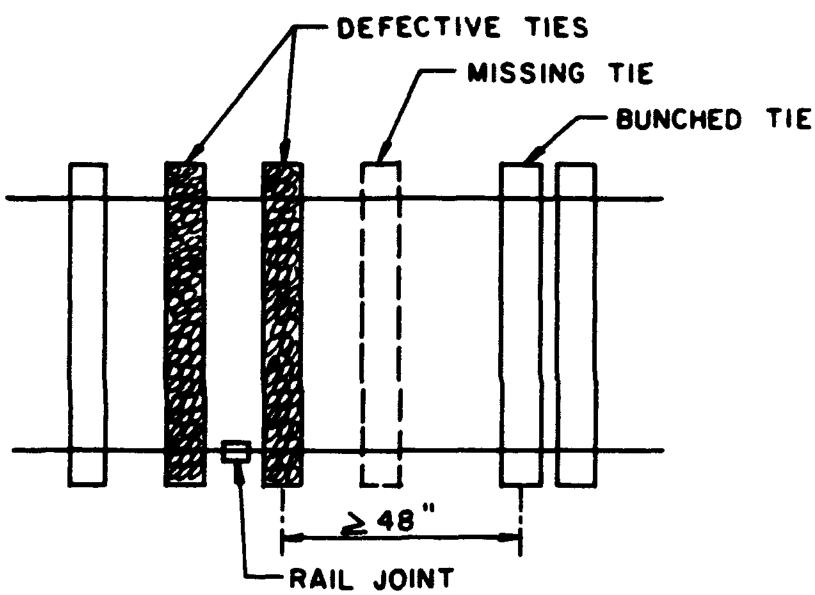
TRACK SEGMENT #: 101	SEGMENT BEGINNING LOCATION: 0+87	INSPECTOR: DRU	DATE: 1/20/93

TIES	DEFECTIVE TIES				MISSING TIES				
CHECK IF DEFECT FREE ☐	SINGLE OR TOTAL (TOTAL circled)	SINGLE AT JT	ALL AT JOINT 1 Tie	ALL AT JOINT 2 Ties	SINGLE OR TOTAL (SINGLE circled)	2 IN A ROW	3 IN A ROW	ALL AT JOINT 1 Tie	ALL AT JOINT 2 Ties
INSPECTION IMPAIRED: TF 5, 5, 1, 1, 5, 3, 2, 1 — 22; %	51	2		1	2	1			1

	ISOLATED CLUSTER	ISOLATED W/1 JOINT TIE	ADJACENT CLUSTER
2 IN A ROW	4	1	3
3 IN A ROW	3		2
4 IN A ROW			
5 IN A ROW			1

IMPROPERLY POSITIONED TIES		
SKEWED, ROTATED, BUNCHED	CENTER - CENTER SPACING > 48" NOT AT JT	CENTER - CENTER SPACING > 48" AT JOINT
2	2	2

Figure 10. Tie Inspection Data.



Occurrences	Defect Type
1	All joint ties defective (2 ties)
1	Single missing tie
1	Center-to-center spacing > 48 in.–not at joint

Figure 11. Example of Multiple Tie Defect Occurrences at the Same Location.

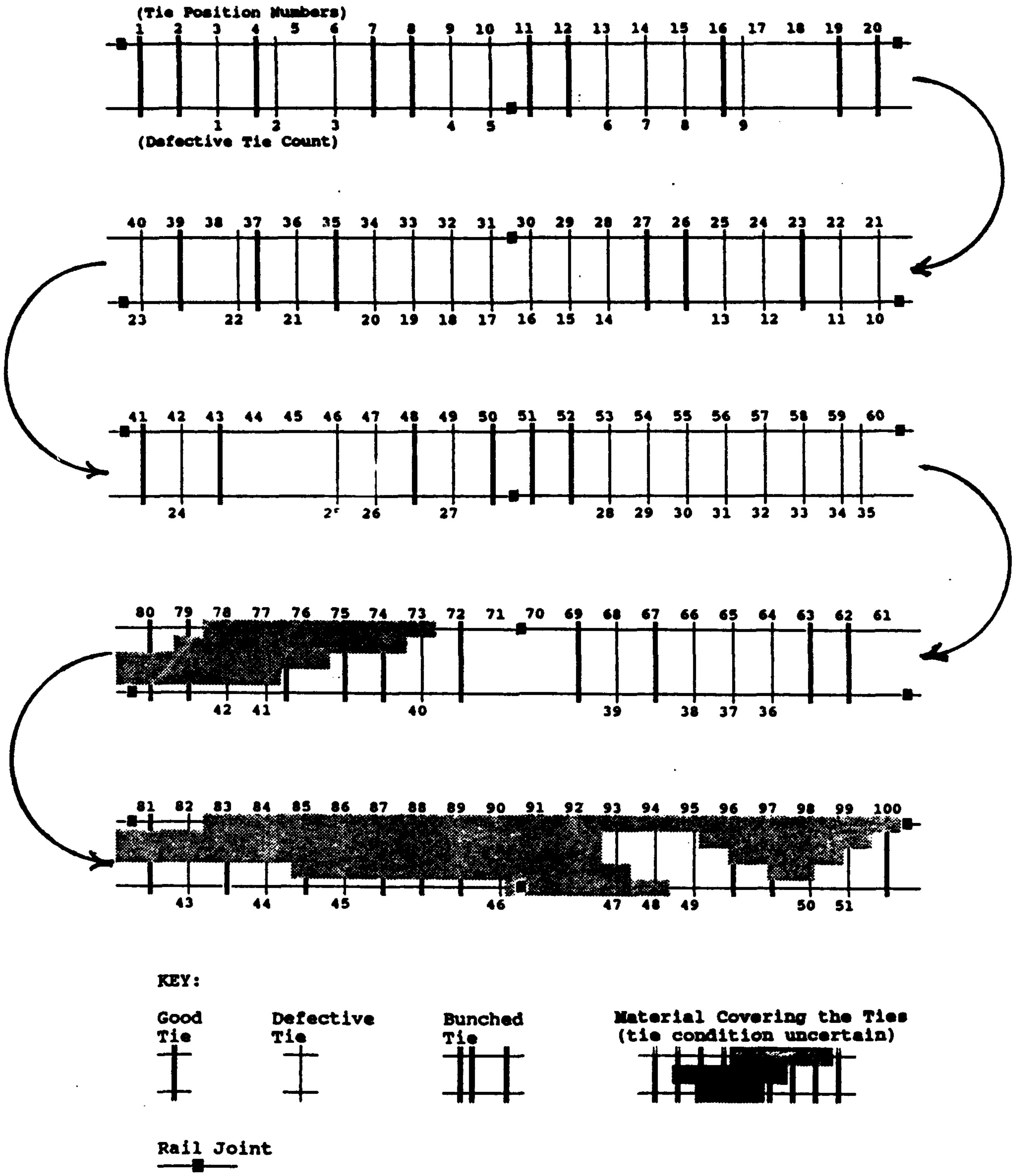


Figure 12. Track Diagram Showing Tie Defects.

Table 3

Tie Defect Occurrences

Tie Position	Tie Defect Type[1]	Comments
5-6	Isolated cluster of 2 defective ties	The skewed, rotated, or bunched defect type is not noted if the tie is defective.
9-10	Isolated cluster of 2 with one joint tie	
13-15	Isolated cluster of 3 defective ties	
17-18	Center-to-center spacing > 48 in.–not at joint	Only the more serious tie position defect type is noted along with the missing tie. If a single missing tie contributes to spacing exceeds 48 in., both the single missing tie and excessive spacing defects are counted.
18	Single missing tie	
21-22	Adjacent cluster of 2 defective ties	Adjacent clusters are not differentiated as to whether they include a joint tie.
24-25	Adjacent cluster of 2 defective ties	
28-29	Adjacent cluster of 2 defective ties	Note how the seven consecutive defective ties (positions 14 through 20) are accounted for by two clusters and the "all at joint" defect type. The two clusters are "adjacent" because they are adjacent to the two defective joint ties.
30-31	All ties at joint are defective (2 ties)	
32-34	Adjacent cluster of 3 defective ties	
38	Skewed, rotated or bunched	
40	Single defective tie at a joint	
44-45	Missing ties -- cluster of 2	Only the missing ties are counted. The wide spacing is automatically noted in RAILER when the missing ties are in a cluster of two or more.
46-47	Isolated cluster of 2 defective ties	
53-57	Adjacent cluster of 5 defective ties	Note how the eight consecutive defective ties (positions 53 through 60) are accounted for by two adjacent clusters.
58-60	Adjacent cluster of 3 defective ties	
60-61	Center-to-center spacing > 48 in.–at joint	Only the more serious tie position defect type is noted along with the missing tie. If a single missing tie contributes to spacing exceeding 48 in., both the single missing tie and excessive spacing defects are counted.
61	Single missing tie	
64-66	Isolated cluster of 3 defective ties	
70-71	All joint ties missing (2 ties)	Only the missing ties are counted. The wide spacing is automatically noted in RAILER when the missing ties are in a cluster of two or more.
76	Skewed, rotated, or bunched	These defects are noted even though they are located in an area that is tie inspection-impaired.
77-78	Isolated cluster of 2 defective ties	
90	Single defective tie at a joint	There may be more serious defects types than those indicated. Ties 83-93 and 96-98 are all inspection impaired and each could be defective. Furthermore, ties 91 and 92, and the hidden parts of other ties could be missing.
93-95	Isolated cluster of 3 defective ties	
98-99	Isolated cluster of 2 defective ties	

[1] This table is based on the defects presented in Figure 12. The table does not include the occurrences of single defective nonjoint ties, which are dealt with separately in the text.

Impairment of Tie Inspection

As discussed in Chapter 2, vegetation, excessive ballast, and other nontrack materials can interfere with the inspection of key components of the track structure. RAILER tie inspection includes a procedure for recording the number of ties that were not inspected properly because of visual impairment.

Criterion

A tie is inspection impaired if a portion or all of the top surface is not visible and the inspector cannot determine if it is defective or improperly positioned. Conversely, if a portion of the top surface is not visible and the inspector can determine if it is defective or improperly positioned, it is not inspection impaired. For example, Figure 12 shows eight such impaired areas; in terms of tie position, these are 74-76, 79-81, 83, 85, 87-89, 91-92, 96-97, and 100. In these areas, the inspector was not certain that the ties were good as defects could be hidden. Note, though, that the inspector was able to determine that some of the ties were defective even though some were partially covered.

Inspection-Impaired Track Length

Impaired tie inspection is accounted for on the basis of the length (in feet) of impaired track. Tie inspection is usually impaired for several consecutive ties. The estimated track length of each impairment is entered in the upper part of the large box on the tie inspection worksheet section labeled "LENGTH (TF):" (see Figure 10), leaving room at the bottom for the calculations discussed below. For example in Figure 12, the three impaired areas are 6 ft, 17 ft, and 5 ft; these values are properly recorded in Figure 10.

After the ties of a track segment have been inspected, the inspection impaired lengths are added and the sum is recorded in the bottom right hand corner of the box. This is illustrated in Figure 10.

Percentage Inspection Impaired

The percentage of track length that is inspection-impaired for ties is calculated automatically with RAILER. It can also be calculated manually by dividing the total track feet of impaired tie inspection by the track segment length (less grade crossing length) and multiplying by 100:

$$PII_t \frac{TOT_t}{TSL-GCL} \times 100 \qquad [Eq\ 1]$$

where:
- PII_t = percentage of inspection-impaired track for ties
- TOT_t = total track feet of impaired tie inspection (excluding grade crossings)
- TSL = track segment length
- GCL = grade crossing length

If inspection is impaired for a large part of the segment, it may be easier for an inspector to record the length in terms of percentage. The inspector can simply enter an estimated percentage of the total track that is noninspectable. This percentage is the same as the "PII_t" computed in Equation 1, except that it is estimated visually. This percentage is based on the track segment minus the length of grade crossings. RAILER will compute the length of impaired inspection in feet.

Defect Free

If, after inspecting a track segment along its entire length, no tie defects of any kind (defective, missing, or improperly positioned ties) are found, and if no portion of the segment is inspection-impaired (except for grade crossings), the inspector should check the defect free box in the upper left corner of the inspection worksheet (see Figure 10).

Comments

Any additional tie inspection information that complements or supplements the defect occurrence information, may be provided by the inspector in the margin or on the reverse of the inspection worksheets. These comments may be entered into the RAILER database. Tie defects that require immediate attention should also be noted.

4 COMMON INSPECTION FEATURES

Recall that Rail; Ballast, Subgrade, and Roadway (BSR); and Drainage inspection, along with most Fastenings and Other Track Material (F&OTM) defects, are recorded in a common area in the middle of the Detail Inspection Worksheet (Figure 2).* An enlargement of this portion of the sheet is presented in Figure 13.** This chapter addresses the common inspection procedures associated with these component areas, including the use of component and defect codes, defect location information, alternative ways of indicating the amount of a particular defect type, and impaired inspection procedures. Details specific to each of the individual component areas are discussed in Chapters 5 through 8.

Component Codes and Defect Codes

Specific defect occurrences are indicated by a two-character component code and a three-character defect code. These codes are listed on the back of the Detail Inspection Worksheet (Figure 3). Note that there is one component code each for Rail and BSR, while multiple component codes are specified for both F&OTM and Drainage. Most of the defect codes are unique to specific component areas, with F&OTM divided into two groups (joints and a variety of components).

For each group of component codes, the choice of available defect codes is confined to those indicated in Figure 3 and, as discussed in Chapters 6 and 8, the choice is often even more limited for individual component codes. In particular, the RAILER software will not accept "creative" combinations of component and defect codes. This characteristic of the RAILER software limits entries to precisely predefined defect types, and thereby prevents ambiguous entries, along with obviously inconsistent entries such as "pumping anchors."

Also, a "Master Defect List" (Appendix B) exists within the RAILER software. Any of the defect codes can be used and RAILER will accept them into the database. This process would be particularly useful if you want to create a customized set of track standards. When developing customized standards, you can simply choose from the RAILER Master Defect List which defects to include. The defect lists provided in Appendix A (on the reverse of the Detail Inspection Worksheet) were customized from the master list for specific Army, Navy, and FRA application.

The component and defect codes associated with each respective component area are discussed in more detail in Chapters 5 through 8. In the case of F&OTM and Drainage, this includes specifying which defect codes are compatible with each of the individual component codes.

Immediate Attention Defects

Circle the defect code if the defect requires immediate attention. Recall from Chapter 2 that defects requiring immediate attention are those that, if present, have a high probability of causing a derailment or cause excessive deflection or rail movement. Some Rail, F&OTM, BSR, and Drainage defect types would receive immediate attention under certain circumstances. Some defects would require immediate attention for the safety of train operations, such as BS/EWA (ballast/subgrade erosion-washout), but may not require immediate attention if the track segment is inactive. Some defects may be relatively minor

*The single exception is the F&OTM flangeway measurements. These are recorded in an isolated section of the same page and are discussed in Chapter 6.

**Explanations for the individual entries in Figure 13, and other example entries, are presented in Chapters 5, 6, 7, and 8.

CHECK IF DEFECT FREE		RAIL ☐		FASTENINGS AND OTM ☐			BALLAST, SUBGRADE AND ROADWAY ☐				DRAINAGE ☒		
COMP CODE	DEFECT CODE	RAIL (L,R,B)	LOCATION (STATION)	LENGTH (T F)	DENSITY (%)	QTY (#)	COMP CODE	DEFECT CODE	RAIL (L,R,B)	LOCATION (STATION)	LENGTH (T F)	DENSITY (%)	QTY (#)
GR	LOS		0+90			1	RL	FLK	R	5+50	250	75	
BS	DTY		1+00	100			JT	LBT	L	5+70			1
RL	BRB	L	1+40			1	RL	LIJ	R	5+80			2
SP	IMP	R	1+50	200	50		TP	IMP	B	6+00	200	50	
BS	VGB		1+50	400	75		JT	LBT	B	6+00	100	75	
RL	SHL	R	2+20			1	BS	CBT		6+00	40		4
RL	ENB	B	3+50	150		10	JT	ABL	L	6+40			1
SP	MIS	B	3+50			5	RL	ENB	L	6+50			2
BS	POE		3+90			3	RL	SHV	L	6+50			1
RL	TCE	R	4+00			1	RL	BHC	L	6+50			1
BS	VII		4+10	30			GC	RFM		7+20			26
JT	CCB	R	5+20			1	RL	FLK	B	8+00	250	75	
BS	IBL		5+50	40									

Figure 13. Enlarged Section of the Detail Inspection Worksheet.

and not require immediate attention by themselves, but should they occur in conjunction with one or more other defects, a hazard may result necessitating immediate action. Clearly, inspector judgement must prevail in this designation.

Defect Location Information

Defect location information may be indicated with two entries, **RAIL (L,R,B)** and **LOCATION (STATION)**.

RAIL (L,R,B)

The RAIL (L,R,B) indicator has two distinct functions. The first is simply location information that may be helpful later in relocating the defect for further scrutiny and/or repair. As will be generally discussed later in this chapter and with specificity in the next two chapters, RAIL (L,R,B) is also sometimes used in calculating certain defect quantities.

The RAIL (L,R,B) location indicator consists of three possible entries:

L: Left Rail or Left Side of the track,
R: Right Rail or Right Side of the track, and
B: Both Rails or Both Sides of the track.

When you are in the middle of the track facing the direction of increasing stationing, the left rail and left side of the track are on your left, and the right rail and right side of the track are on the right. "Facing the direction of increasing stationing" means that the station numbers in front of you are larger than those behind. Therefore, you should be particularly careful with this data element when starting from the end of a track segment (where the station numbers are the highest) and working towards the beginning. In this context, there may be a natural tendency to indicate "R" when, for example, the defect is on your right, which is actually the left side of the track. For this reason, take care when creating an inspection plan. As discussed in Chapter 2, Rail, F&OTM, and BSR are inspected most efficiently when accomplished in the direction of increasing station. Experience has shown that there is less error and the field work actually progresses somewhat faster.

RAIL (L,R,B) is a useful, though sometimes optional, location indicator with all four component areas. It may be used to locate defects that are explicitly associated with one rail or the other, including rail and joint defects, and others such as missing spikes along a given rail. RAIL (L,R,B) may be also used to indicate a side of the track. For example, the embankment may be eroded on the left side only, or when there are ditches on both sides of the track and only the one on the right is obstructed.

The B (Both Rails) entry is used when the same defect type occurs with both rails at more or less the same location. For example, at a given location there may be engine burns on both rails, or in the same length of track (see later discussion on rail length), tie plates may be missing from both rails. The B option may be also used as a general descriptor to indicate both sides of the track with respect to certain defect types. For example, flow in ditches may be obstructed on both sides of the track.

RAIL (L,R,B) should not be used with defect types that cannot be associated with only one rail or side of the track. For example, a gauge rod may be loose, but it cannot really be associated with only one of the rails, so the RAIL (L,R,B) option is not used.

Location (Station)

The station location associated with a defect entry is the actual location of the defect (if it can be discretely identified to a specific station) or the beginning of the defect (or series of occurrences of the same defect) should it cover a given length of track. The location can be estimated by pacing, measuring, or otherwise approximating the distance from the nearest station marker (commonly occurring at 200-ft intervals). This data element identifies the defect location to help work crews locate the problem area later.

Defect Length, Density, and/or Quantity

In addiuon to the component code, defect code, and location indicators, three other descriptors—Length, Density, and Quantity—are used with each defect entry. In conjunction with the location descriptors, they permit the inspector to indicate the abundance of discrete defects or the linear extent of continuous defects such as ballast erosion. In particular, with discrete defects such as missing spikes, these descriptors are used to indicate the exact or approximate number of occurrences at a given location or along a specified length of track. With continuously occurring defects, such as various vegetation defect types, they are used to indicate the linear length of a given occurrence, or the relative proportion of a defect type within a given length of track.

A quantity must accompany each defect entry to indicate the number of discreet defects found or the extent of a continuous defect. As will be discussed in the following two subsections, length and density may be used together to provide an estimate of quantity. Alternatively, quantity can be recorded directly with or without a length measurement. Work quantities and cost estimates result from this information. The default quantity value is 1.

Length

The length descriptor is used to indicate the approximate length of the affected area, in track feet. This descriptor is most useful for characterizing continuous defects (e.g., ballast and subgrade problems) or large numbers of discrete defects that occur over relatively long lengths of track (e.g., missing rail anchors in a 50-ft. interval or improperly positioned spikes over a 1000 ft interval). The length descriptor is not to be used with a single instance of a discrete defect.

The length value can usually be determined by pacing, or by estimation. A measuring tape may be useful in some instances, but is usually not necessary. The default value is segment length. A length value is not permitted for certain defect types.

Density

The density descriptor is used to indicate the relative abundance of the defect type within a specified length of track, and is therefore usually recorded in combination with the length descriptor. For example, approximately 25 percent of the tie plates may be missing in a 100-ft length, or perhaps vegetation is growing in the ballast somewhat discontinuously, with about 50 percent density, over the entire length of the track segment. When the density descriptor is left blank and the length descriptor is used, density is assumed to be 100 percent over that track length. The density descriptor is formally defined somewhat differently for discrete and continuous defects. A density value is not permitted for certain defect types.

Multiple Discrete Occurrences. The density descriptor for multiple occurrences of a discrete defect type is defined:

$$\text{Density} = (Nd / Nt) \times 100 \quad \text{[Eq 2]}$$

where: Nd = number of defective items within the length of occurrence; and
Nt = total number of items within the length of occurrence.

Continuous Occurrences. The density descriptor for continuous defect types is defined:

$$\text{Density} = (Ld / Lt) \times 100 \quad \text{[Eq 3]}$$

where: Ld = length of track actually affected by defect; and
Lt = total distance between the beginning and the end of the affected track length.

These equations are presented here only to clarify how the density descriptor is defined, and are not intended as formulas for calculating density in the field. Instead, density is usually estimated by a simple, visual judgement. For example, since a tie plate is required under each rail on all ties, the inspector may readily estimate a 25 percent density when it is obvious that about one-fourth of the tie plates are missing along a given length of track.

Quantity

The quantity descriptor is used to indicate the actual count for one or more occurrences of a discrete defect type at approximately the same station location, or along a specified length of track. A quantity count is generally more accurate than a quantity estimate based on length/density, however, for work planning purposes, particularly at the network management level (see Chapter 1), the difference is usually of no consequence. Quite often, estimating quantity based on length/density speeds the inspection and significantly reduces the inspection recording and RAILER data entry requirements. The most common use of the quantity descriptor is to indicate a single occurrence of a discrete defect.

When length/density are not recorded and a quantity is not specified, a default value of 1 is used in RAILER. Where length/density are recorded, quantity is estimated using Equations 2 and 3. The estimated quantity value can be "overridden" at the time of entry into the RAILER database.

Indicator Combinations

There is a great deal of flexibility in which the location indicators and pure abundance indicators may be used in numerous combinations. The indications and potential problems of various combinations are presented in Tables 4 and 5 for discrete and continuous defects, respectively. These tables are presented to convey the logic by which the indicators may be used in combination; there should be no need to constantly refer to these tables during the inspection process.

As was shown in Figure 13, each defect entry should include length, density, and/or quantity; i.e., they should not all be left blank. Quantity is most typically recorded when relatively small numbers of discreet defects occur. Length/density estimations of quantity are most typically used when the quantities are rather large in number and cover a relatively long distance (more than a few feet).

Although all these indicator combinations provide considerable flexibility, defects are most often noted on a "per occurrence" basis using two combinations, as in Figure 13. Individual occurrences of

Table 4

Indicator Combinations for Discrete Defects

	Rail	Station Location (S)	Length (L), Density (D) or Quantity (Q)	Indications (I) and Potential Problems (P)
1.	Blank, R, L, or B	Blank or S	Blank	I: Default quantity of defect occurrence. P: Preferable not to leave all three quantity indicators blank.
2.	Blank or B	Blank	L	I: For L track ft all of the given component type has the given defect type.[a,b] P: Preferable to have beginning station location.[c]
3.	L or R	Blank	L	I: For L track ft along the given rail, all of the given component type has the given defect type.[a,b] P: Preferable to have beginning station location.[c]
4.	Blank or B	S	L	I: For L track ft beginning at S location, all of the given component type has the given defect type.[a,b]
5.	L or R	S	L	I: For L track ft along the given rail beginning at S location, all of the given component type has the given defect type.[a,b]
6.	Blank or B	Blank	D	I: For the entire track segment, D percent of the given component type has the given defect type.[b]
7.	L or R	Blank	D	I: For the entire track segment along the given rail, D percent of the given component type has the given defect type.[b]
8.	Blank or B	S	D	I: For the rest of the segment, beginning at S location, D percent of the given component type has the given defect type.[b]
9.	R or L	S	D	I: For the rest of the segment along the given rail, beginning at S location, D percent of the given component type has the given defect type.[b]
10.	Blank or B	Blank	L and D	I: For L track ft, D percent of the given component type has the given defect type.[b] P: Preferable to have beginning station location.[c]
11.	R or L	Blank	L and D	I: For L track ft along the given rail, D percent of the given component type has the given defect type.[b] P: Preferable to have beginning station location.[c]
12.	Blank or B	S	L and D	I: For L track ft beginning at S location, D percent all of the given component type has the given defect type.[b]
13.	R or L	S	L and D	I: For L track ft along the given rail beginning at S location, D percent of the given component type has the given defect type.[b]
14.	Blank	Blank	Q	I: Q number of occurrences, location(s) unspecified. P: Preferable to have some location (station) information.[c]
15.	R, L, or B	Blank	Q	I: Q number of occurrences found along right, left or both rails, location(s) unspecified. P: Preferable to have some location (station) information.[c]
16.	Blank	S	Q	I: Q number of occurrences at or near S location.
17.	R, L, or B	S	Q	I: Q number of occurrences at or near S location, in association with the specified rail(s).

Table 4 (Cont'd)

	Rail	Station Location (S)	Length (L), Density (D), or Quantity (Q)	Indications (I) and Potential Problems (P)
18.	Blank	Blank	L and Q	I: Q number of occurrences found along L track ft. P: Preferable to have beginning station location.[c]
19.	R, L, or B	Blank	L and Q	I: Q number of occurrences found along L track ft, in association with the specified rail(s). P: Preferable to have beginning station location.[c]
20.	Blank	S	L and Q	I: Beginning at S location, Q number of occurrences found along L track ft.
21.	R, L, or B	S	L and Q	I: Beginning at S location, Q number of occurrences found along L track ft, in association with the specified rail(s).
22.	Blank, R, L, or B	Blank or S	D and Q[e]	I: Q number of defect occurrences. P: The Density and Quantity indicators should not be used together; the quantity value will always override the quantity implied by the density value and the original density entry will not be retained in RAILER.

[a] Density is assumed to be 100 percent when there is a length entry and no density entry.

[b] With Rail and rail associated F&OTM components, a B rail entry will indicate twice as many defect occurrences as with an R or L entry.

[c] Defaults to the beginning station location of the track segment.

[d] While entering the data in the computer, after the length is entered and density is left blank, the computer will calculate a quantity value based on 100 percent density. The operator must then override the calculated value with the quantity value collected in the field.

[e] Either with or without a L (length) entry.

discrete defects are frequently noted by recording a quantity of one with a station location, while occurrences of continuous defects are most commonly indicated with the length, location, and sometimes density descriptors.

As discussed earlier, the RAIL (L,R,B) indicator is sometimes used to calculate quantity of certain discrete Rail and F&OTM defect types that are rail-specific. For example, cracked joint bars are rail-specific in that each bar is linked to a rail joint associated with either the left or right rail. With these rail-specific defects, if the quantity is not otherwise specified, a "B" used with length/density will indicate twice as many defect occurrences as a "L" or "R" entry.

Most of the potential sources of error in data recording and entry into RAILER center on the lack of station location information. Lack of this information could result in wasted effort for section gangs or crews in looking for the defects to be corrected. Also, since default values are used with station location and length (when not specified), error can occur when RAILER estimates quantities.

Impaired Inspection for Rail and F&OTM

As discussed in Chapter 2, vegetation, excessive ballast, and other materials can interfere with the visual inspection of key components of the track structure. This interference may prevent an inspector from observing small but serious defects, such as along the base of a rail. Therefore, for the Rail and F&OTM component areas, the inspection process includes procedures for indicating the portion that was

Table 5

Indicator Combinations for Continuous Defects

	Rail	Station Location (S)	Length (L), Density (D) or Quantity (Q)	Indications (I) and Potential Problems (P)
1.	Blank, R, L, or B	Blank or S	Blank	I: Default quantity of one track foot with this defect type.[a] P: Preferable not to leave all three quantity indicators blank.
2.	Blank	Blank	L	I: Defect type is L track ft long.[b] P: Preferable to have beginning station location.[c]
3.	L, R, or B	Blank	L	I: Defect type is L track ft long and occurs on the specified side(s) of the track.[b,c] P: Preferable to have beginning station location.[c]
4.	Blank	S	L	I: Defect type is L track ft long, beginning at S location.[b]
5.	L, R, or B	S	L	I: Defect type is L track ft long, begins at S location, and occurs on the specified side(s) of the track.[b,c]
6.	Blank	Blank	D	I: Defect type has an average density of D over the length of the entire track segment.
7.	L, R, or B	Blank	D	I: Defect type has an average density of D over the length of the entire track segment, and occurs on the specified side(s) of the track.[d]
8.	Blank	S	D	I: Beginning at S location, defect type has an average density of D for the rest of the track segment.
9.	R, L, or B	S	D	I: Beginning at S location, defect type has an average density of D for the rest of the track segment, occurring on the specified side(s) of the track.[d]
10.	Blank	Blank	L and D	I: For L track ft, defect type is D percent dense. P: Preferable to have beginning station location.[c]
11.	R, L, or B	Blank	L and D	I: For L track ft, defect type is D percent dense, occurring on the specified side(s) of the track.[d] P: Preferable to have beginning station location.[c]
12.	Blank	S	L and D	I: For L track ft beginning at S location, defect type is D percent dense.
13.	R, L, or B	S	L and D	I: For L track ft beginning at S location, defect type is D percent dense and occurs on the specified side(s) of the track.
14.	Blank, R, L, or B	Blank or S	Q [e]	I: There are Q track feet with this defect type.[a] P: Length (L) should be used instead of Quantity (Q) when recording continuous defect types.

[a] Continuous defects are measured in track feet—not by the number of occurrences.
[b] Density is assumed to be 100% when there is a length entry and no density entry.
[c] Defaults to starting at the track segment's beginning station location.
[d] With continuous defects, the Rail(R,L,B) descriptor only provides location information; it had no role in calculating defect quantity.
[e] Either with or without a L (length) and/or D (density) entry.

not properly inspected due to visual impairment. A single set of procedures is used to record this impairment.

Rail and F&OTM impaired inspection information is recorded in the lower right-hand area of the Detail Inspection Worksheet (Figure 2). This portion of the form is presented in Figure 14. Note that this is different than the tie component area impaired inspection portion located in the upper left area of the worksheet (see Chapter 3). Rail and F&OTM impaired inspection information includes recording the amount impaired in units of track feet. This amount is based on "quarters of coverage" or a simple percentage. The procedures for collecting and recording these quantities are addressed later in this chapter.

Criterion

A proper rail inspection requires an inspection of the rail base. Research indicates that base defects are critical factors that often control the fatigue life of rail (Kurath and White, December 1985). Furthermore, many F&OTM components are concealed when the rail base is not visible. For this reason, if the base of the rail is concealed, the covered length is considered inspection-impaired for both the Rail and F&OTM component areas. Of course, you should still inspect any exposed Rail or F&OTM component, or component part such as the rail head and record any observed defects. As discussed in Chapter 2, impairment due to grade crossings are not recorded. These are handled automatically within RAILER. The BSR and drainage component areas cannot be inspection-impaired.

Inspection-Impaired Track Length and Quarters of Coverage

If the base of only one rail (or one side of a rail, etc.) is covered, the inspection is then only partially impaired at that station location. Consequently, inspection-impaired track for Rail and F&OTM is accounted for by quarters of coverage: one side of one rail is a quarter of coverage; both sides of one rail or one side of each rail is two quarters; both sides of one rail plus one side of the other is three quarters; and both sides of both rails corresponds to four quarters of coverage. For each of these instances of coverage, the length of each inspection impairment is recorded separately. Ultimately, they will be combined to compute an equivalent track length of inspection impairment.

Figures 14 and 15 illustrate the quarters of coverage method for recording Rail and F&OTM inspection impairment. The shaded areas shown in Figure 15 represent areas where the base and part of the web on the various rail sides are covered by ballast or debris. This information is recorded in the "Length" column as shown in Figure 14.

The example presented in Figures 14 and 15 illustrates the impaired inspection procedures, but not the level of detail required. These procedures are not expected to be very exacting. You do not have to be very precise about the lengths of various stretches of coverage, but you do need to be accurate enough to generate reasonable estimates of length or percent impaired.

The Equivalent Track Length

To provide for a meaningful parameter, the four totals (for one, two, three, and four quarters of coverage) must be combined into a single "normalized" equivalent track length value. This value is calculated automatically by the RAILER computer software. It can also be calculated manually as illustrated in Figure 14 and discussed in the following four steps.

Step 1: Add up each line total and record the result in the "Line Total" column.

INSPECTION IMPAIRED				
1/4'S	LENGTH (LF)	LINE TOTAL (LF)	Q.L. (LF)	SUM OF Q.L.
1	10	10	10	114
2	9, 5, 4	18	36	TOTAL SUM OF Q.L./4
3	7, 5	12	36	28.5
4	8	8	32	%

Figure 14. Completed Rail and F&OTM Impaired Inspection Section.

Step 2: Multiply each line total by the quarters of coverage for that line. This is accomplished by multiplying the "Line Total" column by the "¼'s" column. The product is recorded in the "Q.L." column. This converts the lengths to "equivalent quarter lengths."

Step 3: Sum the "Q.L." column and record the result on the "Sum of Q.L." box.

Step 4: Divide the sum by 4 and place the result in "Total Sum of Q.L./4" box.

When entering impaired inspection data into the RAILER database, you only need to enter the line totals. Referring to Figure 2, the "Q.L." and "sum of Q.L." boxes are normally left blank.

Percentage Inspection-Impaired

The percentage inspection-impaired is a relative value consisting of the impaired inspection length divided by the track segment length (adjusted for grade crossing length) multiplied by 100. This is shown as Equation 4.

$$PII_{rf} = \frac{TOT_{rf}}{TSL - GCL} x100 \qquad \text{[Eq 4]}$$

where: PII_{rf} = percentage of inspection-impaired track for rail and F&OTM,
TOT_{rf} = total equivalent track length of impaired rail, and F&OTM track inspection (excluding grade crossings),
TSL = track segment length, and
GCL = grade crossing length.

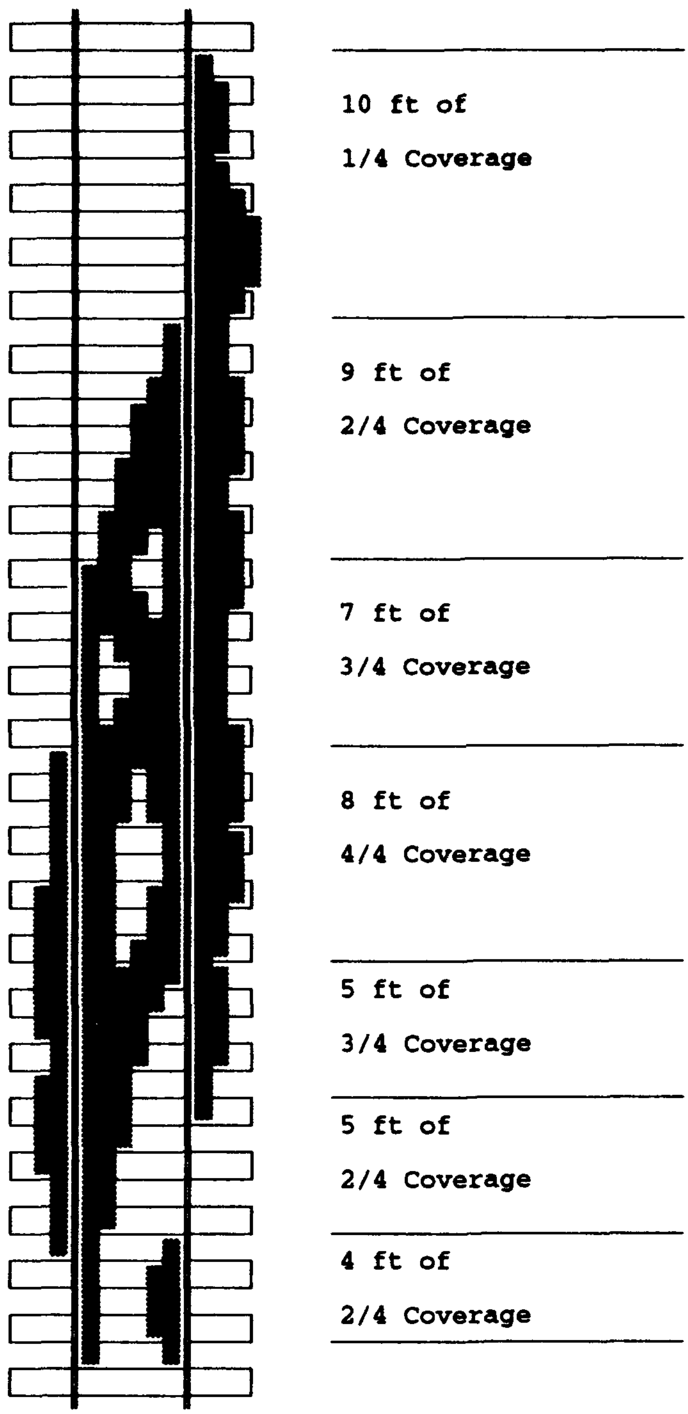


Figure 15. Quarters of Coverage for Rail and F&OTM Impaired Inspection.

Percentage is automatically computed within the RAILER software based on the line totals entered (discussed above).

Often the inspection-impaired portion of a segment may be quite long. If so, it may be much easier to estimate the percentage instead of recording actual lengths. If this is more practical for a given situation, you need to record the estimate in the box labeled "%" (see Figures 2 and 14). Thus, a 50 percent impaired length implies that half of the track segment length not covered by grade crossings is not completely inspectable. After the data is entered into the RAILER database, an estimate of equivalent length will be computed and reported.

Defect Free

A defect free box is provided on the inspection form for each of the four component areas (see Figure 13). Two requirements must be met for a component area to be considered "defect free." These are:

1. The entire track segment must be inspected with respect to the given component area.
2. No corresponding recordable defects can be found in the track segment.

Additionally, the Rail and F&OTM component areas must not be inspection-impaired (see Chapter 2 and the discussion above) to be considered defect free.

Note that the drainage component area *defect free* box is checked in Figure 13.

Comments

If you want to record any additional rail, F&OTM, BSR, and/or drainage inspection information that complements or supplements the defect occurrence information, provide comments in the margin or the reverse of the inspection worksheet. These comments may be entered into the RAILER database.

5 RAIL INSPECTION

Description

The rails provide a running surface for railroad cars and locomotives, guide their movements, and distribute train loads to the ties. All of the other track components support this function by linking and anchoring the individual rails, keeping the rail upright, helping distribute train loads, and maintaining gauge and track geometry.

Rail inspection only includes inspection of the rail and specifically does not include joints, fastenings, and turnout and rail crossing components (other than the rail, itself).

Elements of Rail Inspection

Rail inspection involves observing and recording defects found in the following rail elements (as shown in Figure 16):

- Head,
- Web,
- Base, and
- Bolt holes.

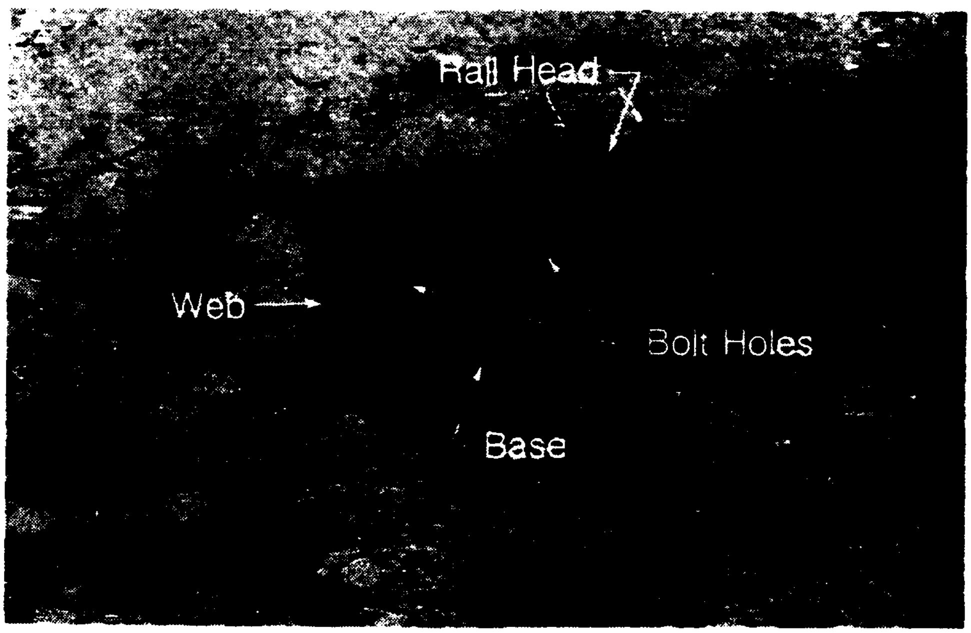


Figure 16. Parts of Rail To Be Inspected.

Defects and Causes

The rail defects considered in RAILER for Army users are listed in Table 6. This list includes the rail defects found in the Army Railroad Track Standards. However, while the list is extensive, it is not all-encompassing. Other track standards may consider other defects or expansions of certain defects into different size categories. The reverse of the Detail Inspection Worksheet (Figure 3), lists the possible rail defects. Note that in Appendix A, separate worksheets are available for Army/Air Force and other uses. The reverse of these worksheets lists the applicable defects with codes associated with the applicable track standards.

Rail defects result from quality control problems in the manufacturing process of the rail, improper handling or installation, lack of maintenance, and environmental effects. Also, repeated wheel loads induce stresses and deflections leading to fatigue damage, wear, and metal flow. Some defects can result from a combination of these factors. For example, a manufacturing defect, such an as internal fissure, can become a fracture under repeated loading (fatigue).

Data Collection and Recording

Although some rail defects can be easily seen, many of the defects that occur are very difficult or impossible to detect by visual inspection. Some are internal to the rail, others are very small, and still others may be hidden behind joint bars. The defects listed in Table 6 have been separated into three general categories based on the likelihood of being detected visually. For this reason, rail flaw detection procedures have been developed that can detect internal, small, and hidden defects, as well as many visible defects.

Rail defects are recorded differently based on whether or not the defects are minor. Multiple incidents of minor defect types, such as surface spalls, are simply recorded as a single occurrence for a given rail. The individual spalls are not recorded. If present in other rails, they too are recorded as separate occurrences. These minor defects are flagged with a "+" (see the defect list, Figure 3). All other defects are recorded individually. For example, if a vertical split head occurred on both ends of a rail, both would be recorded.

Visual Inspection

When performing a visual rail inspection, use the procedures discussed in Chapter 4 to record the observed rail defect occurrences. For rail, the component code is **RL** and the various defect codes are listed in Table 6 for Army users. These codes are also listed on the back of the Detail Inspection Worksheet (Army users see Figure 3, others see Appendix A).

All rail defects are discrete defects as discussed in Chapter 4. They may be recorded either individually or using length/density estimates for defects that occur repetitively over a given distance. Individual recording requires the specification of Rail (L, R, or B) and the station location. If there are multiple defect types on the same individual rail, all should be recorded listing the same station location. The RAILER program will recognize this as multiple defects in the same individual rail. Otherwise, RAILER will assume that the defects occur in different rails because the location of rail joints is not known.

Several ways to record rail defects were discussed in Chapter 4 and were presented in Table 4. A portion of the inspection worksheet is presented in Figure 17 with explanations of the individual entries.

Table 6

Rail Defects and Defect Codes

Defect types that are usually visible:

BRB: Broken Base
BRC: Break (Complete) - Clean and Square
BRR: Break (Complete) - Angled and Rough
BRL: Bent Rail
BRS: Bent Rail (Surface Bent)
CB1: Corroded Base >.25 in.
CD1: Chip/Dent in Head >.25 in..
CRH: Crushed Head
CRR: Corrugation
ENB: End Batter >.25 in.
EB1: Engine Burn >.25 in.
FDL: Fracture (Detail) >40%
FEL: Fracture (Engine Burn) >40%
FJB: Fracture Repaired with Joint Bar
FLK: Flaking
HCK: Head Checks (Surface Cracks)
L13 Rail Length < 13 in.
OVF: Overflow
RSD: Running Surface Damage (Depth >.25 in)
SHL: Shelling
SLV: Slivers
SPL: Surface Spalls
TCE: Torch Cut Rail End
WRS: Wear (Side) [3/8 in. for < 90 lb rail, and 1/2 in. for ≥ 90 lb rail]
WRV: Wear (Vertical) [3/8 in. for < 90 lb rail, and 1/2 in. for ≥ 90 lb rail]

Defects that are only sometimes visible (depends primarily on extent):

BHC: Bolt Hole Crack
FDS: Fracture (Detail) Small ≤40%
FES: Fracture (Engine Burn) Small ≤40%
HWS: Head/Web Separation
MDF: Mill Defects
SHH: Split Head (Horizontal)
SHV: Split Head (Vertical)
SWB: Split Web
WDD: Weld Defect

Defects that are seldom visible:

FCM: Fissure (Compound)
FTL: Fissure (Transverse) >40%
FTS: Fissure (Transverse) ≤40%
PPR: Piped Rail
TCH: Torch Cut Hole

Entry	COMP CODE	DEFECT CODE	RAIL (L,R,B)	LOCATION (STATION)	LENGTH (TF)	DENSITY (%)	QTY (#)
1)	RL	(BRB)	L	1+40			1
2)	RL	SHL	R	2+20			1
3)	RL	ENB	B	3+50	150		10
4)	RL	TCE	R	4+00			1
5)	RL	FLK	R	5+50	250	75	
6)	RL	L13	R	5+80			2
7)	RL	ENB	L	6+50			2
8)	RL	(SHV)	L	6+50			1
9)	RL	(BHC)	L	6+50			1
10)	RL	FLK	B	8+00	250	75	

Explanations

The following defects were found during rain inspection:

1. The left rail at station 1+40 has a broken base at one location. The circled defect code indicates that this is an immediate hazard.

2. The right rail at station 2+20 has one or more shelly spots.

3. Beginning at station 3+50, there are 10 total occurrences of end batter greater than 1/4 in. over the next 150 ft on both rails.

4. The right rail at station 4+00 has one torch cut end.

5. Beginning at station 5+50 on the right side, approximately 75 percent of the rails over the next 250 ft have flaking.

6. Beginning at station 5+80 on the right side, two rails in close proximity are less than 13 ft long.

7, 8, and 9. The left rail located at station 6+50 has end batter greater than 0.25 in. on both ends; a vertical split head somewhere in the rail; and visible bolt hole crack. The inspector feels that the vertical split head and bolt hole crack are immediate hazards.

10. Beginning at station 8+00, approximately 75 percent of the rails on both sides over the next 250 ft have flaking. Note that this indicates approximately twice as many defect occurrences as does defect entry 5.

Figure 17. Example Rail Inspection Entries With Explanations.

Internal Rail Flaw Inspection Surveys

Applicable track standards specify the requirements and frequency for performing internal rail flaw inspection surveys. For the Army, the surveys should be accomplished every 3 to 6 years on active track; there is no requirement for inactive track.

Internal rail flaw inspection surveys are generally performed by contractors, but sometimes agencies or railroad companies perform their own. Regardless of who performs the inspection surveys, specialized equipment is used. The two most common methods of detecting internal defects are induction and ultrasonic searches. The induction method, which forces a high amperage current through the rail at a very low voltage, generally is not appropriate for low-volume trackage because it requires a very clean rail head to accept the low voltage current. Therefore, the ultrasonic rail search method is preferred for the type of low-volume trackage found on Army installations (Coleman 1988 Draft; TM 5-628). In both methods, the sensors ride on the rail and can detect many head and web defects, both visible and invisible.

The contractor typically provides a report of the findings. The report will list the defects individually and the location of the defect (usually accurate to the nearest foot of measurement). To facilitate use of contractor data within RAILER, the location reference system must be the same as that used when RAILER was implemented so the survey results can be easily entered into the database. Since the ultrasonic methodology is capable of locating rail joints, defects associated with an individual rail can be consolidated to a single station location. Thus, the internal defect data may be recorded on a RAILER compatible inspection form to facilitate entry into the database. Contractors could provide the completed forms with their report or the internal rail flaw data could be extracted from the survey report and converted for use within RAILER by the database manager or others. Unless the number of defects is high, the conversion would not be difficult nor time consuming.

6 FASTENINGS AND OTHER TRACK MATERIALS INSPECTION

Description

Fastenings and Other Track Materials (F&OTM) primarily includes all the manufactured and/or machined track components other than ties, rail, and turnout components. This specifically excludes earthen materials such as ballast, subgrade, and other right-of-way materials, which are discussed in the next chapter. F&OTM components are mostly steel hardware items, although other materials may be included. Each component performs a specialized function, including joining the rails together, providing load transfer from one rail to the next, helping distribute loads from the rail to the crosstie, anchoring the rail to the crosstie, preventing rail creep, helping to hold gauge, providing a means for vehicular or rail traffic to cross the track, electrically isolating portions of the track, preventing derailments, causing derailments, and conveying messages pertaining to train movements to train engineers or vehicle operators.

Components of F&OTM Inspection

For discussion, it is convenient to divide the F&OTM component area into two component groups: rail joint (joints) and nonjoint components. Within RAILER, these two groups are primarily distinguished by their respective sets of available defect codes.

Joints

Joints are the mechanical devices that join the individual rails together into continuous lengths. Joint inspection involves identifying and recording defects in the following components (as shown in Figure 18):

- Rail end positions,
- Joint bars/Compromise bars, and
- Joint bolts, nuts, and washers.

Nonjoint F&OTM Components

The nonjoint components included in F&OTM inspection are:

- Car bumpers,
- Car stops,
- Derails,
- Gauge rods,
- Grade crossings,
- Hold-down devices,
- Insulation component,
- Rail anchors,
- Rail crossings,
- Shims,
- Signals,
- Signs,
- Spikes, and
- Tie plates.

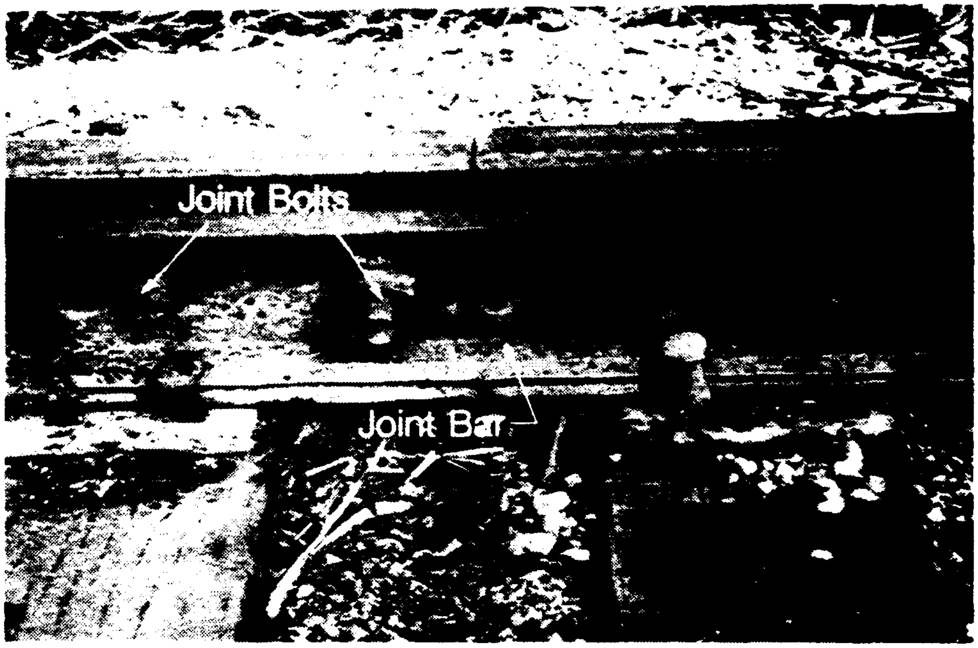


Figure 18. Parts of Joints To Be Inspected.

Defects and Causes

Joint defects and nonjoint F&OTM component defects are listed in Tables 7 and 8, respectively, along with their defect codes. In addition to these coded defects, flangeway measurements for ensuring proper width and depth are associated with grade and rail crossings.

Joint defects result from improper installation, lack of maintenance, and environmental effects. Also, repeated wheel loads induce stresses, deflections, and vibrations leading to fatigue damage and loose bolts and bars. Nonjoint defects result from improper handling or installation; defective ties or tie movement; vibrations from train movements; deflections imposed from train operations resulting in bending, breakage, or cracking from fatigue; derailments; vandalism; lack of maintenance; and environmental effects. Some defects can result from a combination of these factors.

Data Collection and Recording

Most F&OTM defects are determined by visual inspection. Also, some joint defects may be determined via an internal rail flaw inspection survey. Flangeway width and depth measurements are required for grade and rail crossings.

F&OTM Visual Inspection

All defects found during a visual inspection are recorded using the component and defect codes; rail designation (as appropriate); location; and length, density, or quantity indicators as discussed in Chapter 4. These defects include all the defect types listed in Tables 7 and 8. The component code for joints is **JT** and the joint defect codes are listed in Table 7; the other F&OTM component codes and defect codes are presented in Table 8. All of these codes are also listed on the back of the Detail

Table 7

Joint Defects and Defect Codes

ABL:	All Bolts in Joint Loose
ABM:	All Bolts on a Rail End Missing or Broken
BBB:	Both Bars Broken
BBM:	Both Bars Missing
BCC:	Both Bars Center Cracked
BCB:	Broken or Cracked Bar (not through center)
CCB:	Center Cracked or Center Broken Bar
IBP:	Improper Joint Bolt Pattern
IBT:	Improper Size/Type Joint Bolt
IIB:	Improperly Installed Joint Bar
ISB:	Improperly Size/Type Joint Bar
LJB:	Loose Joint Bar
LBT:	Loose Joint Bolt
MBT:	Missing/Bent/Cracked or Broken Bolt
IBT:	Only One Bolt with One Rail End
RG1:	Rail End Gap > 1 in. but ≤ 2 in.
RG2:	Rail End Gap > 2 in.
RM1:	Rail End Mismatch > 3/16 in. but ≤ 1/4 in.
RM2:	Rail End Mismatch > 1/4 in.
SMB:	Single Missing Bar
TCB:	Torch Cut/Alt Joint Bar

Inspection Worksheet (Figure 3). The inspector should be careful to avoid incompatible component/defect code combinations (see Table 8). RAILER only accepts the combinations listed.

All of the F&OTM defect types presented in Tables 7 and 8 are discrete defects as discussed in Chapter 4. There are several ways to quantify these defects, either individually or aggregately, using the location and length/density or amount indicators as indicated in Table 4. However, using length/density to estimate the defect quantities is only permitted for the following component types:

- HD: Hold-down devices,
- JT: Joints,
- RA: Rail anchors,
- SP: Spikes,
- TP: Tie plates, and
- GC: Grade crossings.

Table 8

Nonjoint F&OTM Defects and Defect Codes

Nonjoint F&OTM Defects and Defect Codes	Nonjoint F&OTM Components and Component Codes													
	CB: Car Bumper	CS: Car Stop	DL: Derail	GR: Gauge Rod	GC: Grade Crossing	HD: Hold-Down Device	IC: Insulation Comp	RA: Rail Anchor	RR: Rail Crossing	SH: Shim	S1: Signal	S2: Sign	SP: Spike	TP: Tie Plate
BRK: Broken	✓	✓	✓	✓		✓			✓	✓	✓	✓	✓	✓
COR: Corroded	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓
CRB: Cracked/Bent	✓	✓	✓	✓		✓			✓	✓	✓	✓	✓	✓
IMP: Improper Position	✓	✓	✓	✓		✓		✓		✓	✓	✓	✓	✓
IIV: Insuf Insulation Value							✓							
IST: Improper Size/Type				✓		✓				✓	✓	✓	✓	✓
LOS: Loose	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓
MIS: Missing	✓	✓	✓			✓		✓		✓	✓	✓	✓	✓
NFL: Non-Functional											✓	✓		
RFL: Rough – Low Severity					✓									
RFM: Rough – Medium Severity					✓									
RFH: Rough – High Severity					✓									
WOR: Worn									✓					

✓ : Compatible Component/Defect Code Combination

■ : Incompatible Combination (shaded cells)

The remaining component types that make up the F&OTM component area, when present in track, occur relatively infrequently when compared to the above components. Thus, they do not lend themselves to defect estimation through the length/density method.

All defects are recorded as "Each" (EA), counting the number of times that the defect occurs at a given location or within a location range. The example is grade crossings, which are recorded as the length of crossing affected.

A partial completed inspection worksheet with only F&OTM defects is presented in Figure 19 along with explanations of the individual entries.

Internal Rail Flaw Inspection Surveys

Some joint defects, such as cracked bars, may be detected during an internal rail flaw inspection survey. A discussion of these surveys was presented in the previous chapter. Any joint defects found during a survey should be entered into the RAILER database in conjunction with the detected rail defects as discussed in Chapter 5. Care should be exercised to ensure that all joint defects are recorded with the "JT" component code and the defect codes listed in Table 7.

Crossing Flangeway Inspection

The flangeways of grade crossings and road crossings are special inspection items requiring further visual inspection consisting of width and depth measurements. A separate section for recording this additional information is located in the bottom left-hand corner of the inspection worksheet (Figure 2). Figure 20 shows the flangeways section of the sheet.

The first step in inspecting flangeways is to identify and locate the crossing. This is accomplished by circling the appropriate component code ("GC" for grade crossing and "RR" for rail crossing) and recording the name and station location of the crossed road (or crossed segment for a rail crossing).

Second, the *minimum* flangeway width and depth observed in the crossing are recorded. For both the width and depth measurements, the values recorded are the effective minimum measurement of any portion of both flangeways (left and right). For rail crossings, one pair of flangeways is associated with each of the two crossing segments; the flangeways that parallel the current track segment are inspected with this segment, and the crossing flangeways are inspected with the crossing track segment. Figure 21 shows how effective flangeway depth and width are determined. Flangeway measurements, like all other RAILER inspection measurements, should be recorded as decimals; a fraction-decimal conversion table is provided on the back of the Turnout Inspection Worksheet (Figure 5). Only measurements less than the minimum required for full compliance need to be recorded. For road crossings, this is a flangeway width less than 2 1/2 in. or a depth less than 2 in. For rail crossings, this is a flangeway width less than 1 7/8 in. or a depth less than 1 7/8 in. These are shown on the bottom of the worksheet (Figure 2).

Third, indicate whether the flangeways are fouled. If a flangeway dimension is too small due to rocks, dirt, or other debris that could be removed by cleaning, the flangeway is considered fouled.

Fourth, record the total flangeway length that does not meet the minimum requirements. This length value is the total over both flangeways. Flangeway length not meeting the width and/or depth requirements is recorded separetly for (1) flangeways not meeting the requirment due to wear, poor construction, or movement and (2) those not meeting the requirement due to fouling. If both situations exist simultaneously at a given location, the lengths for both are recorded, but separately. This may result in a given flangeway being recorded twice.

Entry	COMP CODE	DEFECT CODE	RAIL (L,R,B)	LOCATION (STATION)	LENGTH (TF)	DENSITY (%)	QTY (#)
1)	GR	LOS		0+90			1
2)	SP	IMP	R	1+50	200	50	
3)	SP	MIS	B	3+50			5
4)	JT	(CCB)	R	5+20			1
5)	JT	LBT	L	5+70			1
6)	TP	IMP	B	6+00	200	50	
7)	JT	LBT	B	6+00	100	75	
8)	JT	(ABL)	L	6+40			1
9)	GC	RFM		7+20			26

Explanations

The following defects were found during F&OTM inspection:

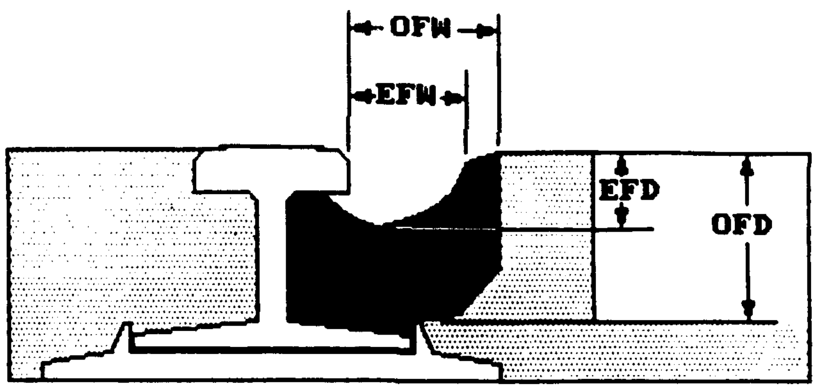
1. A gauge rod is loose at station 0+90.
2. Starting at station 1+50 and continuing for 200 ft, on the right rail, about 50 percent of the spikes are improperly positioned due to an improper spike pattern.
3. Five spikes are missing on both rails at or near station 3+50.
4. One joint bar is center broken at a joint on the right rail at station 5+20. The circled defect code indicates that this is an immediate hazard.
5. One bolt is loose at a joint on the left rail at station 5+70.
6. Starting at station 6+00 and continuing for 200 ft, about 50 percent of the tie plates on both rails are placed in a reverse position (improperly positioned).
7. Starting at station 6+00 and continuing for 100 ft, about 75 percent of the joints bolts are loose. Each joint has at least one tight bolt. [Note: When using length/density to estimate loose bolts, RAILER assumes two loose bolts per joint.]
8. All bolts are loose on one rail at a joint in the left rail at station 6+40. Note that this occurs in the midst of several occurrences of the less severe loose bolt defect type indicated by the previous entry. This is an immediate hazard.
9. The grade crossing at station 7+20 is rough with moderate severity. Twenty-six feet of the crossing is rough.

Figure 19. Example F&OTM Inspection Entries With Explanations.

FLANGEWAYS	COMP CODE	LOCATION: ROAD NAME	LOCATION: STATION	MIN DEPTH (IN)	MIN WIDTH (IN)	FOULED	LENGTH (FT)
	(GC) RR	Infantry Rd	2+50	1.50	1.65	N (Y)	25
	(GC) RR	Parking Lot #5	4+50	1.75	1.75	(N) Y	50
	GC (RR)	Seg 107	5+90	2.0	2.0	(N) Y	–
	(GC) RR	Bradley Rd	7+20	2.50	2.50	(N) Y	–

Minimum Full Compliance Values	Depth	Width
GC:	2" (2.0)	2 1/2" (2.5)
RR:	1 7/8" (1.875)	1 7/8" (1.875)

Figure 20. Flangeways Section of Inspection Worksheet.



KEY:

= Crossing Material

= Dirt, Rocks, or Debris

OFW = Original Flangeway Width

EFW = Effective Flangeway Width

OFD = Original Flangeway Depth

EFD = Effective Flangeway Depth

Figure 21. Effective Flangeway Depth and Width.

7 BALLAST, SUBGRADE, AND ROADWAY INSPECTION

Description

The Ballast, Subgrade, and Roadway (BSR) component area includes all earthen materials in the track structure, general rights-of-way, and embankments. Ballast serves to secure the track structure in place, provide for track structure drainage, and transmit loads from the ties to the subgrade. The subgrade is either the natural earth or placed fill upon which the track structure rests.

Components of BSR Inspection

The BSR components include:

- Ballast,
- Subgrade, and
- Embankments.

Inspecting the interface between the ties and the ballast is a key portion of the BSR inspection. The ties, however, are not the defective component and, thus, not included within the BSR component area.

Defects and Causes

The BSR defect types are listed in Table 9 along with the defect codes and additional useful information.

A major potential BSR defect is vegetation growth, which includes grass, weeds, bushes, trees, and other natural cover. Vegetation is considered a defect when it is present in excessive amounts along the railroad right-of-way. In general, vegetation is allowable beyond the limits of the track shoulders, but not within the shoulder-to-shoulder limits of the track structure. Along the right-of-way and particularly on side slopes of cuts and fills, some vegetation is necessary to prevent soil erosion. However, this material must be controlled so it does not interfere with train movement or track inspection. Any vegetation located within the track structure is considered excessive as it will degrade the ballast and subgrade, may interfere with train movements, and can prevent complete track inspection.

Some of the common causes for BSR defects are:

Center Bound: Deflections from wheel loads at the outer portion of ties. Over time, the ballast under the tie ends may become compacted or a plastic deformation may occur resulting in a permanent deformation in the ballast section. Since the tie centers are virtually unloaded, a loss of contact area between the ties and ballast section occurs at the outer portion of the ties.

Dirty Ballast: Contamination from subgrade intrusion, droppings from cars of coal, sand, etc., and wind or water deposition of fine material. Also, ballast may wear or disintegrate from mechanical abrasion and weathering causing fine material to form in place.

Erosion: Excessive water flowing either along the track shoulder, over the track, along the right-of-way, or along the base of an embankment with sufficient velocity to carry aggregate and soil away.

Table 9

Ballast, Subgrade, and Roadway Defects and Defect Codes

Defect Code	Defect Type	Relative Severity	Discrete or Continuous
DTY	Dirty—Fouled (Ballast)		Continuous
POE	Pumping Ties—One End		Discrete[a]
PBE	Pumping Ties—Both Ends		Discrete[a]
PJE	Pumping Ties—Only Joint End of Joint Tie		Discrete[a]
IBC	Insufficient Ballast (Crib)		Continuous
IBL	Insufficient Ballast (Left)		Continuous
IBR	Insufficient Ballast (Right)		Continuous
HTB	Hanging Ties at Bridge Approach		Discrete[a]
CBT	Center Bound Track—Nonjoint Tie[b]		Discrete[a]
CBJ	Center Bound Track—Joint Tie[b]		Discrete[a]
EMB	Embankment Erosion		Continuous
UNS	Unstable Slope		Continuous
ESS	Erosion—Single Shoulder	1	Continuous
ECS	Erosion—Crib and Shoulder	2	Continuous
ERM	Erosion—Restricted Movements	3	Continuous
EWA	Erosion—Washout	4	Continuous
VGB	Vegetation—Growing in Ballast	1	Continuous
VII	Vegetation—Interferes with Inspection	2	Continuous
VIM	Vegetation—Interferes with Train Movement	3	Continuous
VPM	Vegetation— Prevents Train Movement	4	Continuous

[a] Occurrence for these defect types is on a per-tie basis.
[b] Center Bound Track occurs when the tie is supported in the middle but not on the ends.

Hanging Ties: Settlement or consolidation of fill material behind a bridge abutment resulting in a lack of tie support.

Insufficient Amount: Lack of placement during construction, rehabilitation, or other work adjacent to the track.

Pumping: A combination of dirty ballast, water, and traffic results in fine material being liquified from tie deflection and forced through the ballast section leaving a muddy condition that may harden into an impermeable mass.

Unstable Slope: Water, excessive water pressure within the slope, and a slope angle cut too steep for a given soil type contribute to instability.

Vegetation: Seeds may be blown in by wind, deposited by water, or dropped by freight cars. Excessive root structure from vegetation growing along the right-of-way may cause sprouting in the track structure. Combinations of water and fine material in ballast and/or subgrade are needed to sustain growth.

Data Collection and Recording

All BSR defects are determined by visual inspection. Record defects as described in Chapter 4 except use the rail designation only for embankment defects. Rail designation with embankment defects will clarify the side of track where the defect resides. The component code is always **BS** and the defect codes are as presented in Table 9. These codes are also listed on the back of the inspection worksheet (Figure 3). Table 9 indicates which defects are discrete and which are continuous (see Chapter 4). Length/density estimations may be used for all defects except "Hanging Ties at Bridge Approach" because, when present, these are very few in number and "Embankment Erosion" and "Unstable Slope" where specificity is desired for prompt M&R action.

A partially completed inspection worksheet with only BSR defects is presented in Figure 22 along with explanations of the individual entries. Further explanation follows.

Entry	COMP CODE	DEFECT CODE	RAIL (L,R,B)	LOCATION (STATION)	LENGTH (TF)	DENSITY (%)	QTY (#)
1)	BS	DTY		1+00	100		
2)	BS	VGB		1+50	400	75	
3)	BS	POE		3+90			3
4)	BS	VII		4+10	30		
5)	BS	IBL		5+50	40		
6)	BS	CBT		6+00	50		4

Explanations

The following defects were found during BSR inspection:

1. Beginning at station 1+00, the ballast is dirty or otherwise fouled for 100 ft.
2. Beginning at station 1+50, vegetation is growing in the ballast on and off for about 75 percent of the next 400 ft; i.e., within this overall length, vegetation is growing in the ballast for an approximate total of 300 track ft.
3. At station 3+90, three ties are pumping at one end. (This is not at a joint, although one or more of these ties might be joint ties with respect to a joint on the other side of the track.)
4. For 30 ft, beginning at station 4+10, the vegetation interferes with inspection. Note that this occurs within the 400 ft range of entry 2. To avoid double counting, and because it represents a lower relative severity, the 300 ft associated with entry 2 should not include this 30-ft section.
5. Beginning at station 5+50, there is an insufficient amount of ballast for the next 40 ft on the left side.
6. Beginning at station 6+00, 4 center bound cross ties exist for the next 50 feet.

Figure 22. Example BSR Inspection Entries With Explanations.

Ballast and Subgrade (General)

Dirty Ballast. Dirty ballast is concerned with the track, in general, with no reference to crib or shoulder. The unit of measurement is "Track Feet" (TF).

Insufficient Ballast. Insufficient ballast differentiates between the shoulders and crib area. Each are recorded separately in units of "Track Feet" (TF).

Erosion. Table 9 shows that the erosion defect has associated with it four relative severity levels. For a specified length of track only the most severe condition must be recorded. For example, "Erosion—Crib and Shoulder" and "Erosion—Washout" would not be recorded together. Only the more severe (in this case the washout), would be recorded since it encompasses the less severe defect. However, the severity may change along the length of the track. If so, the different erosion defects would be recorded where found. The units of measurement are "Track Feet" (TF).

Tie-related Defects

The various tie-related defects (center bound, pumping, and hanging) are all recorded on an "Each Tie" (EA) basis. The appropriate defect type for a given tie is to be recorded.

It is not necessary to record "Dirty Ballast" along with pumping ties. Pumping implies dirty ballast.

Insufficient ballast is implied when hanging ties occur. Thus, it is not necessary to record the insufficient amount defect. Center bound track may imply insufficient ballast (at least under the tie) and, thus, that defect need not be recorded simply because the track is center bound. However, there may be an inadequate amount of crib and/or shoulder ballast present, as well. If so, record the insufficient amount defect.

Vegetation

For vegetation, do not record a single defect type more than once at a given location. For example, do not record both ""Vegetation–Growing in Ballast" and "Vegetation–Interferes with Inspection" for the same length of track. Instead, only the highest relative severity level, as indicated in Table 9, should be recorded, which in this case is interfering with inspection. However, the severity may change along the length of the track. For example, vegetation that initially is growing in the ballast may become worse after 200 ft so it is interfering with train movement; these are two separate incidents and each is reported. The unit of measurement is "Track Feet" (TF).

Generally, if vegetation defects are present, dirty ballast is implied; only the vegetation defects need to be recorded.

Embankments

Embankment erosion and unstable slopes are recorded on the basis of "Track Feet" (TF).

8 DRAINAGE INSPECTION

Description

A well-drained roadbed is essential to good track maintenance. Because subgrades may weaken and become less stable when excess moisture is present, drainage structures are needed to collect and transport water away from the track. Proper maintenance of drainage structures will help reduce the extent of the maintenance problems in all of the other component areas discussed throughout this report.

Components of Drainage Inspection

Drainage inspection includes four types of drainage structures:

- Culverts,
- Ditches,
- Drains, and
- Storm Sewers.

Defects and Causes

Drainage defects are listed in Table 10, along with the defect codes, components, and component codes.

The common causes for drainage defects include excessive water flow with sufficient velocity to carry material away, the depositing of foreign material or debris from water flow or poor maintenance practices, excessive vegetation, lack of vegetation, improper or lack of maintenance, littering, climatic related deterioration, and a general inability to handle storm water flows.

Data Collection and Recording

The RAILER inventory database includes the track station location of most drainage components. Before starting drainage inspection, it is suggested that the inspector obtain this information for the given track segment(s). Otherwise, some drainage components that may be hidden from view may be overlooked during the inspection.

All drainage defect occurrences are determined by visual inspection and recorded as discussed in Chapter 4. The component and defect codes presented in Table 10 are also listed on the back of the inspection worksheet (Figure 3).

As indicated in Table 10, some drainage defect types are discrete defects while others are continuous (see Chapter 4). Culverts, drains, and storm sewers are all discrete due to their localized nature. As such, should defects be present for these, they should be recorded on an "Each" (EA) basis meaning each culvert, etc. with the denoted defect. Length/density does not apply. Ditches are continuous as they may run the entire length of track on one or both sides. The rail indicator, except "both" may be used, as may the length/density feature.

A partially completed inspection worksheet with only drainage defects is presented in Figure 23 along with explanations of the individual entries.

Table 10

Drainage Defects and Defect Codes

	Component Code	CU	DI	DR	SS
	Component	Culvert	Ditch	Drain	Storm Sewer
Defect Code	**Defect**				
COR	Corroded	D		D	D
IST	Improper Size/Type	D		D	D
ERO	Erosion		C		
RFL	Restricted Flow		C		
RFP	Restricted Flow -- Partial	D		D	D
RFM	Restricted Flow -- Major	D		D	D
SCR	Scour	D			
STD	Structural Deterioration	D	C	D	D

D: Discrete Defect Type
C: Continuous Defect Type

: Incompatible Component/Defect Code Combination

Entry	COMP CODE	DEFECT CODE	RAIL (L,R,B)	LOCATION (STATION)	LENGTH (TF)	DENSITY (%)	QTY (#)
1)	DI	RBF	R	3+00	100		
2)	CU	RBP	R	3+50			1
3)	DR	COR	L	4+30			1
4)	CU	STD		4+80			1
5)	DI	ERO	L	5+00	150	80	

Explanations

The following defects were found during Drainage inspection:

1. Beginning at station 3+00, the flow is restricted for 100 ft in the ditch on the right side of the track.
2. Flow in the culvert located at station 3+50 is partially restricted on the right side of the track; in this case the flow is not obstructed on the left side of the track.
3. The drain on the left side of the track at station 4+30 is corroded.
4. The culvert located at station 4+80 has suffered structural deterioration.
5. Beginning at station 5+00, the ditch on the left side of the track is eroded off and on for approximately 120 of the next 150 track feet (i.e., 80 percent).

Figure 23. Example Drainage Inspection Entries With Explanations.

9 TURNOUT INSPECTION

Description

A turnout is an arrangement of rail and spec'al track components that permits trains to be diverted from one track to another and hence allows route choice. Because of their complexity and critical importance, turnouts require special attention during inspection.

Components of Turnout Inspection

Turnouts are divided into several major component groups. These include: ties, switch and stand, frog, and guard rails. Each group includes a variety of components.

Ties

The tie group consists of two components. These are:

- Switch ties and
- Head blocks.

Switch and Stand Components

Switch and stand components include:

- Switch stand,
- Target,
- Ground throw lever,
- Point locks/lever latches,
- Jam nut,
- Connecting rod,
- Connecting rod bolts (includes nuts and washers),
- Switch rods,
- Switch rod bolts (includes nuts and washers),
- Switch clips,
- Clip bolts (includes nuts and washers),
- Cotter keys,
- Insulation filler or bushing,
- Switch points,
- Switch point protectors,
- Point rails,
- Stock rails,
- Closure rails,
- Gauge plate,
- Rail braces,
- Slide plates,
- Turnout plates,
- Twin tie plates,
- Heel fillers,
- Heel bolts (includes nuts and washers), and
- Heel joint bars/shoulder bars.

Frog Components and Elements

The frog consists of three components: the frog itself, the bolts that secure it in place, and the frog plates upon which it rests. Several key elements of the frog require special attention during inspection, including:

- Point,
- Top surface,
- Guarding faces (self-guarded frogs only),
- Hinged wing rail (spring frogs only),
- Springs and assemblies (spring frogs only), and
- Movable points (swing point frogs only).

Guard Rail Components

Four components are included. These are:

- Guard rails,
- Fillers,
- Bolts (including nuts and washers), and
- Clamps.

The various turnout components are illustrated in Figure 24.

Defects and Causes

The turnout defects listed in Table 11 are divided into six inspection categories:

1. General. These defects are not specific to any major component group. Rather, they apply to the turnout, in total.

2. Ties. For tie defects within the limits of a turnout, there is no distinction between defective ties and missing ties. Otherwise, the criteria for tie inspection within a turnout are generally consistent with the tie defect types discussed in Chapter 3.

3. Switch and Stand. This category covers the turnout parts responsible for diverting the wheels on one side from the stock rail to the point rail and then onto the closure rail, while keeping the other wheels on the other stock rail. The group includes all the moving parts and their connectors. Many of these parts are indicated on the detailed (lower) portion of Figure 24. Note that there are multiple defect types for most of these parts (see Table 11). Figure 25 shows the maximum allowable wear for switch points (defect 22). Figure 26 demonstrates the proper relationship between the point and stock rails for defects 22 and 24. These two defects are also illustrated (in the improper positions) on the back of the Turnout Inspection Worksheet (Figure 5).

4. Frog. The frog permits the inside rails of the two diverging tracks to cross each other. The defect types primarily involve the surface of the frog. Figure 27 shows the maximum allowable wear for the frog point (defect 35), and Figure 28 illustrates that for the top surface (defect 36). Allowable wear on the guarding face of self-guarded frogs (defect 37) is shown in Figure 29.

Table 11

Turnout Defects

General

1. Switch difficult to operate
2. Rail weight and/or section change
3. Debris in crib area
4. Poor or fair surface and alignment

Ties

5. Defective head blocks
6. Consecutive defective or missing ties
7. Defective or missing ties (by size)
8. Defective or missing joint ties (by size)
9. Improperly positioned (by size)

Switch and Stand

10. Switch stand (improper size or type; loose or improper position; damaged; missing)
11. Target (improper size or type; loose or improper position; damaged; missing)
12. Ground throw lever (improper size or type; loose or improper position; damaged; missing)
13. Point locks/lever latches (improper size or type; loose or improper position; damaged; missing)
14. Jam nut (improper size or type; loose or improper position; damaged; missing)
15. Connecting rod (improper size or type; loose or improper position; damaged; missing)
16. Switch rods (improper size or type; loose or improper position; damaged; missing)
17. Switch clips (improper size or type; loose or improper position; damaged; missing)
18. Connecting rod bolts (improper size or type; loose or improper position; damaged; missing)
19. Switch rod bolts (improper size or type; loose or improper position; damaged; missing)
20. Clip bolts (improper size or type; loose or improper position; damaged; missing)
21. Cotter keys (missing on any required bolt)
22. Insulation filler (improper size or type; damaged; missing [where required])
23. Switch points (damaged; worn)
24. Switch point protectors (improper size or type; loose or improper position; damaged or worn; missing [where required])
25. Point rails (improper size or type; loose or improper position; damaged; missing)
26. Gauge plate (improper size or type; loose or improper position; damaged)
27. Rail braces (improper size or type; loose or improper position; damaged; missing)
28. Rail braces (less than four functional on each stock rail)
29. Slide plates (improper size or type; loose or improper position; damaged; missing)
30. Turnout plates (improper size or type; loose or improper position; damaged; missing)
31. Twin tie plates (improper size or type; loose or improper position; damaged; missing)
32. Heel filler (improper size or type; loose or improper position; damaged; missing [where required])

Table 11 (Cont'd)

33. Heel joint bolts (improper size or type; loose or improper position; damaged; missing)
34. Heel joint bars (improper size or type; loose or improper position; damaged; missing)

Frog

35. Frog (improper size or type; loose or improper position; damaged; missing)
36. Point (damaged or worn)
37. Top surface (damaged or worn)
38. Guarding face (damaged or worn [self-guarded frog only])
39. Hinged wing rail (improper size or type; loose or improper position; damaged; missing [spring frogs only])
40. Springs and assemblies (loose or improper position; damaged; missing [spring frogs only])
41. Movable point (improper size or type; loose or improper position; damaged; missing [swing point frogs only])
42. Bolts (improper size or type; loose or improper position; damaged; missing)
43. Turnout plates (improper size or type; loose or improper position; damaged; missing)

Guard Rails

44. Guard rail (improper size or type; loose or improper position; damaged; missing)
45. Fillers (improper size or type; loose or improper position; damaged, or missing [where required])
46. Bolts (improper size or type; loose or improper position; damaged; missing [where required])
47. Clamps (improper size or type; loose or improper position; damaged; missing [where required])
48. Guard rail plates (improper size or type; loose or improper position; damaged; missing [where required])

Measurements

49. Switch point gap–left side
50. Switch point gap–right side
51. Gauge just ahead of switch points
52. Gauge at joints of curved closure rails
53. Gauge at point of frog–main track side
54. Gauge at point of frog–turnout side
55. Guard check gauge–main track side
56. Guard check gauge–turnout side
57. Guard face gauge–main track side
58. Guard face gauge–turnout side
59. Flangeway width of frog–main track side
60. Flangeway width of frog–turnout side
61. Flangeway depth of frog–main track side (flangeway fouled?)
62. Flangeway depth of frog–turnout side (flangeway fouled?)
63. Flangeway width of guard rails–main track side (flangeway fouled?)
64. Flangeway width of guard rails–turnout side (flangeway fouled?)

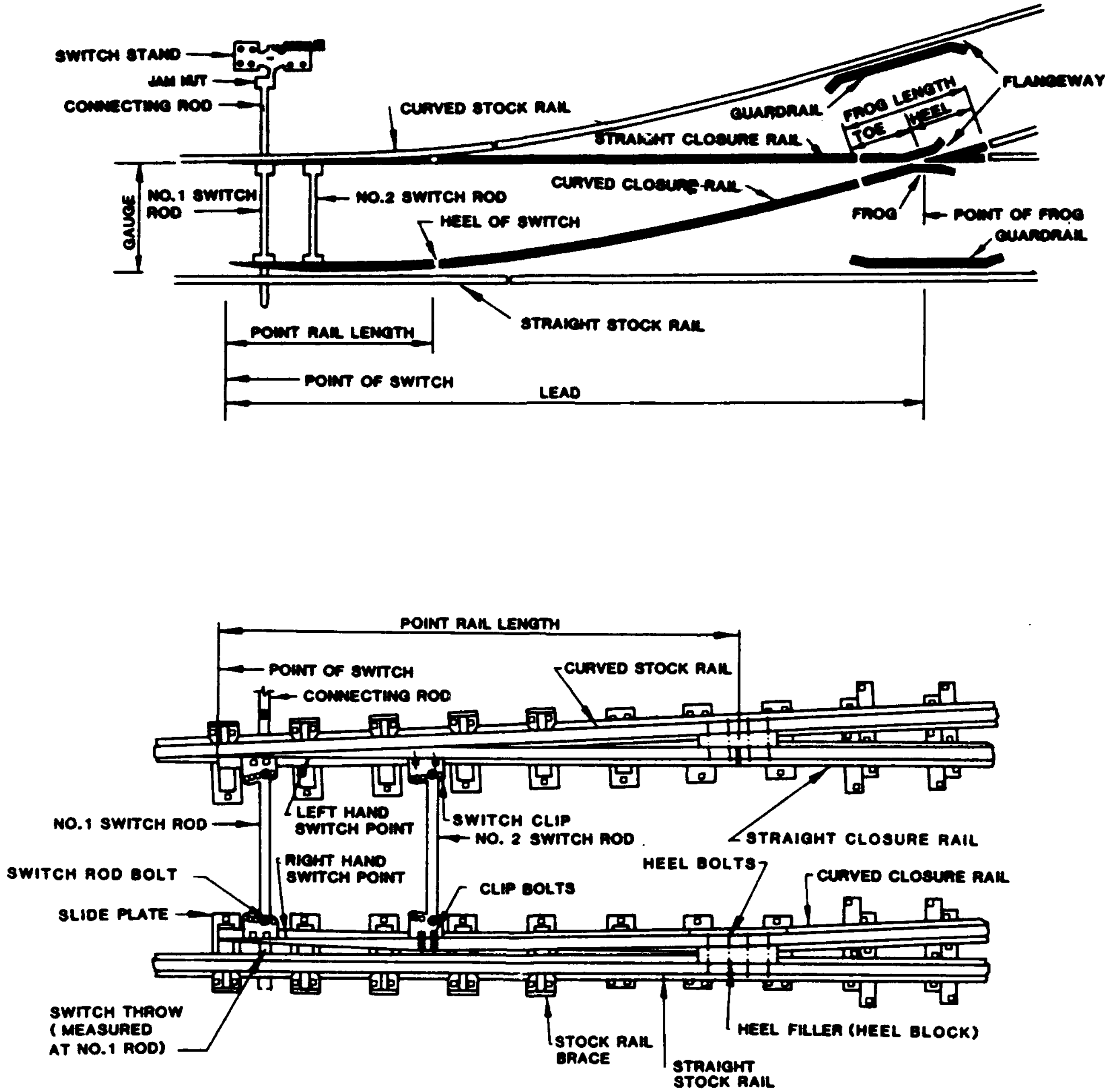


Figure 24. Typical Turnout Arrangements.

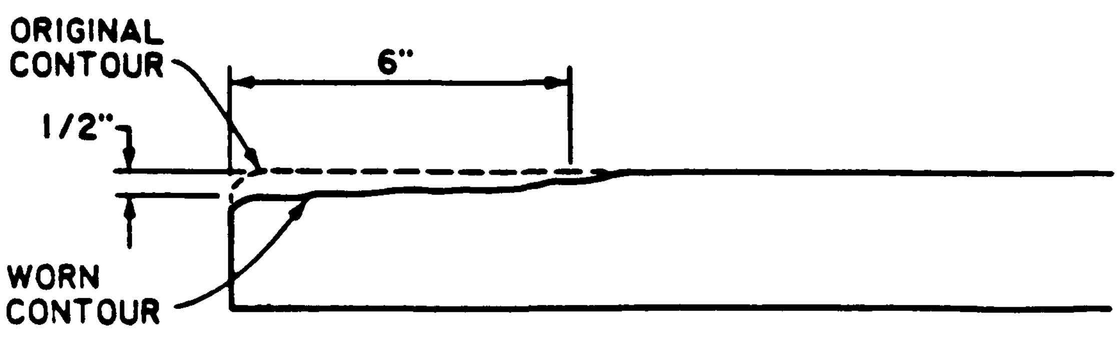


Figure 25. Maximum Allowable Switch Point Wear.

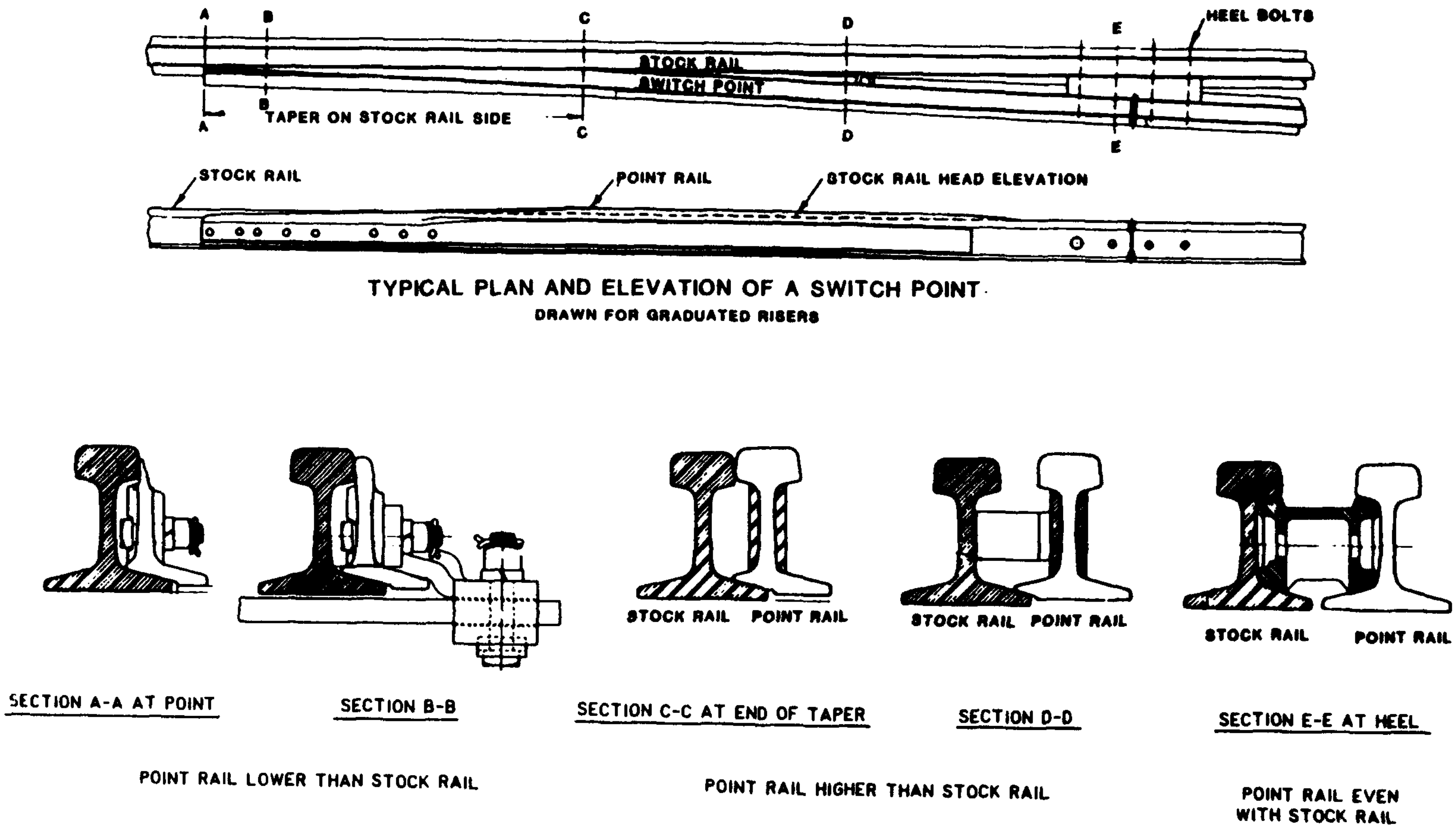


Figure 26. Proper Relationship Between Point Rail and Stock Rail.

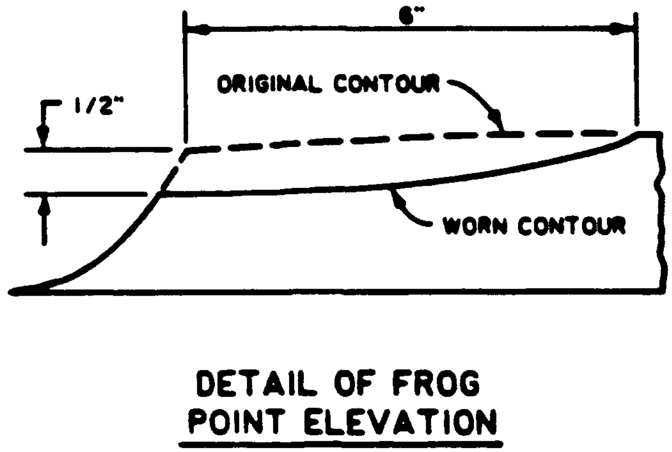


Figure 27. Maximum Allowable Frog Point Wear.

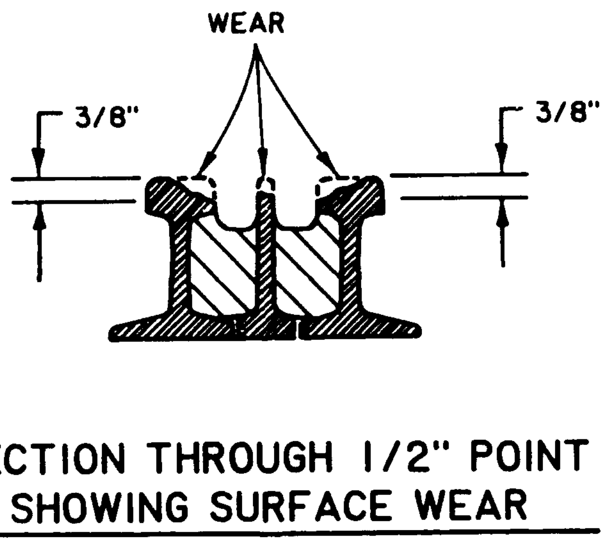


Figure 28. Maximum Allowable Wear for Surface of Frog.

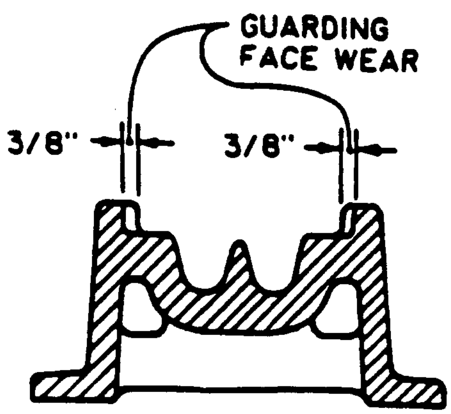


Figure 29. Maximum Allowable Wear for Guarding Face of Self-guarded Frog.

5. Guard Rails. Guard rails help prevent derailment at the frog; self-guarded frogs do not need guard rails. "Improper position" (defect 43) includes insufficient straight guarding face in advance of the frog point (see Table 12).

6. Measurements. Various measurements are taken within the limits of the turnout and compared with the track standards to determine defect occurrences and severity restrictions. This comparison is done within the RAILER computer software. Most of the measurement points around the frog and guard rails are shown in Figure 30.

Causes of turnout defects include manufacturing, wear, fatigue, corrosion, environment, vibration, heavy loads, improper installation or maintenance procedures, and improper train operations. The moving parts of the switch are particularly sensitive to traffic volume and switch operation.

Data Collection and Recording

The RAILER Turnout Inspection Worksheet is arranged to guide you through the turnout inspection process. A sample completed turnout inspection form is presented in Figure 4. Note that the form is organized around the six defect categories discussed above. Defects are simply checked (or their number noted) and measurements are entered where requested. In addition, diagrams are provided on the back of the sheet (Figure 5) to illustrate the required measurements and certain switch point and frog defects.

Inspection and Recording Tips

The following inspection and recording tips are presented to help you use the Turnout Inspection Worksheet (Figure 4). Note that turnout inspection only encompasses those components germane to turnouts. Rail, F&OTM, BSR, and drainage components located within turnouts are inspected and recorded as described in Chapters 5 through 8.

General. This portion of the inspection requires subjective judgement; circle the appropriate response.

Ties. Switch ties increase in size throughout the turnout. The sizes of these ties are established by tie number for the specific turnout size. Thus, to aid in maintenance and repair (M&R) planning, each defective, missing, or improperly positioned tie, including joint ties, should be recorded by tie length. Consecutive defective or missing tie entries should be circled. This recording technique will capture the number and size of clusters, including those that may be at joints. Also, due to the unique nature of the head blocks, they are recorded separately on the form. You need to circle if none, one, two, or three are defective.

Table 12

Minimum Length of Straight Guarding Face in Advance of Frog Point

Frog Number	Length (in.)
4,5,6,7,8,9,10	14
11,12,14	18
15,16	26
18,20	30

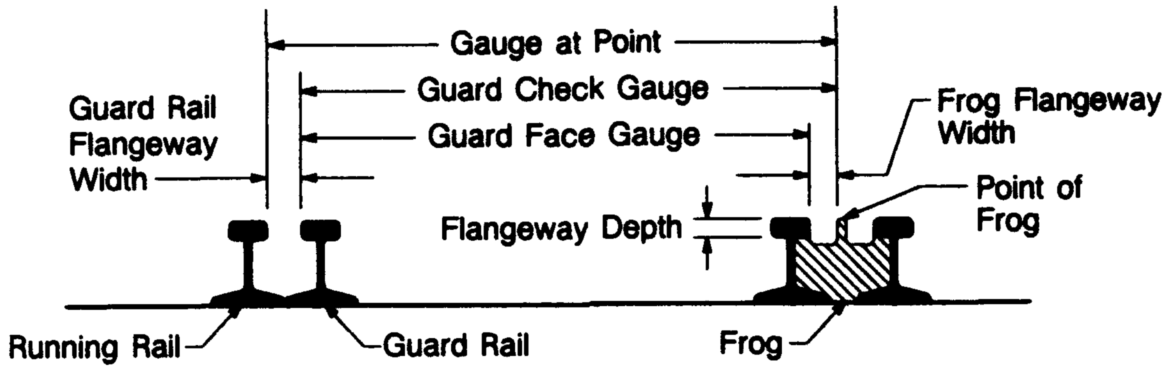


Figure 30. Frog and Guard Rail Measurement Points.

Switch and Stand, Frog, and Guard Rails. This portion of the sheet affords you a variety of recording options.

First, if any component is not present *by design or intent* Y (yes - when side location is not applicable or needed), L (left side), and/or R (right side) in the "N/A" (not applicable) column should be circled and no other entries made for that component. Depending on the turnout design, certain listed components may or may not be present. Also, certain components may have been removed. For example, the diverging (turnout) route to the right may be closed to traffic and thus, the left point rail removed and the right spiked closed. In this case, the L would be circled in the "N/A" column.

Second, any inspected component that is found to be free of observable distress should have the Y, L, and/or R circled in the "Defect Free" column. No other entries are then recorded for a given component.

Third, any component found to be missing or not defect free shall have either the Y, L, and/or R entry circled, as appropriate. Only a single entry should be made. Where no letters are provided, an appropriate number should be recorded. For example, three rail braces may be loose on the left side. Note that for rail braces, you should record whether or not there are at least four functional braces on each stock rail. Also, separate numerical entries should be made for the left and right guard rail components; separate left and right boxes are provided.

Finally, if any component was not inspected or is not inspectable, the component entry is left blank.

Measurements. Record all appropriate measurements. Note that the reverse of the worksheet (Figure 5) provides diagrams of where the measurements should be made. If any are not applicable, such as those related to guard rails on self guarded frogs, the entry is simply left blank.

Comments. Comments can be recorded at any time and anywhere on the form. They are entered into the RAILER database after all of the above entries are entered.

Inspection Procedure

The following three-pass procedure is recommended when a single inspector is inspecting turnouts.

If, as part of the overall inspection plan, you approach the turnout from the switch point end, begin with general items and continue with the switch and stand items followed by the frog and guard rail items as you move to the frog end of the turnout. It will be most convenient if you measure the point gaps at the time the switch is operated to check difficulty. Pass two (frog end back to point end) should concentrate on measurements. Pass three (point end to frog end) covers the ties.

When inspecting from the frog end towards the point end, the procedures are somewhat different. The first pass should cover the general items along with the guard rails, frog, and switch and stand. Pass two (point end to frog end) is for ties. The final pass back to the points will encompass the measurements.

10 TRACK GEOMETRY INSPECTION

Description

Track geometry describes the positions of the rails relative to a desired position. A track geometry defect is a position deviation from the desired by more than a given amount as determined by track standards. Track geometry defects are continuous defects that are quantified by the affected track length and a geometry measurement. For example, gauge may be measured at a maximum of 58 in. for a 75-ft length. Over this length, the gauge went from standard (56.5 in.) up to its maximum of 58 in. and then back to standard gauge.

Defects and Causes

Gauge

Gauge is the right-angle distance between the two rails at a given location, measured 5/8 in. below the top surface of the rail head. Ideally, standard gauge is 56.5 in.

Gauge tends to increase with traffic because of lateral forces imposed by the train wheels. Defective ties also contribute to wide gauge because of the inability to resist lateral forces. Poor construction or maintenance practices can cause gauge to become too wide or narrow.

Gauge that is too wide can cause cars to "wander" back and forth laterally when moving, causing excessive rail head wear and increased risk of derailment from the wheels dropping between the rails. Gauge that is too narrow can cause the wheel flanges to rub inside of the rail heads, producing rail and wheel wear and a much increased risk of derailment due to wheels wanting to climb the rails. Figure 31 illustrates gauge.

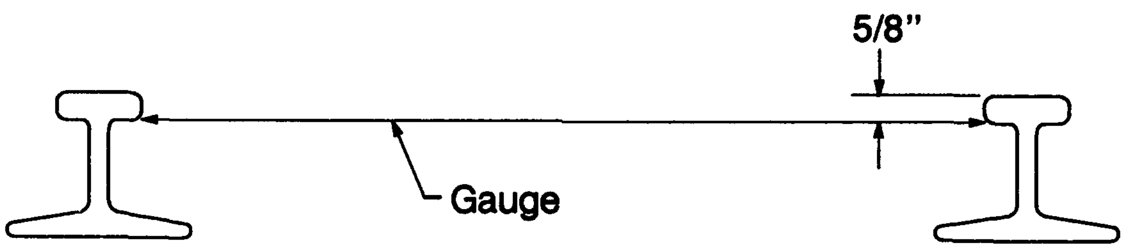


Figure 31. Rail Gauge.

Rail Displacement

In general, rail displacement occurs whenever the rail moves laterally relative to the ties, particularly on curves, which can lead to gauge widening. If unchecked, this would simply be a gauge defect due the failure of the ties to resist the widening, but sometimes gauge rods are placed to prevent gauge widening. Since the rails are linked together by the gauge rods, they may both move together relative to the ties. The rail displacement concept is illustrated in Figure 32 with some exaggeration; actual rail displacement is typically less than 1 in.

Rail displacement is generally caused by lateral track forces particularly in curves. While the ties work to restrain these forces, this places a lateral force on the spikes, which tends to widen the spike holes in the ties. This can lead to spike kill, perhaps necessitating tie replacement, but in the early stages the ties are quite functional even though some minor gauge widening will occur. While gauge rods might maintain the gauge, the rail component of the track can still be out of line relative to where it should be on the ties. Some of the problems with rail displacement are that the movement of the rail causes additional wear, leads to spike kill, and loosens the track structure.

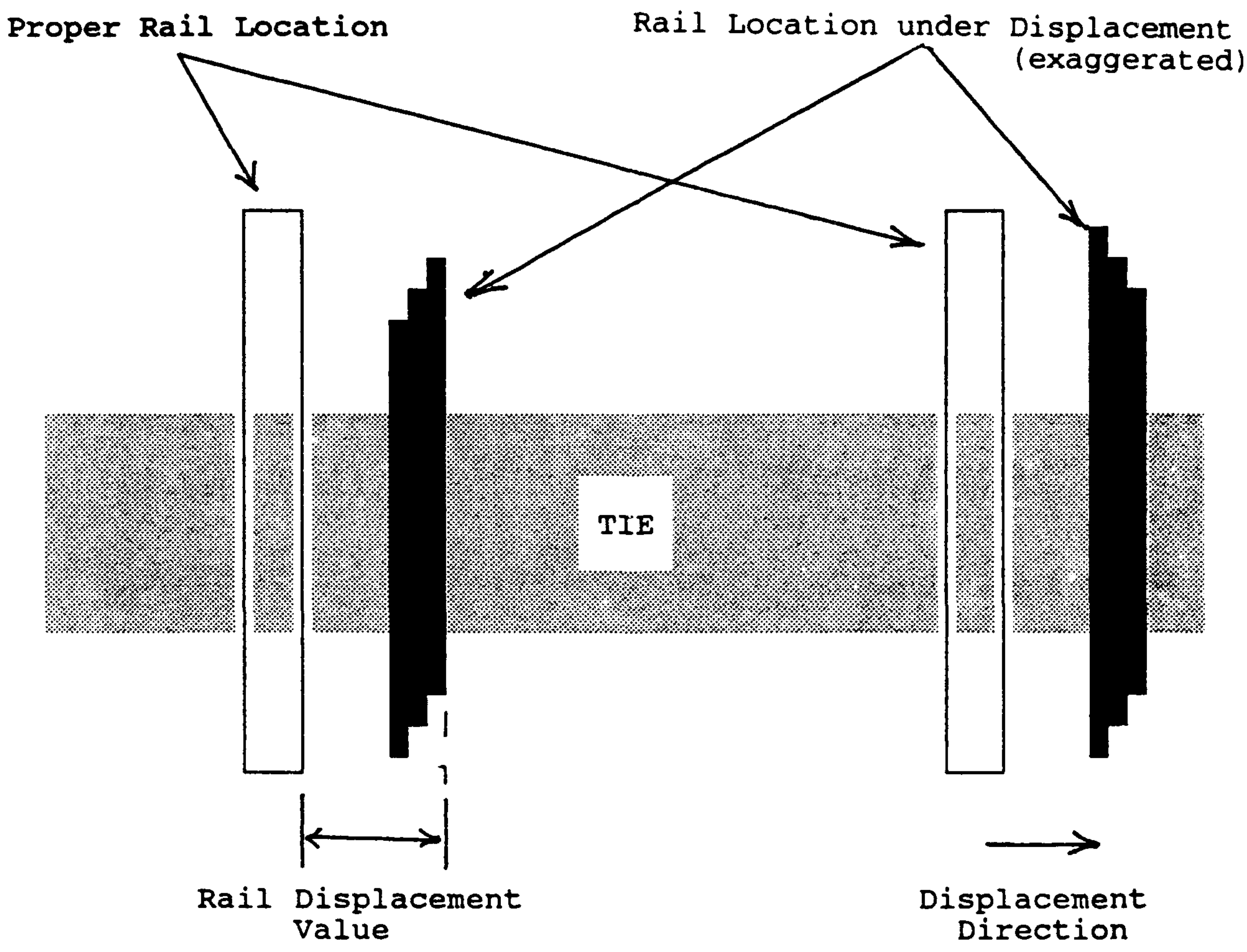


Figure 32. Rail Displacement.

Cross-level

Cross-level is the difference in elevation between the top surface of two rails at a given location (Figure 33). Deviations result from improper construction or maintenance, nonuniform tamping, frost heave, unstable soil, poor drainage, pumping ties, dirty ballast, differential track settlement, bent rail, and defective ties. Traffic action accelerates the problem. Ideally, cross-level should be zero, which indicates that both rails are at the same elevation. Since cross-level deviation causes cars to tilt and rock, and leads to rough track, in general, cargo damage or increased risk of derailment can result. Overstressing of track components accelerates this deterioration. Shock to cars and locomotives leads to this deterioration.

In curves, the outside rail is supposed to be at a higher elevation than the inside rail. This raising of the outside rail is called "superelevation" and helps compensate for the centrifugal force on cars rounding the curve. Since superelevation represents a designated cross-level, it is both intentional and beneficial. It is not considered a defect unless it deviates from the desired superelevation.

Warp

Warp is another measure of elevation difference between the top surfaces of two rails (Figure 34). Warp specifically relates to the difference in cross-level at any two points less than or equal to 62 ft apart. Since warp is based on cross-level measurements, the causes and defects are identical to cross-level deviations. Excessive warp accentuates the problems described above.

Alignment

Alignment is an indicator of how well positioned the rails are horizontally along the intended route. Alignment deviation is measured as the horizontal distance between the gauge side rail head (measured at 5/8 in. below the top) and the center of a 62-ft chord. Alignment deviation is the difference between designated alignment and actual alignment (Figure 35). On tangent track, this difference ideally should be zero. On curves, alignment deviations are noted as departures from the required degree of curvature.

Alignment deviation can be caused by traffic action coupled with poor lateral restraint by the ballast, expansion of the rails along the length due to high temperatures, and poor construction and maintenance procedures. Excessive alignment deviation leads to rough tracks with the resulting negative effects described earlier. Clearance restriction may also result.

Profile

Deviation in profile is the change in elevation of the two rails along the track relative to a designated grade. Profile is measured as the vertical deviation from a 62-ft chord (Figure 36).

The causes of improper profile include expansion of the rail in hot weather, settlement, ballast and/or subgrade, pumping ties, and improper construction and maintenance practices. Traffic action accelerates profile deviation. Excessive profile deviations cause problems similar to those of alignment deviations.

Data Collection and Recording

Track geometry data can be collected by automated or manual methods. At most Army installations, automated track geometry inspection is necessary only occasionally, if at all (Coleman [Draft] 1988). The RAILER system provides for use of either method.

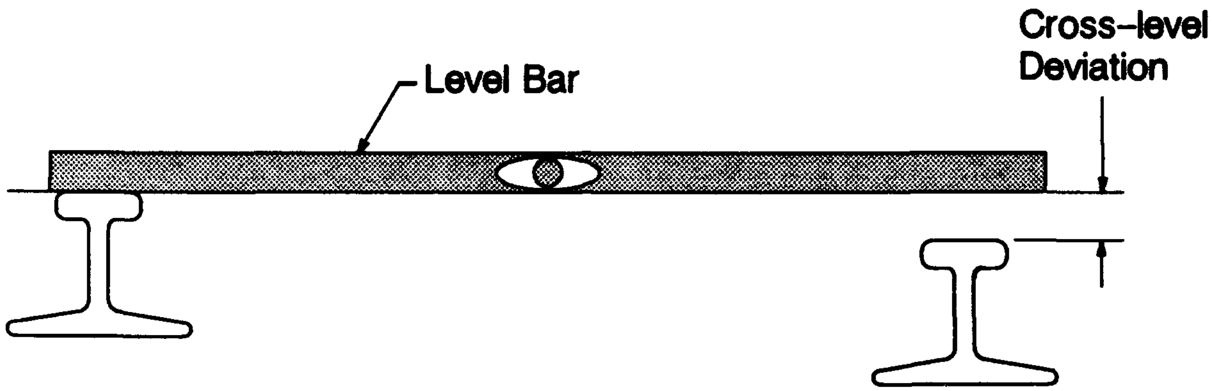


Figure 33. Example of Cross-level Deviation.

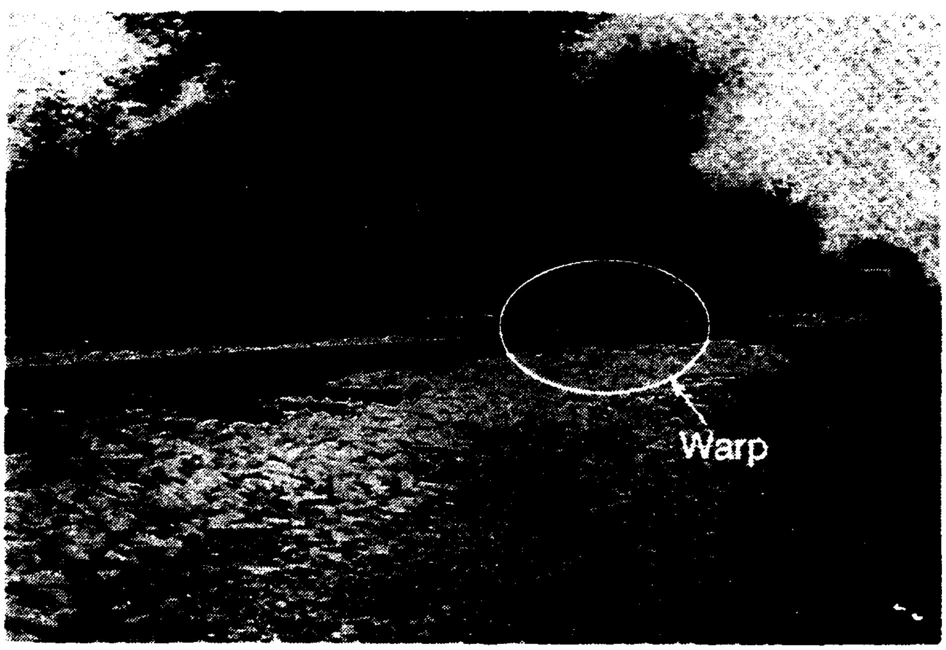


Figure 34. Example of Warp.

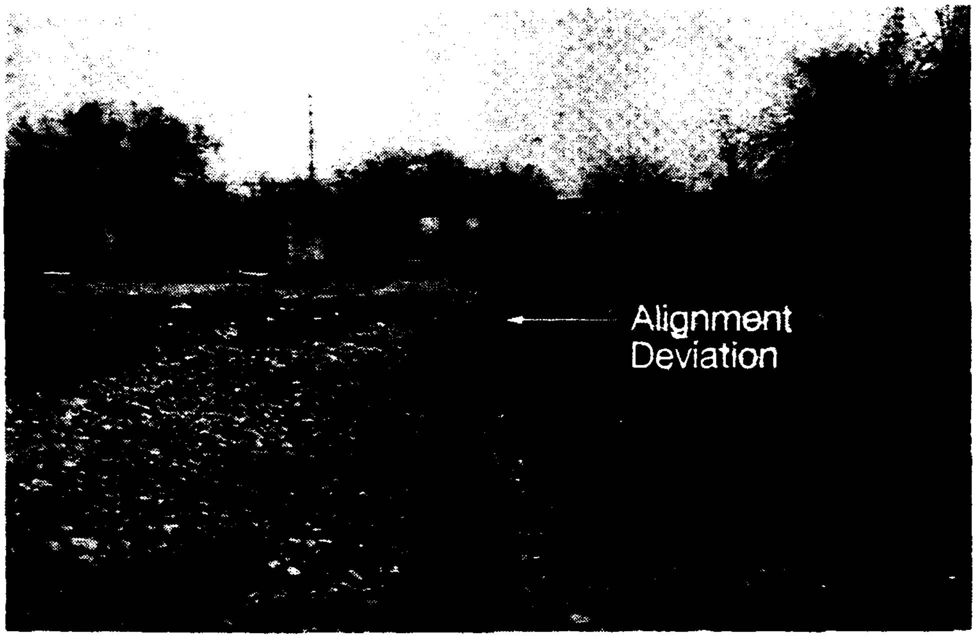


Figure 35. Example of Alignment Deviation.

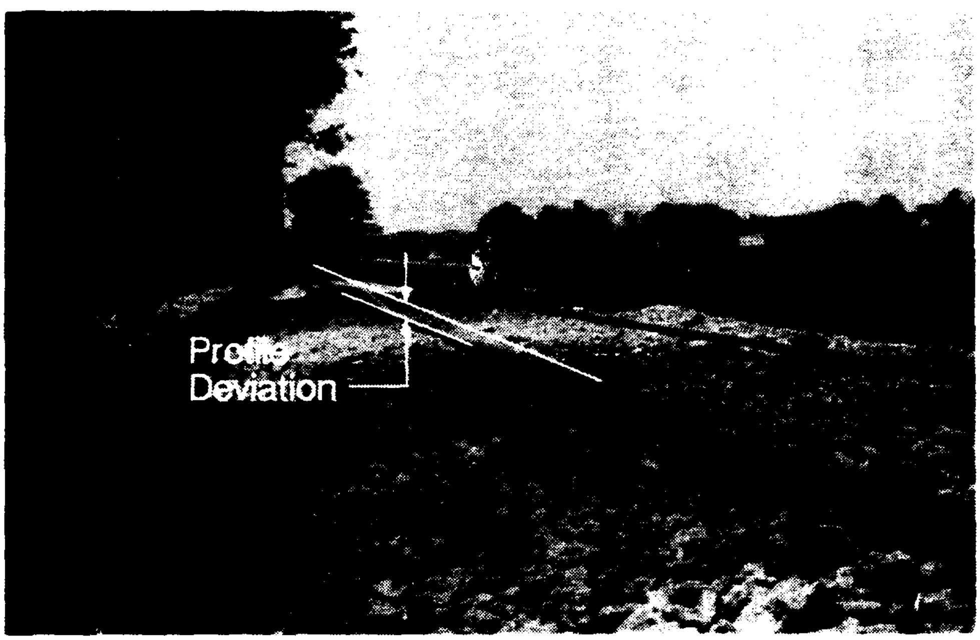


Figure 36. Example of Profile Deviation.

Automated Inspection

This inspection usually is performed by a contractor using special equipment mounted in a rail car, high rail vehicle, or geometry cart. Measurements for gauge, cross-level, profile, and alignment are usually taken along every foot of track, and warp is computed at the same interval. This process results in a tremendous amount of data. For effective management, it is typically condensed into "exception reports." The contractor should provide exception information in a hard-copy report for entry and processing within RAILER.

Manual Inspection

Manual inspection typically focuses on areas where geometry problems are occurring. These are located by sighting down the track and noting areas where line and surface deviations are occurring. Measurements should be taken in those areas. Areas of suspected gauge problems should also be measured. Some telltale signs of gauge problems are rail movement on ties, gauge side rail contact with wheel flanges, wheel tread location on the top of rail, and "flange squeal." Also, areas such as turnouts (Chapter 9) where geometry is critical should be inspected manually at regular intervals.

Some examples of manual track geometry inspection entries, along with explanations, are presented in Figure 37. Note that only one geometry defect type is recorded per line. During a manual track geometry inspection, a measurement is usually recorded only if it deviates from the proper value; i.e., gauge that differs from standard gauge. However, a measurement may also be recorded if the inspector is not sure what the proper value is. For example, when measuring for alignment and cross-level deviations on curves, the inspector may not know the required degree of curvature or superelevation. The inspector should record the actual measurements for track standard comparison analysis later within RAILER.

Individual track geometry defect occurrences are logged by recording the track segment, a station location, the measurement type or code associated with the geometry defect of interest, a geometry measurement, and the affected length. If the location is in a curve, the curve identification number* is also recorded. The reference rail must be indicated with any cross-level, alignment, and profile measurement. Comments are useful but optional with most geometry defect occurrences.

The station location is usually the approximate location where the recorded measurement was taken. However, it is sometimes useful to use the station location to indicate where the defect occurrence appears to begin; this should be indicated in the comments. The recorded geometry measurement should be the most extreme (furthest from the proper value) obtained over the affected area. The approximate limits of the affected area may be found by a combination of geometry measurements and/or simply "eye-balling" the track. The length of this affected area can usually be determined by pacing, observing the end locations (stations) based on station marker positions, or estimated from rail lengths. A measuring tape may be useful in some instances, but is usually not necessary. The distinction between the left and right rail is discussed in Chapter 4.

If two or more abutting portions of track have the same geometry defect type, but at significantly different deviation values, it may be desirable to record the specific defect type separately for each track portion. For example, if the gauge is ¾ in. wide for several hundred feet, and then changes to 1¼ in. for many more feet, it could be recorded as two separate gauge defect occurrences. This separate recording should also be accomplished when the affected length includes significant portions of both tangent and

*Curve identification numbers are established during the network implementation of RAILER and may be obtained either from the RAILER database or the maps created as a part of RAILER implementation.

Entry	TRACK SEGMENT NUMBER	LOCATION (STATION)	CURVE ID NUMBER	MEAS TYPE (OR CODE)	REF RAIL (L or R)	MEAS VALUE (in.)	AFFECTED LENGTH (ft)	COMMENTS
1)	101	5+50		GA		57.50	30	
2)	101	7+00		AL	L	4.25	50	
3)	101	7+00		PR	L	3.00	32	
4)	102	12+20	1C1	RD		0.25	75	
5)	102	15+75		CL	L	2.25	55	

Explanations

The following defects were found during a manual track geometry inspection:

1. At station 5+50 in track segment 101, the gauge is a maximum of 57.5 in. over a length of 30 ft.
2. At station 7+00 in track segment 101, the track appears to have moved slightly to the left. An alignment measurement at the maximum point gave a value of 4.5 in. The alignment deviation is 50 ft long.
3. Also beginning of station 7+00 in track segment 101, a dip in the track is observed over a length of 32 ft. The largest measured profile deviation is 3.0 in. measured on the left rail.
4. Shiny spots on the tie plates indicate a rail displacement for about 75 ft in curve 1C1 of track segment 102. The greatest displacement seams to occur near station 12+20 and is about 1/4 in. in magnitude. Gauge rods have been placed approximately every 20 ft. Gauge measurements along this length of track indicated no problems.
5. Using the left rail as the reference rail, a cross-level measurement at station 15+75 is 2.25 in. The left rail is higher than the right rail for about 55 feet.

Figure 37. Example of Manual Track Geometry Inspection Entries With Explanations.

curved track. In this case, the end points of the curve would define the boundaries between the individual occurrences.

Gauge Measurement. Gauge data is collected by measuring the distance between rails as indicated by Figure 31. If marks or wear on the ties or tie plates indicate that the rail moves significantly under traffic, an estimate of this movement should be added to the measured gauge.

Rail Displacement. Rail displacement is typically recognized by marks or wear on the ties or tie plates. Since the rails are actually displaced only under traffic and return to (or at least toward) their proper positions after the traffic has passed, the movement is indicated on the field side of the outside of the curve and on the gauge side of the inside rail at the same location (see Figures 38 and 39). The displacement depicted in Figures 38 and 39 is also exaggerated.

Generally, these measurements are small and can vary from tie to tie. Only the maximum displacement over a given length on track should be recorded.

Cross-level. Cross-level must be measured with reference to one rail or the other. The reference rail identification (left or right) must be indicated. The reference rail in curves should always be the

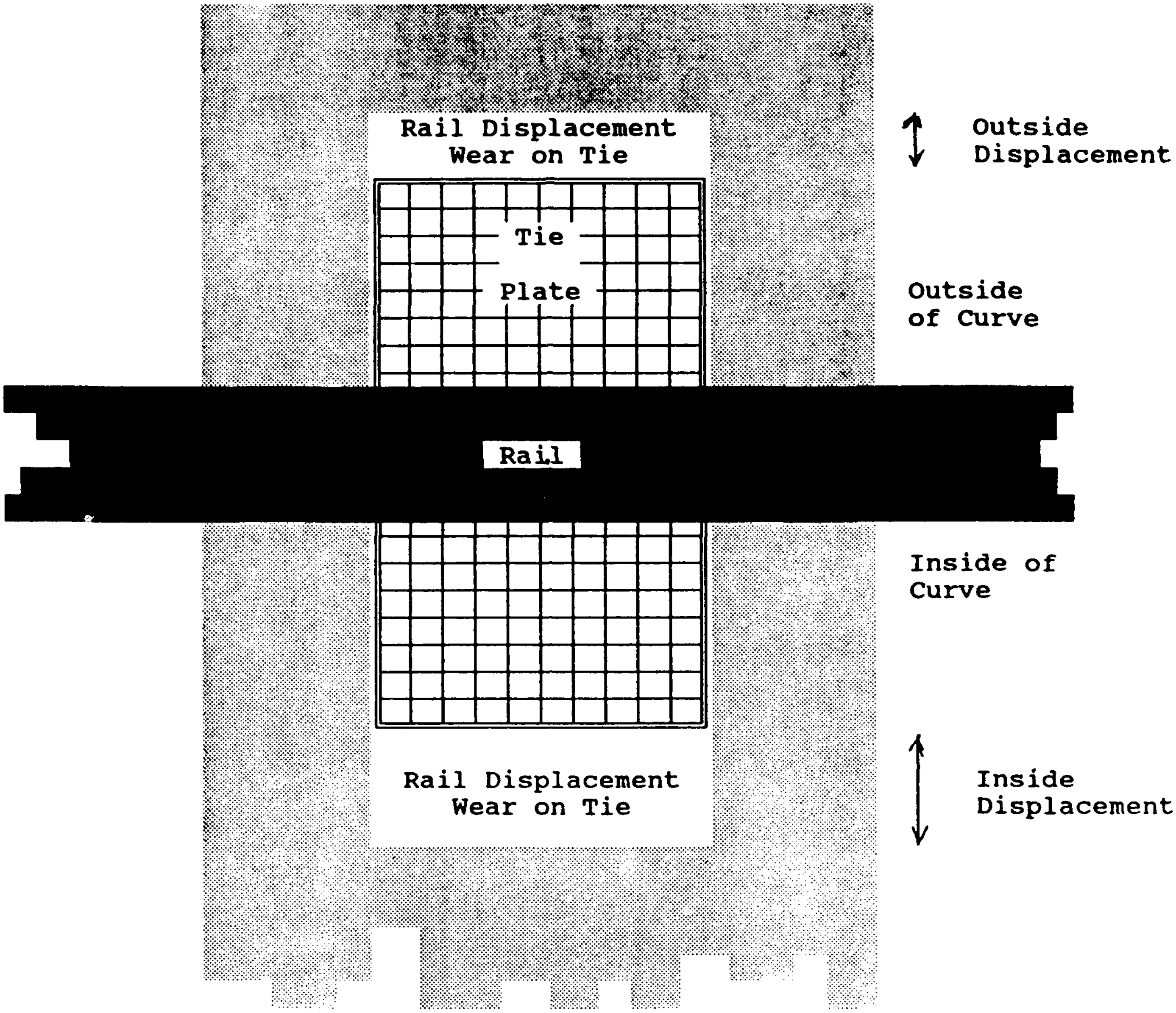


Figure 38. Rail Displacement Measurement–Wear on Tie.

outside (high) rail. On tangent track, either rail may be used as the reference, as long as the same rail is used on all tangent track throughout the segment. The cross-level is then measured by using a standard track gauge/cross-level bar or by using a standard level and a ruler. The cross-level is positive if the reference rail is higher than the opposite rail and it is negative if the reference rail is lower. If there is evidence of vertical movement under load (e.g., severe pumping, rail sitting above ties), an estimate of the movement should be added or subtracted from the measured cross-level, as appropriate. Refer to Figure 33 to review cross-level measurements.

Warp. Warp is the difference in cross-level between any two points less than or equal to 62 feet apart. It represents "twist" in the track, as shown in Figure 34. Warp is not recorded, as it is automatically computed within the RAILER program from the cross-level measurements.

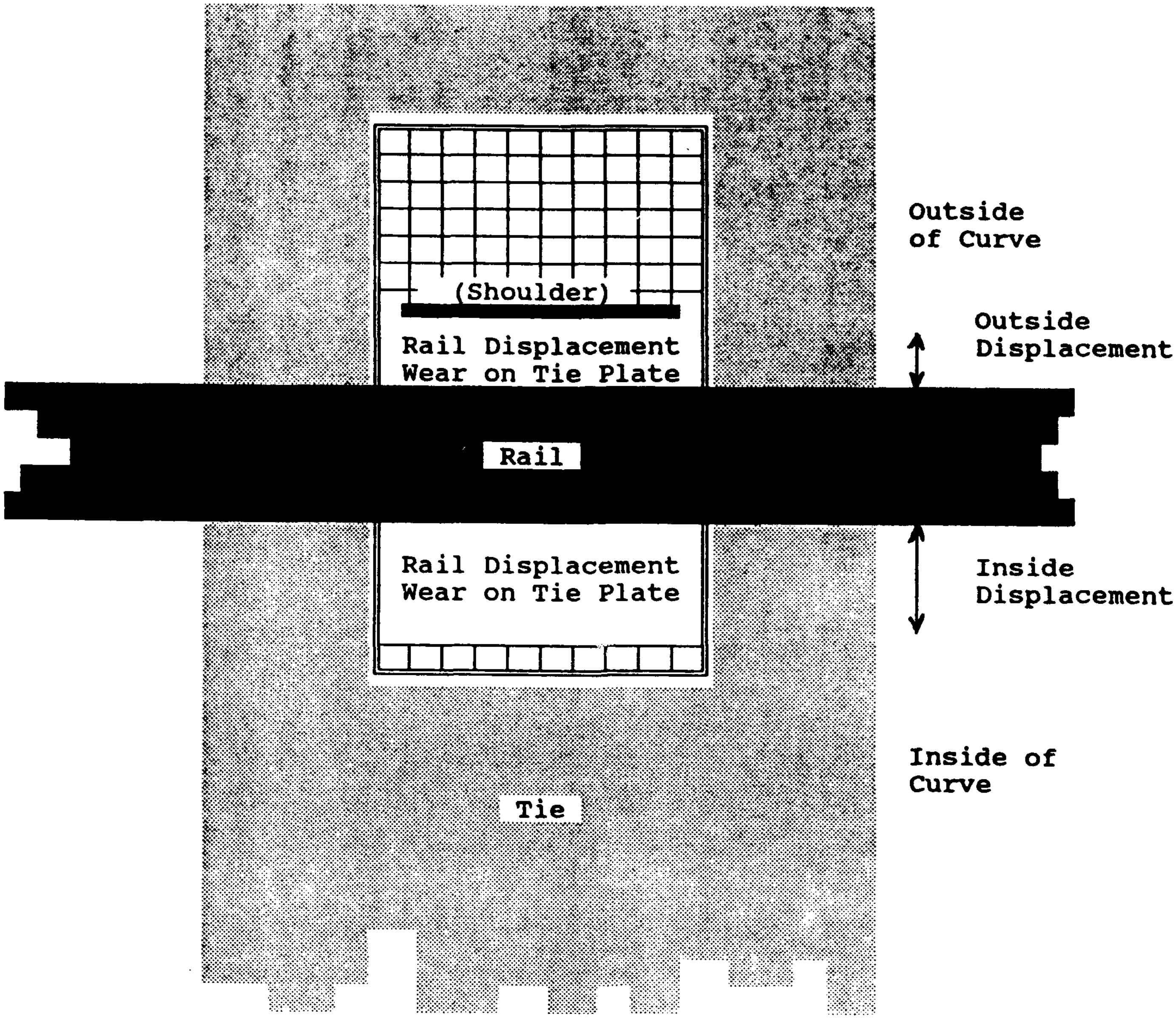


Figure 39. Rail Displacement Measurement–Wear on Tie Plate.

Alignment. Alignment deviations, as shown in Figure 35, are measured at the gauge side of the reference rail. Alignment is measured using a 62-ft stringline or a tape measure. Using either of these, a 62-ft chord is stretched between two points on the edge of the rail head, 5/8 in. from the top of rail, and the distance from the line at the midpoint (or 31-ft mark on the tape) is measured with a ruler. The horizontal distance from the line to the rail head is the alignment deviation value.

Profile. Profile measurement follows the same general procedure used for alignment except that the stringline or tape is placed on top of the reference rail. Figure 36 shows an example of a profile deviation.

11 FIELD TESTING

The detailed inspection procedures described in this report have been under development for several years. They have evolved into present form with the concurrent development of the Army Track Standards in TM 5-628, and the railroad track condition indexes. Both sets of guidance were developed by ascertaining the information needed, devising procedures to collect this information, field-testing the procedures, and making revisions based on feedback. The overall goal was to make it easy for trained installation track inspectors to collect the necessary information.

USACERL and RAILER users have field-tested the procedures extensively. USACERL teams worked at the Tooele Army Depot, UT; Fort Devens, MA; Fort Stewart, GA; Hunter Army Airfield, GA; Fort Carson, CO, Indiana Army Ammunition Plant, IN; and the Naval Weapons Support Center, Crane, IN. In addition, the Urbana Yard of the Consolidated Rail Corporation (CONRAIL) and the yard trackage at The Anderson's (grain elevator) served as local test sites. Generally, data collection procedures were first developed in the laboratory and tested locally. Then, field trips to the installations were scheduled for the purpose of uncovering procedural shortcomings. The various locations were chosen to provide the great variety of operating, climatic, and maintenance differences needed to properly test and evaluate the data collection procedures. Also during the initial phases of this work, the requirements of TM 5-628 were tested. Feedback to the TM 5-628 developers resulted in some changes which, in turn, resulted in some changes to USACERL's inspection and data collection procedures. In the later phase of this work, feedback was solicited from RAILER users. Further refinement resulted, particularly for application outside of the Army.

The field work has shown that inspection productivity rates are strongly dependent on the condition of the track (i.e., the more defects there are, the longer the inspection takes). Inspection of a track with many defects may progress only at a slow walking pace because the defects often are quite finite and require acute attention to be observed. Also, for this same reason, it was found that it can be nearly impossible for a single inspector to inspect all of the components concurrently. In fact, it may take up to three passes of the track by a single inspector to note all defects for all components. The track can be inspected by one person, but a team of two will improve the efficiency. As discussed in Chapter 2, it can be nearly impossible for one person to perform certain track geometry inspections.

Based on the range of conditions found at the various installations, a single inspector could completely inspect, on foot, approximately 0.2 mi/h. Turnouts take approximately 15 min each to inspect (time actually spent at the turnout). These are average rates and do include an allowance for nonproductive walking time (time lost walking back from the end of a terminating track at the completion of an inspection). They also do not include travel time to and from the network portion being inspected.

A two-person inspection team was found to be able to inspect at a rate of approximately 0.5 mi/h. Turnout inspection was reduced to about 10 min.

None of the above productivity rates include time for manual track geometry measurements. Track inspection from a moving track vehicle, even at slow speeds (<5 mi/h), resulted in a number of missed defects.

12 SUMMARY AND RECOMMENDATIONS

Detailed inspection procedures for use with the RAILER system have been described. Inspection data collection worksheets have been developed to facilitate data compiling and recording as well as eventual loading into installation RAILER databases for processing and analysis. Field testing has shown that the procedures are valid and easy to learn. The field testing also showed that a two-person team can inspect at a rate of approximately 0.5 mi/h and a single inspector can progress at approximately 0.2 mi/h.

These inspection procedures were designed to satisfy the requirements of AR 420-72, which prescribes the track standards in TM 5-628. Even if RAILER is not formally implemented at an installation, the procedures described in this report can be used to satisfy the inspection requirements.

The inspection procedures can be labor-intensive. As track condition worsens, inspection time will increase in direct proportion to the increase in track defects. Unfortunately, as inspection time increases, there is a possibility that the tracks will not be inspected at the desired frequency, detail, or both due to resource constraints. Consequently, managers need to consider their inspection data requirements for performing network and project level management tasks.

The procedures and information described in this report are best suited for project level management and for the periodic safety inspections required by various track standards, including the Army Track Standards, in which detail is very important. These procedures are also applicable for establishing an initial inspection baseline when implementing RAILER, but these are not mandatory for that implementation.

The procedures and information described in this report may be used for performing network level management tasks. However, the procedures provide more detail than typically is needed for those tasks. Therefore, the network level inspection requirements (best done annually in conjunction with a scheduled safety inspection) can be performed at considerable cost savings if the condition survey inspection procedures (described in USACERL Technical Report FM-93/14) are followed instead of these detailed procedures, especially when inspector resources are constrained. Also, if the detailed inspection procedures are not used to establish an initial condition baseline within RAILER, the condition survey inspection procedures must be used.

It is recommended that affordable inspection technologies be investigated as a means of speeding the inspection process. Off-the-shelf technologies such as electronic clipboards and voice recording should be field tested to determine the improvement in data collection and transfer time and accuracy. Emerging and new technologies, such as video imaging, hand lasers, and radar should also be researched.

METRIC CONVERSION TABLE

1 in. = 2.54 cm
1 ft = 0.305 m
1 mi = 1.61 km

REFERENCES

Coleman, D., Procedures and *Criteria for the Testing and Evaluation of Army Railroad Track*, Draft Technical Report (U.S. Army Waterways Experiment Station, 1988).

Federal Railroad Administration (FRA) Office of Safety, *Track Safety Standards* (U.S. Department of Transportation, November 1982).

Hay, W.W., *Railroad Engineering*, 2nd ed. (John Wiley and Sons, 1982).

Kurath, P., and D.R. White, *Preliminary Results of Army Rail Fatigue Failure Testing for Mobilization Planning*, Interim Report M-86/02/ADB098293L (USACERL, December 1985).

MO-103.9, *Navy Railroad Trackage Field Assessment Manual*, Draft (Department of the Navy, Naval Facilities Engineering Command, July 1993).

Technical Manual (TM) 5-628 and Air Force Regulation (AFR) 91-44, *Railroad Track Standards* (Headquarters, Departments of the Army and Air Force, April 1991).

Uzarski, D.R., *Condition Index Development for Low Volume Railroad Track*, Technical Report FM-93/13 (USACERL, September 1993a).

Uzarski, D.R., *Condition Indexes for Low Volume Railroad Track: Condition Survey Inspection and Distress Manual*, Technical Report FM-93/14 (USACERL, September 1993b).

Uzarski, D.R., D.E. Plotkin, and D. G. Brown, *Maintenance Management of U.S. Army Railroad Networks—The RAILER System: Component Identification and Inventory Procedures*, Technical Report M-88/13/ADA200276 (U.S. Army Construction Engineering Research Laboratory [USACERL], August 1988).

Uzarski, D.R., D.E. Plotkin, and D.G. Brown, *The RAILER System for Maintenance Management of U.S. Army Railroad Networks: RAILER I Description and Use*, Technical Report M-88/18/ADA199859 (USACERL, September 1988).

APPENDIX A: Inspection Worksheets

RAILER DETAILED TRACK INSPECTION

TRACK SEGMENT #:	SEGMENT BEGINNING LOCATION:	INSPECTOR:	DATE:

TIES	DEFECTIVE TIES				MISSING TIES				
CHECK IF DEFECT FREE ☐	SINGLE OR TOTAL	SINGLE AT JT	ALL AT JOINT 1 Tie	ALL AT JOINT 2 Ties	SINGLE OR TOTAL	2 IN A ROW	3 IN A ROW	ALL AT JOINT 1 Tie	ALL AT JOINT 2 Ties
INSPECTION IMPAIRED TF / %									

	ISOLATED CLUSTER	ISOLATED w/1 JOINT TIE	ADJACENT CLUSTER
2 IN A ROW			
3 IN A ROW			
4 IN A ROW			
5 IN A ROW			

IMPROPERLY POSITIONED TIES

SKEWED, ROTATED, BUNCHED	CENTER - CENTER SPACING > 48" NOT AT JT	CENTER - CENTER SPACING > 48" AT JOINT

CHECK IF DEFECT FREE: RAIL ☐ FASTENINGS AND OTM ☐ BALLAST, SUBGRADE AND ROADWAY ☐ DRAINAGE ☐

COMP CODE	DEFECT CODE	RAIL (L,R,B)	LOCATION (STATION)	LENGTH (T F)	DENSITY (%)	QTY (#)	COMP CODE	DEFECT CODE	RAIL (L,R,B)	LOCATION (STATION)	LENGTH (T F)	DENSITY (%)	QTY (#)

FLANGEWAYS

COMP CODE	LOCATION ROAD NAME	LOCATION STATION	MIN DEPTH (IN)	MIN WIDTH (IN)	FOULED	LENGTH (FT)	INSPECTION IMPAIRED 1/4 'S	INSPECTION IMPAIRED LENGTH (LF)	LINE TOTAL (LF)	Q.L. (LF)	SUM OF Q.L.
GC RR					N Y		1				
GC RR					N Y		2				TOTAL SUM OF Q.L./4
GC RR					N Y		3				
GC RR					N Y		4				%

Minimum Full Compliance Values	Depth	Width
GC:	2" (2.0)	2 1/2" (2.5)
RR:	1 7/8" (1.875)	1 7/8" (1.875)

COMPONENT AND DEFECT CODES (ARMY AND AF USERS)

Component Codes	Defect Codes	
RAIL RL = RAIL	BRL = BENT RAIL + BRS = BENT RAIL (SURFACE BENT) + BHC = BOLT HOLE CRACK BRC = BREAK (COMPLETE) - CLEAN AND SQUARE BRR = BREAK (COMPLETE) - ROUGH AND ANGLED BRB = BROKEN BASE CD1 = CHIP / DENT IN HEAD > .25" + CB1 = CORRODED BASE > .25" + CRR = CORRUGATION + CRH = CRUSHED HEAD ENB = END BATTER > .25" EB1 = ENGINE BURN > .25" + FCM = FISSURE (COMPOUND) FTL = FISSURE (TRANSVERSE) > 40% FTS = FISSURE (TRANSVERSE) <= 40% FLK = FLAKING + FDL = FRACTURE (DETAIL) > 40% FDS = FRACTURE (DETAIL) <= 40% FEL = FRACTURE (ENGINE BURN) > 40% FES = FRACTURE (ENGINE BURN) <= 40%	FJB = FRACTURE REPAIRED WITH JOINT BAR HCK = HEAD CHECKS (SURFACE CRACKS) + HWS = HEAD / WEB SEPARATION MDF = MILL DEFECTS + OVF = OVERFLOW + PPR = PIPED RAIL L13 = RAIL LENGTH < 13' RSD = RUNNING SURFACE DAMAGE (DEPTH > .25") + SHL = SHELLING + SLV = SLIVERS + SHH = SPLIT HEAD (HORIZONTAL) SHV = SPLIT HEAD (VERTICAL) SWB = SPLIT WEB SPL = SURFACE SPALLS + TCE = TORCH CUT END TCH = TORCH CUT HOLE WRS = WEAR (SIDE) | 0.375 for < 90lb WRV = WEAR(VERTICAL) | 0.5 for => 90lb WDD = WELD DEFECT
	+ If recurring in a given individual rail, only record once	
FASTENINGS AND OTHER TRACK MATERIALS JT = JOINT	ABL = ALL BOLTS IN JOINT LOOSE ABM = ALL BOLTS ON A RAIL END MISSING OR BROKEN BBB = BOTH BARS BROKEN BBM = BOTH BARS MISSING BCC = BOTH BARS CENTER CRACKED BCB = BROKEN OR CRACKED BAR (not through center) CCB = CENTER CRACKED OR CENTER BROKEN BAR CDB = CORRODED BAR IBP = IMPROPER BOLT PATTERN IST = IMPROPER SIZE / TYPE BOLT IIB = IMPROPERLY INSTALLED JOINT BAR	ISB = IMPROPER SIZE / TYPE BAR LJB = LOOSE JOINT BAR(S) LBT = LOOSE JOINT BOLT MBT = MISSING/BENT/CRACKED OR BROKEN BOLT 1BT = ONLY 1 BOLT PER RAIL END RG1 = RAIL END GAP > 1" BUT <= 2" RG2 = RAIL END GAP > 2" RMI = RAIL END MISMATCH (HOR. OR VERT.) > 0.1875" BUT <= 0.25" RM2 = RAIL END MISMATCH (HOR. OR VERT.) > 0.25" SMB = SINGLE MISSING BAR TCB = TORCH CUT/ALT JOINT BAR
IC = INSULATION COMPONENT	IIV = INSUFFICIENT INSULATION VALUE	
GC = GRADE CROSSING	RFL = ROUGH (LOW SEV) RFM = ROUGH (MED SEV)	RFH = ROUGH (HIGH SEV)
CB = CAR BUMPER CS = CAR STOP DL = DERAIL GR = GAUGE ROD HD = HOLD-DOWN DEVICE RA = RAIL ANCHOR RR = RAIL CROSSING SH = SHIM S1 = SIGNAL S2 = SIGN SP = SPIKE TP = TIE PLATE	BRK = BROKEN (NOT FOR RA) COR = CORRODED CRB = CRACKED/BENT (NOT FOR RA) IMP = IMPROPER POSITION (NOT FOR RR)	IST = IMPROPER SIZE/TYPE (NOT FOR CB,CS,DL,RA OR RR) LOS = LOOSE MIS = MISSING (NOT FOR GR OR RR) NFL = NON-FUNCTIONAL (S1,S2 ONLY) WOR = WORN (RR ONLY)
BALLAST, SUBGRADE, AND ROADWAY BS = BALLAST, SUBGRADE, AND ROADWAY	CBT = CENTER BOUND TRACK (CROSS TIE) CBJ = CENTER BOUND TRACK (JOINT TIE) DTY = DIRTY (FOULED) EMB = EMBANKMENT EROSION ECS = EROSION (CRIB AND SHOULDER) ERM = EROSION (RESTICTED MOVEMENTS) ESS = EROSION (SINGLE SHOULDER) EWA = EROSION (WASHOUT) HTB = HANGING TIES AT BRIDGE APPROACH IBC = INSUFFICIENT BALLAST (CRIB)	IBL = INSUFFICIENT BALLAST (LEFT) IBR = INSUFFICIENT BALLAST (RIGHT) PBE = PUMPING TIES (BOTH ENDS) PJE = PUMPING TIES (JT TIE AT JT END) POE = PUMPING TIES (ONE END) UNS = UNSTABLE SLOPE VGB = VEGETATION GROWING IN BALLAST VII = VEGETATION INTERFERES WITH INSPECTION VIM = VEGETATION INTERFERES WITH TRAIN MOVEMENT VPM = VEGETATION PREVENTS TRAIN MOVEMENT
DRAINAGE CU = CULVERT DI = DITCH DR = DRAIN SS = STORM SEWER	COR = CORRODED (NOT FOR DI) ERO = EROSION (DI ONLY) IST = IMPROPER SIZE/TYPE (NOT FOR DI) RFL = RESTRICTED FLOW (DI ONLY)	RFM = RESTRICTED FLOW (MAJOR) (NOT FOR DI) RFP = RESTRICTED FLOW (PARTIAL) (NOT FOR DI) SCR = SCOUR (CU ONLY) STD = STRUCTURAL DETERIORATION

MEASUREMENT REFERENCE TABLE

1/16" = 0.0625"	5/16" = 0.3125"	9/16" = 0.5625"	13/16" = 0.8125"
1/8" = 0.125"	3/8" = 0.375"	5/8" = 0.625"	7/8" = 0.875"
3/16" = 0.1875"	7/16" = 0.4375"	11/16" = 0.6875"	15/16" = 0.9375"
1/4" = 0.25"	1/2" = 0.5"	3/4" = 0.75"	1" = 1.0"

RAILER DETAILED TRACK INSPECTION

TRACK SEGMENT #:	SEGMENT BEGINNING LOCATION:	INSPECTOR:	DATE:

TIES — CHECK IF DEFECT FREE ☐

INSPECTION IMPAIRED

(TF)	%

DEFECTIVE TIES

SINGLE OR TOTAL	SINGLE AT JT	ALL AT JOINT 1 Tie	ALL AT JOINT 2 Ties

	ISOLATED CLUSTER	ISOLATED w/1 JOINT TIE	ADJACENT CLUSTER
2 IN A ROW			
3 IN A ROW			
4 IN A ROW			
5 IN A ROW			

Minimum Number of Good Ties per 39'	

MISSING TIES

SINGLE OR TOTAL	2 IN A ROW	3 IN A ROW	ALL AT JOINT 1 Tie	ALL AT JOINT 2 Ties

IMPROPERLY POSITIONED TIES

SKEWED, ROTATED, BUNCHED	CENTER - CENTER SPACING > 48" NOT AT JT	CENTER - CENTER SPACING > 48" AT JOINT

CHECK IF DEFECT FREE: RAIL ☐ FASTENINGS AND OTM ☐ BALLAST, SUBGRADE AND ROADWAY ☐ DRAINAGE ☐

COMP CODE	DEFECT CODE	RAIL (L,R,B)	LOCATION (STATION)	LENGTH (T F)	DENSITY (%)	QTY (#)	COMP CODE	DEFECT CODE	RAIL (L,R,B)	LOCATION (STATION)	LENGTH (T F)	DENSITY (%)	QTY (#)

FLANGEWAYS

COMP CODE	LOCATION ROAD NAME	LOCATION STATION	MIN DEPTH (IN)	MIN WIDTH (IN)	FOULED	LENGTH (FT)
GC RR					N Y	
GC RR					N Y	
GC RR					N Y	
GC RR					N Y	

INSPECTION IMPAIRED

1/4 'S	LENGTH (LF)	LINE TOTAL (LF)	Q.L. (LF)	SUM OF Q.L.
1				
2				TOTAL SUM OF Q.L./4
3				
4				%

Minimum Full Compliance Values	Depth	Width
GC:	2" (2.0)	2 1/2" (2.5)
RR:	1 7/8" (1.875)	1 7/8" (1.875)

AD-A274 459 MAINTENANCE MANAGEMENT OF US ARMY RAILROAD NETWORKS - 2/2
THE RAILER SYSTEM:..(U) CONSTRUCTION ENGINEERING
RESEARCH LAB (ARMY) CHAMPAIGN IL.. D R UZARSKI ET AL.
UNCLASSIFIED OCT 93 CERL-TR-FM-94/01 XA-CECPW NL

END
FILMED
DTIC

COMPONENT AND DEFECT CODES

Component Codes	Defect Codes	
RAIL RL = RAIL	BRL = BENT RAIL + BRS = BENT RAIL (SURFACE BENT) + BC0 = BOLT HOLE CRACK WITH HEAD BREAKOUT BC1 = BOLT HOLE CRACK > 1.5" BC2 = BOLT HOLE CRACK > 0.75" BUT <= 1.5" BC3 = BOLT HOLE CRACK > 0.5" BUT <= 0.75" BC4 = BOLT HOLE CRACK <= 0.5" BRC = BREAK (COMPLETE) - CLEAN AND SQUARE BRR = BREAK (COMPLETE) - ROUGH AND ANGLED BB1 = BROKEN BASE > 12" BB2 = BROKEN BASE > 6" BUT <= 12" BB3 = BROKEN BASE > 3" BUT <= 6" BB4 = BROKEN BASE > 1.5" BUT <= 3" BB5 = BROKEN BASE <= 1.5" CD1 = CHIP / DENT IN HEAD > .25" + CB1 = CORRODED BASE > .25" + CRR = CORRUGATION + CRH = CRUSHED HEAD ENB = END BATTER > .25" EB1 = ENGINE BURN > .25" + FT1 = FISSURE (TRANSVERSE OR COMPOUND) = 100 % FT2 = FISSURE (TRANSVERSE OR COMPOUND) > 50% BUT < 100% FT3 = FISSURE (TRANSVERSE OR COMPOUND) > 20% BUT <= 50% FT4 = FISSURE (TRANSVERSE OR COMPOUND) <= 20 % FLK = FLAKING + FD1 = FRACTURE (DETAIL) = 100 % FD2 = FRACTURE (DETAIL) > 20 % BUT < 100 % FD3 = FRACTURE (DETAIL) <= 20 % FE1 = FRACTURE (ENGINE BURN) = 100 % FE2 = FRACTURE (ENGINE BURN) > 20 % BUT < 100 % FE3 = FRACTURE (ENGINE BURN) <= 20 % FJB = FRACTURE REPAIRED WITH JOINT BAR HCK = HEAD CHECKS (SURFACE CRACKS) + HW0 = HEAD/WEB SEPARATION WITH HEAD BREAKOUT HW1 = HEAD/WEB SEPARATION > 3" HW2 = HEAD/WEB SEPARATION > 1.5" BUT <= 3" HW3 = HEAD/WEB SEPARATION > 0.5" BUT <= 1.5" HW4 = HEAD/WEB SEPARATION <= 0.5" MDF = MILL DEFECTS + OF1 = OVERFLOW > 0.375" + OF2 = OVERFLOW > 0.3125" BUT <= 0.375" +	OF3 = OVERFLOW > 0.25" BUT <= 0.3125" + OF4 = OVERFLOW > 0.1875" BUT <= 0.25" + PR0 = PIPED RAIL WITH HEAD BREAKOUT PR1 = PIPED RAIL > 3" PR2 = PIPED RAIL > 1.5" BUT <= 3" PR3 = PIPED RAIL > 0.5" BUT <= 1.5" PR4 = PIPED RAIL <= 0.5" RD1 = RAIL DAMAGE > 0.375" RD2 = RAIL DAMAGE > 0.25" BUT <= 0.375" RD3 = RAIL DAMAGE > 0.1875" BUT <= 0.25" L13 = RAIL LENGTH < 13' SHL = SHELLING + SLV = SLIVERS + SH0 = SPLIT HEAD (HORIZONTAL) WITH HEAD BREAKOUT SH1 = SPLIT HEAD (HORIZONTAL) > 4" SH2 = SPLIT HEAD (HORIZONTAL) > 2" BUT <= 4" SH3 = SPLIT HEAD (HORIZONTAL) > 1" BUT <= 2" SH4 = SPLIT HEAD (HORIZONTAL) <= 1" SV0 = SPLIT HEAD (VERTICAL) WITH HEAD BREAKOUT SV1 = SPLIT HEAD (VERTICAL) > 4" SV2 = SPLIT HEAD (VERTICAL) > 2" BUT <= 4" SV3 = SPLIT HEAD (VERTICAL) > 1" BUT <= 2" SV4 = SPLIT HEAD (VERTICAL) <= 1" SW0 = SPLIT WEB WITH HEAD BREAKOUT SW1 = SPLIT WEB > 3" SW2 = SPLIT WEB > 1.5" BUT <= 3" SW3 = SPLIT WEB > 0.5" BUT <= 1.5" SW4 = SPLIT WEB <= 0.5" SPL = SURFACE SPALLS + TCE = TORCH CUT END TCH = TORCH CUT HOLE WSS = WEAR (SIDE) SMALL WSM = WEAR (SIDE) MEDIUM WSL = WEAR (SIDE) LARGE WSV = WEAR (SIDE) VERY LARGE WVS = WEAR (VERTICAL) SMALL WVM = WEAR (VERTICAL) MEDIUM WVL = WEAR (VERTICAL) LARGE WD1 = WELD DEFECT = 100 % WD2 = WELD DEFECT > 20 % BUT < 100 % WD3 = WELD DEFECT > 10 % BUT <= 20 % WD4 = WELD DEFECT <= 10 %
	+ If recurring in a given individual rail, only record once	
FASTENINGS AND OTHER TRACK MATERIALS JT = JOINT	ABL = ALL BOLTS IN JOINT LOOSE ABM = ALL BOLTS ON RAIL END MISSING OR BROKEN BBB = BOTH BARS BROKEN BBM = BOTH BARS MISSING BCC = BOTH BARS CENTER CRACKED BCB = BROKEN OR CRACKED BAR (NOT THROUGH CENTER) CCB = CENTER CRACKED OR CENTER BROKEN BAR CDB = CORRODED BAR IBP = IMPROPER BOLT PATTERN ISB = IMPROPER SIZE / TYPE BAR IST = IMPROPER SIZE / TYPE BOLT IIB = IMPROPERLY INSTALLED JOINT BAR LJB = LOOSE JOINT BAR(S)	LBT = LOOSE JOINT BOLT MBT = MISSING/BENT/CRACKED OR BROKEN BOLT 1BT = ONLY 1 BOLT PER RAIL END RG1 = RAIL END GAP > 1" BUT < 2" RG2 = RAIL END GAP > 2" RH1 = RIGHT END MISMATCH (HORIZ.) > 0.25" RH2 = RIGHT END MISMATCH (HORIZ.) > 0.1875" BUT <= 0.25" RH3 = RIGHT END MISMATCH (HORIZ.) > 0.125" BUT <= 0.1875" RV1 = RAIL END MISMATCH (VERT.) > 0.25" RV2 = RAIL END MISMATCH (VERT.) > 0.1875" BUT <= 0.25" RV3 = RAIL END MISMATCH (VERT.) > 0.125" BUT <= 0.1875" SMB = SINGLE MISSING BAR TCB = TORCH CUT/ALT JOINT BAR
IC = INSULATION COMPONENT	IIV = INSUFFICIENT INSULATION VALUE	
GC = GRADE CROSSING	RFL = ROUGH (LOW SEV) RFM = ROUGH (MED SEV)	RFH = ROUGH (HIGH SEV)
CB = CAR BUMPER; RR = RAIL CROSSING CS = CAR STOP; SH = SHIM DL = DERAIL; S1 = SIGNAL GR = GAUGE ROD; S2 = SIGN HD = HOLD DOWN DEVICE; SP = SPIKE RA = RAIL ANCHOR; TP = TIE PLATE	BRK = BROKEN (NOT FOR RA) COR = CORRODED CRB = CRACKED/BENT (NOT FOR RA) IMP = IMPROPER POSITION (NOT FOR RR)	IST = IMPROPER SIZE/TYPE (NOT FOR CB,CS,DL,RA OR RR) LOS = LOOSE MIS = MISSING (NOT FOR GR OR RR) NFL = NON-FUNCTIONAL (S1,S2 ONLY) WOR = WORN (RR ONLY)
BALLAST, SUBGRADE, AND ROADWAY BS = BALLAST, SUBGRADE, AND ROADWAY	CBJ = CENTER BOUND TRACK (JOINT TIE) CBT = CENTER BOUND TRACK (CROSS TIE) DTY = DIRTY (FOULED) ECS = EROSION (CRIB AND SHOULDER) EMB = EMBANKMENT EROSION ERM = EROSION (RESTRICTED MOVEMENTS) ESS = EROSION (SINGLE SHOULDER) EWA = EROSION (WASHOUT) HTB = HANGING TIES AT BRIDGE APPROACH IBC = INSUFFICIENT BALLAST (CRIB)	IBL = INSUFFICIENT BALLAST (LEFT) IBR = INSUFFICIENT BALLAST (RIGHT) POE = PUMPING TIES (ONE END) PBE = PUMPING TIES (BOTH ENDS) PJE = PUMPING TIES (JOINT TIE AT JOINT END) UNS = UNSTABLE SLOPE VGB = VEGATATION GROWING IN BALLAST / ROADWAY VII = VEGETATION INTERFERES WITH INSPECTION VIM = VEGATATION INTERFERES WITH TRAIN MOVEMENT VPM = VEGETATION PREVENTS TRAIN MOVEMENT
DRAINAGE CU = CULVERT; DR = DRAIN DI = DITCH; SS = STORM SEWER	COR = CORRODED (NOT FOR DI) ERO = EROSION (DI ONLY) IST = IMPROPER SIZE/TYPE (NOT FOR DI) RFL = RESTRICTED FLOW (DI ONLY)	RFM = RESTRICTED FLOW (MAJOR) (NOT FOR DI) RFP = RESTRICTED FLOW (PARTIAL) (NOT FOR DI) SCR = SCOUR (CU ONLY) STD = STRUCTURAL DETERIORATION

MEASUREMENT REFERENCE TABLE

1/16" = 0.0625"	5/16" = 0.3125"	9/16" = 0.5625"	13/16" = 0.8125"
1/8" = 0.125"	3/8" = 0.375"	5/8" = 0.625"	7/8" = 0.875"
3/16" = 0.1875"	7/16" = 0.4375"	11/16" = 0.6875"	15/16" = 0.9375"
1/4" = 0.25"	1/2" = 0.5"	3/4" = 0.75"	1" = 1.0"

RAILER TURNOUT INSPECTION

TRACK SEGMENT #:	TURNOUT ID #:	INSPECTOR:	DATE:

GENERAL			
Switch Difficult to Operate	No	Yes	
Rail Weight or Section Change	No	Yes	
Debris in Crib Area	No	Yes	
Surface and Alignment	Good	Fair	Poor

TIES								
Defective Head Blocks	0	1	2	3				
Tie Size	9	10	11	12	13	14	15	16
Defective or Missing (circle clusters)								
Defective Joint Ties								
Improperly Positioned								

	Component	Not Applicable (NA)	Defect Free	Improper Size/Type	Loose/ improper position	Damaged (chipped, etc.) or worn	Missing
SWITCH & STAND	Switch Stand	y	y	y	y	y	y
	Target	y	y	y	y	y	y
	Ground Throw Lever	y	y	y	y	y	y
	Point Locks/Lever Latches	y	y				
	Jam Nut	y	y	y	y	y	y
	Connecting Rod	y	y	y	y	y	y
	Switch Rods	y	y				
	Switch Clips	y	y				
	Connecting Rod Bolts	y	y				
	Switch Rod Bolts	y	y				
	Clip Bolts	y	y				
	Cotter Keys	y	y	////	////	////	
	Insulation Filler	y	y		////		
	Switch Points	////	L R	////	////	L R	////
	Switch Point Protector	L R	L R	L R	L R	L R	L R
	Point Rails	L R	L R	L R	L R	L R	L R
	Gauge Plate	y	y				////
	Rail Braces (L) < 4*	y	y				
	Rail Braces (R) < 4*	y	y				
	Slide Plates	y	y				
	Turnout Plates	y	y				
	Twin Tie Plates	y	y				
	Heel Fillers	L R	L R	L R	L R	L R	L R
	Heel Bolts	L R	L R				
	Heel Joint Bars	L R	L R				
FROG	Frog	y	y	y	y	y	y
	Point	////	y	////	////	y	////
	Top Surface	////	y	////	////	y	////
	Guard Faces (SG only)	L R	L R	////	////	L R	////
	Hinged Wing Rail (SP only)	y	y	y	y	y	y
	Springs and Assemblies (SP only)	y	y	////			
	Movable Point (SWP only)	y	y	y	y	y	y
	Bolts	y	y				
	Plates	y	y				
GUARD RAILS	Guard Rails	L R	L R	L R	L R	L R	L R
	Fillers	L R	L R				
	Bolts	L R	L R				
	Clamps	L R	L R				
	Guard Rail Plates	L R	L R				

MEASUREMENTS (in)

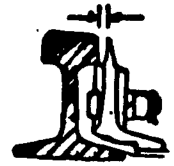
	COMPONENT	LEFT	RIGHT
POINTS & JOINTS	Switch Point Gap		
	Gauge at Switch Points		
	Gauge at Joints in	1st:	
	Curved Closure Rail	2nd:	

Comments

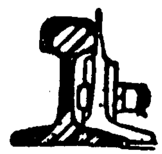
	COMPONENT	LEFT	RIGHT
FROG & GUARD RAILS	Gauge at Point		
	Frog Flangeway Width		
	Frog Flangeway Depth	Fouled+	Fouled+
	Guardrail Flangeway Width	Fouled+	Fouled+
	Guard Check Gauge		
	Guard Face Gauge		

* Circle if less than four braces are functional

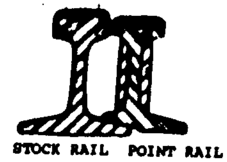
\+ Circle if fouled



Gap greater than 1/8 in. between switch point and stock rail when switch is thrown and locked

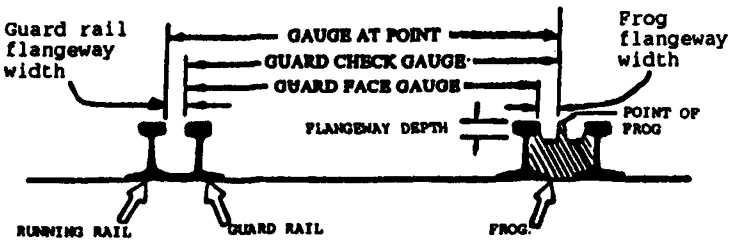


Point of switch higher than stock rail

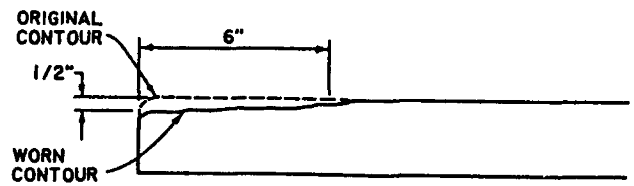


Point rail (beyond taper) lower than stock rail

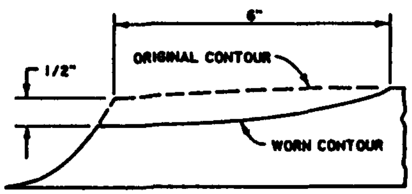
TYPES OF IMPROPER POINT RAIL POSITION



MEASUREMENTS AT FROG AND GUARD RAILS

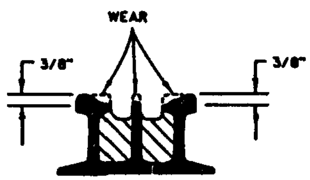


SWITCH POINT WEAR



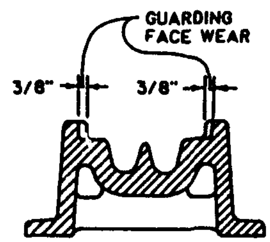
DETAIL OF FROG POINT ELEVATION

FROG POINT WEAR



SECTION THROUGH 1/2" POINT SHOWING SURFACE WEAR

WEAR FOR TOP SURFACE OF FROG



WEAR FOR GUARDING FACE OF SELF-GUARDED FROG

FRACTIONS/DECIMAL CONVERSION TABLE

1/16	0.0625	5/16	0.3125	9/16	0.5625	13/16	0.8125
1/8	0.125	3/8	0.375	5/8	0.625	7/8	0.875
3/16	0.1875	7/16	0.4375	11/16	0.6875	15/16	0.9375
1/4	0.25	1/2	0.5	3/4	0.75	1	1.0

RAILER MANUAL TRACK GEOMETRY INSPECTION

INSPECTORS: DATE:

TRACK SEGMENT NUMBER	LOCATION (STATION)	CURVE ID NUMBER	MEASUREMENT TYPE (OR CODE)	RAIL* (L or R)	MEASUREMENT VALUE (in.)	AFFECTED LENGTH (ft.)	COMMENTS

MEASUREMENT TYPES AND CODES:

GA: Gauge
RD: Rail Displacement
CL: Cross Level
AL: Alignment
PR: Profile

*RAIL is the reference rail for Cross Level measurements, or the measurement rail for Alignment and Profile measurements

APPENDIX B: RAILER Master Defect List

Def. No.	Defect Code	Description	TSCI Indices	Army	German	FRA	Navy M.	Navy S.
				Standards Condition Levels				
0	000000	UNINSPECTED DETERIORATED		0	0	0	0	0
100	001000	TIE INSPECTION IMPAIRED		2	3	4	2	2
200	002000	RAIL AND/OR OTM INSPECTION IMPAIRED		2	3	4	2	2
500	100000	TIES - DEFECT FREE		4	4	5	4	3
600	200000	RAIL - DEFECT FREE		4	4	5	4	3
700	300000	FASTENINGS & OTM - DEFECT FREE		4	4	5	4	3
800	400000	BALLAST, SUBGRADE AND ROADWAY - DEFECT FREE		4	4	5	4	3
900	500000	DRAINAGE - DEFECT FREE		4	4	5	4	3
1000	1TYTDT	TOTAL NUMBER OF DEFECTIVE TIES		3			2	3
1001	1TYSDT	T1L - SINGLE DEFECTIVE TIE	T 1 L	3	3	4	2	2
1002	1TYSJT	T1M - SINGLE DEFECTIVE JOINT TIE	T 1 M	3	3	4	3	2
1004	1TYAJ1	T5 - ALL JOINT TIES DEFECTIVE (1 TIE)	T 5	2	0	0	2	2
1005	1TYAJ2	T5 - ALL JOINT TIES DEFECTIVE (2 TIES)	T 5	2	0	0	0	0
1006	1TYJTD	ALL TIES WITHIN 18" OF JOINT DEFECTIVE	T 5	2	0	0	2	2
1007	1TYJT2	ALL TIES WITHIN 24" OF JOINT DEFECTIVE	T 5	3	0	0	0	0
1022	1TYCD2	T2L - 2 CONSEC DEF TIE CLUSTER (ISOLATED)	T 2 L	3	3	4	2	2
1023	1TYCD3	T2M - 3 CONSEC DEF TIE CLUSTER (ISOLATED)	T 2 M	2	2	3	2	1
1024	1TYCD4	T2H - 4 CONSEC DEF TIE CLUSTER (ISOLATED)	T 2 H	1	1	1	1	0
1025	1TYCD5	T2VH - 5 CONSEC DEF TIE CLUSTER (ISOLATED)	T 2 VH	0	0	1	0	0
1032	1TYDJ2	T3L - 2 CONSEC DEF TIE CLSTR (ISO W/1 JT TIE)	T 3 L	3	3	4	3	2
1033	1TYDJ3	T3M - 3 CONSEC DEF TIE CLSTR (ISO W/1 JT TIE)	T 3 M	2	2	3	1	2
1034	1TYDJ4	T3H - 4 CONSEC DEF TIE CLSTR (ISO W/1 JT TIE)	T 3 H	1	1	1	1	1
1035	1TYDJ5	T3VH - 5 CONSEC DEF TIE CLSTR (ISO W/1 JT TIE)	T 3 VH	0	0	1	0	0
1042	1TYDA2	T4L - 2 CONSEC DEF TIE CLUSTER (ADJACENT)	T 4 L	3	3	3	3	2
1043	1TYDA3	T4M - 3 CONSEC DEF TIE CLUSTER (ADJACENT)	T 4 M	2	2	1	1	2
1044	1TYDA4	T4H - 4 CONSEC DEF TIE CLUSTER (ADJACENT)	T 4 H	1	1	1	1	1
1045	1TYDA5	T4VH - 5 CONSEC DEF TIE CLUSTER (ADJACENT)	T 4 VH	0	0	0	0	0
1060	1TYTMT	TOTAL NUMBER OF MISSING TIES		3				
1061	1TYMT1	T6L - SINGLE MISSING TIE	T 6 L	3	3	4	3	2
1062	1TYMT2	T6M - 2 CONSECUTIVE MISSING TIE CLUSTER	T 6 M	2	2	4	3	2
1063	1TYMT3	T6H - 3 CONSECUTIVE MISSING TIE CLUSTER	T 6 H	2	2	4	1	1
1070	1TYJTM	T7 - ALL JOINT TIES MISSING (1 TIE)	T 7	2	2	0	0	0
1071	1TYJM2	T7 - ALL JOINT TIES MISSING (2 TIES)	T 7	2	2	0	0	0
1080	1TYSKW	T8L - IMPROP POSITIONED TIES (SKEWED, ETC)	T 8 L	3	2	4	2	2
1081	1TYCTC	C-TO-C DISTANCE ALONG EITHER RAIL > 26"		3	0	4	3	2
1082	1TYCEN	T8M - C-TO-C DIST ALONG EITHER RAIL > 48"	T 8 M	2	0	4	3	2
1083	1TYCCJ	T8H - C-TO-C DIST ALONG RAIL AT JOINT > 46"	T 8 H	2	0	0	0	0
1090	1TYSPC	WIDE SPACED TIES		3	3	4	2	2
1100	1TYT14	MINIMUM # OF GOOD TIES PER 39' ≥ 14		3		4	3	2
1101	1TYT13	MINIMUM # OF GOOD TIES PER 39' = 13		3		4	3	2
1102	1TYT12	MINIMUM # OF GOOD TIES PER 39' = 12		3		4	3	2
1103	1TYT11	MINIMUM # OF GOOD TIES PER 39' = 11		3		3	2	2
1104	1TYT10	MINIMUM # OF GOOD TIES PER 39' = 10		3		3	2	2
1105	1TYT09	MINIMUM # OF GOOD TIES PER 39' = 9		3		3	1	2
1106	1TYT08	MINIMUM # OF GOOD TIES PER 39' = 8		3		3	1	2
1107	1TYT07	MINIMUM # OF GOOD TIES PER 39' = 7		3		1	0	1
1108	1TYT06	MINIMUM # OF GOOD TIES PER 39' = 6		3		1	0	1
1109	1TYT05	MINIMUM # OF GOOD TIES PER 39' = 5		3		1	0	1
1110	1TYT04	MINIMUM # OF GOOD TIES PER 39' < 5		3		0	0	0
2011	2RLRL1	R1L (1) - RAIL DEFECTS, LOW SEV, 1 PER RAIL	R 1 L	3	3	4	2	2
2012	2RLRL2	R1L (2) - RAIL DEFECTS, LOW SEV, 2 PER RAIL	R 1 L	3	3	4	2	2
2013	2RLRL3	R1L (3) - RAIL DEFECTS, LOW SEV, 3 PER RAIL	R 1 L	3	3	4	2	2
2014	2RLRL4	R1L (4) - RAIL DEFECTS, LOW SEV, 4 PER RAIL	R 1 L	3	3	4	2	2
2015	2RLRL5	R1L (5) - RAIL DEFECTS, LOW SEV, 5 PER RAIL	R 1 L	3	3	4	2	2
2016	2RLRL6	R1L (6) - RAIL DEFECTS, LOW SEV, 6+ PER RAIL	R 1 L	3	3	4	3	2
2021	2RLRM1	R1M (1) - RAIL DEFECTS, MED SEV, 1 PER RAIL	R 1 M	2	2	4	1	1
2022	2RLRM2	R1M (2) - RAIL DEFECTS, MED SEV, 2 PER RAIL	R 1 M	2	2	4	1	1
2023	2RLRM3	R1M (3) - RAIL DEFECTS, MED SEV, 3 PER RAIL	R 1 M	2	2	4	1	1
2024	2RLRM4	R1M (4) - RAIL DEFECTS, MED SEV, 4 PER RAIL	R 1 M	2	2	4	1	1
2025	2RLRM5	R1M (5) - RAIL DEFECTS, MED SEV, 5 PER RAIL	R 1 M	2	2	4	1	1
2026	2RLRM6	R1M (6) - RAIL DEFECTS, MED SEV, 6+ PER RAIL	R 1 M	2	2	4	1	1
2031	2RLRH1	R1H (1) - RAIL DEFECTS, HIGH SEV, 1 PER RAIL	R 1 H	1	1	2	0	1
2032	2RLRH2	R1H (2) - RAIL DEFECTS, HIGH SEV, 2 PER RAIL	R 1 H	1	1	2	0	1
2033	2RLRH3	R1H (3) - RAIL DEFECTS, HIGH SEV, 3 PER RAIL	R 1 H	1	1	2	0	1
2034	2RLRH4	R1H (4) - RAIL DEFECTS, HIGH SEV, 4 PER RAIL	R 1 H	1	1	2	0	1
2035	2RLRH5	R1H (5) - RAIL DEFECTS, HIGH SEV, 5 PER RAIL	R 1 H	1	1	2	0	1
2036	2RLRH6	R1H (6) - RAIL DEFECTS, HIGH SEV, 6+ PER RAIL	R 1 H	1	1	2	0	1
2041	2RLRV1	R1VH (1) - RAIL DEFECTS, VH SEV, 1 PER RAIL	R 1 VH	0	0	0	0	0
2042	2RLRV2	R1VH (2) - RAIL DEFECTS, VH SEV, 2 PER RAIL	R 1 VH	0	0	0	0	0

Def. No.	Defect Code	Description	TSCI Indices	Army	German	FRA	Navy M.	Navy S.
2043	2RLRV3	R1VH (3) - RAIL DEFECTS, VH SEV, 3+ PER RAIL	R 1 VH	0	0	0	0	0
2045	2RLBRL	BENT RAIL	R 1 L	3	3	2	3	2
2046	2RLBRS	BENT RAIL (SURFACE BENT)	R 1 L	3	3	4	3	2
2050	2RLBHC	BOLT HOLE CRACK	R 1 VH	2	2	0	2	2
2052	2RLBC0	BOLT HOLE CRACK WITH HEAD BREAKOUT	R 1 VH	0	0	0	0	0
2055	2RLBC1	BOLT HOLE CRACK > 1.5"	R 1 VH	2	2	0	1	1
2060	2RLBC2	BOLT HOLE CRACK > 0.75 & ≤ 1.5 "	R 1 H	2	2	2	1	2
2065	2RLBC3	BOLT HOLE CRACK > 0.5" & ≤ 0.75"	R 1 H	2	2	2	2	2
2070	2RLBC4	BOLT HOLE CRACK ≤ 0.5"	R 1 M	2	2	4	2	2
2080	2RLBRC	BREAK (COMPLETE) - CLEAN AND SQUARE	R 1 VH	0	0	0	0	0
2081	2RLBRR	BREAK (COMPLETE) - ROUGH OR ANGLED	R 1 VH	0	0	0	0	0
2082	2RLBAP	BREAK W/ADAPTER OVER 4 INNER-TIE SPACES		3	2		3	2
2084	2RLBBR	BREAK ON BRIDGE OR TUNNEL TRACK	R 1 VH	0	0		0	0
2086	2RLBHL	BREAK & BROKEN HEAD W/EMER CON&GAP < 1"		3	2		3	2
2088	2RLBHG	BREAK & BROKEN HEAD W/GAP > 1"	R 1 VH	0	0		0	0
2090	2RLBOJ	BREAK & BROKEN HEAD OUTSIDE JOINT BAR	R 1 VH	0	0		0	0
2092	2RLBWJ	BREAK WITHIN JOINT BAR REGION	R 1 VH	0	1		0	0
2094	2RLBBT	BREAK BETWEEN TIES	R 1 VH	0	1		0	0
2096	2RLBBE	BREAK BETWEEN TIES W/EMER JOINT BAR		3	1		3	2
2098	2RLBAT	BREAK AT A TIE	R 1 VH	0	0		0	0
2100	2RLBAE	BREAK AT A TIE W/EMERGENCY JOINT BAR		3	1		3	2
2102	2RLHBG	LONG LAT BREAKOUT OF HEAD/GAUGE SIDE	R 1 VH	0	0		0	0
2104	2RLHBF	LONG LAT BREAKOUT OF HEAD/FIELD SIDE	R 1 VH	0	0		0	0
2110	2RLBOH	BREAKOUT OF HEAD	R 1 VH	0	0	0	0	0
2120	2RLBRB	BROKEN BASE	R 1 VH	1	1	0	1	2
2125	2RLBB1	BROKEN BASE > 12"	R 1 VH	1	1	0	1	1
2130	2RLBB2	BROKEN BASE > 6" & ≤ 12"	R 1 H	1	1	0	0	0
2135	2RLBB3	BROKEN BASE > 3" & ≤ 6"	R 1 M	1	1	4	1	1
2140	2RLBB4	BROKEN BASE > 1.5" & ≤ 3"	R 1 M	1	1	4	1	1
2145	2RLBB5	BROKEN BASE ≤ 1.5"	R 1 M	1	1	4	1	1
2150	2RLCDH	CHIP/DENT IN HEAD		3	2	4	3	2
2152	2RLCD1	CHIP/DENT IN HEAD > 0.25"	R 1 L	3	2	4	0	2
2160	2RLCRB	CORRODED BASE	R 1 M	3	2	4	3	2
2162	2RLCB1	CORRODED BASE > 0.25"	R 1 M	2	2	4	0	1
2170	2RLCRR	CORRUGATION	R 1 L	3	3	4	3	2
2180	2RLCRH	CRUSHED HEAD	R 1 M	2	2	2	1	2
2190	2RLEND	END BATTER		3	2		2	2
2192	2RLENB	END BATTER > 0.25"	R 1 M	2	2	2	0	1
2200	2RLEGB	ENGINE BURN		3	3		3	2
2202	2RLEB1	ENGINE BURN > 0.25"	R 1 L	3	3	2	0	1
2210	2RLFCM	FISSURE (COMPOUND)	R 1 VH	0	0	0	1	2
2215	2RLFTL	FISSURE (TRANSVERSE) > 40 %	R 1 VH	0	0	0	0	1
2220	2RLFTS	FISSURE (TRANSVERSE) ≤ 40 %	R 1 H	1	0	0	0	1
2225	2RLFT1	FISSURE (TRANSVERSE OR COMPOUND) = 100 %	R 1 VH	0	0	0	0	0
2230	2RLFT2	FISSURE (TRANS OR COMP) > 50 % & < 100 %	R 1 VH	0	0	0	0	1
2235	2RLFT3	FISSURE (TRANS OR COMP) > 20 % & ≤ 50 %	R 1 H	0	0	0	0	1
2240	2RLFT4	FISSURE (TRANS OR COMP) ≤ 20 %	R 1 M	1	0	0	1	2
2250	2RLFLK	FLAKING	R 1 L	3	3	4	3	2
2260	2RLFDL	FRACTURE (DETAIL) > 40 %	R 1 VH	0	0	2	0	1
2265	2RLFDS	FRACTURE (DETAIL) ≤ 40 %	R 1 H	1	0	2	0	1
2270	2RLFD1	FRACTURE (DETAIL) = 100%	R 1 VH	0	0	0	0	0
2275	2RLFD2	FRACTURE (DETAIL) > 20 % & < 100 %	R 1 VH	0	0	2	0	1
2280	2RLFD3	FRACTURE (DETAIL) ≤ 20 %	R 1 M	1	0	2	1	2
2290	2RLFEL	FRACTURE (ENGINE BURN) > 40 %	R 1 VH	0	0	2	0	1
2295	2RLFES	FRACTURE (ENGINE BURN) ≤ 40 %	R 1 H	1	1	2	0	1
2300	2RLFE1	FRACTURE (ENGINE BURN) = 100 %	R 1 VH	0	3	0	0	0
2305	2RLFE2	FRACTURE (ENGINE BURN) > 20 % & < 100 %	R 1 VH	0	3	2	1	1
2310	2RLFE3	FRACTURE (ENGINE BURN) ≤ 20 %	R 1 M	1	3	2	1	2
2320	2RLFJB	FRACTURE REPAIRED WITH JOINT BAR		3	3	4	3	2
2325	2RLHCK	HEAD CHECKS (SURFACE CRACKS)	R 1 L	3	3	4	3	2
2330	2RLHWS	HEAD/WEB SEPARATION	R 1 VH	0	0	0	2	2
2335	2RLHW0	HEAD/WEB SEPARATION WITH HEAD BREAKOUT	R 1 VH	0	0	0	0	0
2340	2RLHW1	HEAD/WEB SEPERATION > 3"	R 1 VH	0	0	0	0	1
2345	2RLHW2	HEAD/WEB SEPARATION > 1.5" & ≤ 3"	R 1 H	0	0	2	1	2
2350	2RLHW3	HEAD/WEB SEPARATION > 0.5" & ≤ 1.5"	R 1 H	0	0	2	2	2
2355	2RLHW4	HEAD/WEB SEPARATION ≤ 0.5"	R 1 M	0	0	4	2	2
2360	2RLHWB	HOLE WELD RAIL AT BRIDGE,TUNNEL,ETC		3	3		3	2
2370	2RLMDF	MILL DEFECTS	R 1 L	3	3	4	3	2
2380	2RLOVF	OVERFLOW	R 1 L	3	3	4	3	2

Def. No.	Defect Code	Description	TSCI Indices	Army	German	FRA	Navy M.	Navy S.
2385	2RLOF1	OVERFLOW > 0.375"	R 1 L	3	3	4	1	1
2390	2RLOF2	OVERFLOW > 0.3125" & ≤ 0.375"	R 1 L	3	3	4	1	1
2395	2RLOF3	OVERFLOW > 0.25" & ≤ 0.3125"	R 1 L	3	3	4	1	2
2400	2RLOF4	OVERFLOW > 0.1875" & ≤ 0.25"		3	3	4	2	2
2410	2RLPPR	PIPED RAIL	R 1 VH	2	0	0	3	2
2415	2RLPRO	PIPED RAIL WITH HEAD BREAKOUT	R 1 VH	0	0	0	0	0
2420	2RLPR1	PIPED RAIL > 3"	R 1 VH	2	0	0	0	1
2425	2RLPR2	PIPED RAIL > 1.5" & ≤ 3"	R 1 H	2	0	2	1	2
2430	2RLPR3	PIPED RAIL > 0.5" & ≤ 1.5"	R 1 H	2	0	2	2	2
2435	2RLPR4	PIPED RAIL ≤ 0.5"	R 1 M	2	0	4	2	2
2440	2RLRD1	RAIL DAMAGE > 0.375"	R 1 L	2	3	2	0	1
2445	2RLRD2	RAIL DAMAGE > 0.25" & ≤ 0.375"	R 1 L	2	3	2	0	2
2450	2RLRD3	RAIL DAMAGE > 0.1875" & ≤ 0.25"		2	3	2	3	2
2460	2RLRLI	RAIL LENGTH (IMPROPER)	R 1 L	3	3	4	3	2
2465	2RLL15	RAIL LENGTH < 50'		3	3	4	4	3
2470	2RLL13	RAIL LENGTH < 13'	R 1 L	3	3	4	1	1
2475	2RLARL	RAIL LENGTH (ADJ RAIL) < 33'		3	3	4	4	3
2480	2RLARW	RAIL LENGTH (ADJ RAIL WELD) < 7'		3	3	4		
2490	2RLRSD	RUNNING SURFACE DAMAGE > 0.25"	R 1 M	2	2	2	3	2
2500	2RLSHL	SHELLING	R 1 L	3	2	4	3	
2510	2RLSLV	SLIVERS	R 1 L	3	3	4	3	2
2520	2RLSHH	SPLIT HEAD (HORIZONTAL)	R 1 VH	1	0	0	3	2
252	2RLSHO	SPLIT HEAD (HORIZONTAL) WITH HEAD BREAKOUT	R 1 VH	0	0	0	0	0
2530	2RLSH1	SPLIT HEAD (HORIZONTAL) > 4"	R 1 VH	1	0	0	0	1
2535	2RLSH2	SPLIT HEAD (HORIZONTAL) > 2" & ≤ 4"	R 1 H	1	0	2	1	1
2540	2RLSH3	SPLIT HEAD (HORIZONTAL) > 1" & ≤ 2"	R 1 M	1	0	4	2	2
2545	2RLSH4	SPLIT HEAD (HORIZONTAL) ≤ 1"	R 1 M	1	0	4	2	2
2550	2RLSHV	SPLIT HEAD (VERTICAL)	R 1 VH	0	0	0	3	2
2555	2RLSVO	SPLIT HEAD (VERTICAL) WITH HEAD BREAKOUT	R 1 VH	0	0	0	0	0
2560	2RLSV1	SPLIT HEAD (VERTICAL) > 4"	R 1 VH	0	0	0	0	1
2565	2RLSV2	SPLIT HEAD (VERTICAL) > 2" & ≤ 4"	R 1 H	0	0	2	1	1
2570	2RLSV3	SPLIT HEAD (VERTICAL) > 1" & ≤ 2"	R 1 M	0	0	4	2	2
2575	2RLSV4	SPLIT HEAD (VERTICAL) ≤ 1"	R 1 M	0	0	4	2	2
2580	2RLSWB	SPLIT WEB	R 1 VH	1	0	0	3	2
2585	2RLSWO	SPLIT WEB WITH HEAD BREAKOUT	R 1 VH	0	0	0	0	0
2590	2RLSW1	SPLIT WEB > 3"	R 1 VH	1	0	0	0	1
2595	2RLSW2	SPLIT WEB > 1.5" & ≤ 3"	R 1 H	1	0	2	1	1
2600	2RLSW3	SPLIT WEB > 0.5" & ≤ 1.5"	R 1 H	1	0	2	2	2
2605	2RLSW4	SPLIT WEB ≤ 0.5"	R 1 M	1	0	4	2	2
2620	2RLSPL	SURFACE SPALLS	R 1 L	3	3	4	3	2
2630	2RLTCE	TORCH CUT END	R 1 M	2	2	2	2	1
2635	2RLTCH	TORCH CUT HOLE	R 1 H	1	2	2	2	1
2640	2RLWRS	WEAR (SIDE)	R 1 M	2	2	4	3	2
2645	2RLWSV	WEAR (SIDE) VERY LARGE	R 1 M	3			1	0
2650	2RLWSL	WEAR (SIDE) LARGE	R 1 M	3			2	0
2655	2RLWSM	WEAR (SIDE) MEDIUM	R 1 M	3			2	1
2660	2RLWSS	WEAR (SIDE) SMALL	R 1 M	3			2	2
2665	2RLWRV	WEAR (VERTICAL)	R 1 M	2	2	4	3	2
2670	2RLWVL	WEAR (VERTICAL) LARGE	R 1 M	3			1	0
2675	2RLWVM	WEAR (VERTICAL) MEDIUM	R 1 M	3			2	0
2680	2RLWVS	WEAR (VERTICAL) SMALL	R 1 M	3			2	1
2690	2RLWDD	WELD DEFECT	R 1 VH	2	2		3	2
2695	2RLWD1	WELD DEFECT = 100 %	R 1 VH	2	2	0	0	0
2700	2RLWD2	WELD DEFECT > 20 % & < 100 %	R 1 H	2	2	2	1	1
2705	2RLWD3	WELD DEFECT > 10 % & ≤ 20 %	R 1 H	2	2	2	2	2
2710	2RLWD4	WELD DEFECT ≤ 10 %	R 1 H	2	2	2	3	3
3001	3JTJL1	R2L (1) - JOINT DEFECTS, LOW SEV, 1 PER JT	R 2 L	3	3	2	3	2
3002	3JTJL2	R2L (2) - JOINT DEFECTS, LOW SEV, 2 PER JT	R 2 L	3	3	2	3	2
3003	3JTJL3	R2L (3) - JOINT DEFECTS, LOW SEV, 3 PER JT	R 2 L	3	3	2	3	2
3004	3JTJL4	R2L (4) - JOINT DEFECTS, LOW SEV, 4+ PER JT	R 2 L	3	3	2	3	2
3011	3JTJM1	R2M (1) - JOINT DEFECTS, MED SEV, 1 PER JT	R 2 M	2	2	1	1	1
3012	3JTJM2	R2M (2) - JOINT DEFECTS, MED SEV, 2 PER JT	R 2 M	2	2	1	1	1
3013	3JTJM3	R2M (3) - JOINT DEFECTS, MED SEV, 3 PER JT	R 2 M	2	2	1	1	1
3014	3JTJM4	R2M (4) - JOINT DEFECTS, MED SEV, 4+ PER JT	R 2 M	2	2	1	1	1
3021	3JTJH1	R2H (1) - JOINT DEFECTS, HIGH SEV, 1 PER JT	R 2 H	1	1	0	0	0
3031	3JTJV1	R2VH (1) - JOINT DEFECTS, VH SEV, 1 PER JT	R 2 VH	0	0	0	0	0
3032	3JTJV2	R2VH (2) - JOINT DEFECTS, VH SEV, 2 PER JT	R 2 VH	0	0	0	0	0
3033	3JTJV3	R2VH (3) - JOINT DEFECTS, VH SEV, 3 PER JT	R 2 VH	0	0	0	0	0
3040	3JTABL	ALL BOLTS IN A JOINT LOOSE	R 2 M	2	2	0	2	2

Def No.	Defect Code	Description	TSCI Indices	Standard Condition Levels Army	German	FRA	Navy M.	Navy S.
3050	3JTABM	ALL BOLTS ON RAIL END MISS OR BROKEN	R 2 VH	0	2	0	0	0
3060	3JTBBB	BOTH BARS BROKEN	R 2 VH	0	0	0	0	0
3061	3JTBBM	BOTH BARS MISSING	R 2 VH	0	0	0	0	0
3070	3JTBCC	BOTH BARS CENTER CRACKED	R 2 H	1	0	0	0	0
3080	3JTBCB	BROKEN OR CRACKED BAR (NOT THROUGH CENTER)	R 2 L	3	0	2	1	2
3090	3JTCCB	CENTER CRACKED OR CENTER BROKEN	R 2 M	2	0	0	0	0
3100	3JTCDB	CORRODED BAR	R 2 M	2	2	4	3	2
3101	3JTSMB	SINGLE MISSING BAR	R 2 M	2	0	0	0	0
3110	3JTIBP	IMPROPER BOLT PATTERN		3	3	4	4	3
3120	3JTISB	IMPROPER SIZE/TYPE BAR	R 2 L	3	3	4	3	2
3130	3JTIBT	IMPROPER SIZE/TYPE BOLT	R 2 L	3	3	4	3	2
3140	3JTIIB	IMPROPERLY INSTALLED JOINT BAR	R 2 L	3	3	4	3	2
3150	3JTLJB	LOOSE JOINT BARS	R 2 M	0	3	0	2	1
3160	3JTLBT	LOOSE JOINT BOLT	R 2 L	3	3	4	3	2
3170	3JTMBT	MISSING/BENT/CRACKED/OR BROKEN BOLT	R 2 L	3	3	4	3	2
3180	3JT1BT	ONLY 1 BOLT PER RAIL END	R 2 M	2	1	1	1	1
3190	3JTRGE	RAIL END GAP (EXCESSIVE)	R 2 VH	3				
3195	3JTRG1	RAIL END GAP > 1" & < 2"	R 2 M	2	1	4	1	1
3200	3JTRG2	RAIL END GAP > 2"	R 2 VH	0	0	4	1	1
3205	3JTRGO	RAIL END GAP DOESN'T CONFORM TO OBRI-NE		3	1			
3210	3JTRGN	NONUNIFORM RAIL END CAP		2	2			
3220	3JTRV1	RAIL END MISMATCH (VERT) > 0.25"	R 2 VH	0	1	0	0	0
3225	3JTRV2	RAIL END MISMATCH (VERT) > 0.1875" & ≤ 0.25"	R 2 M	2	1	2	1	2
3230	3JTRV3	RAIL END MISMATCH (VERT) > 0.125" & ≤ 0.1875		3	1	3	1	2
3235	3JTRH1	RAIL END MISMATCH (HORIZ) > 0.25"	R 2 VH	0	1	0	0	0
3240	3JTRH2	RAIL END MISMATCH (HORIZ) > 0.1875" & ≤ 0.25"	R 2 M	2	1	1	1	1
3245	3JTRH3	RAIL END MISMATCH (HORIZ) > 0.125" & ≤ 0.1875		3	1	3	1	2
3250	3JTRMO	RAIL END MISMATCH	R 2 VH	3	2			
3255	3JTRM1	RAIL END MISMATCH > 0.1875" & < 0.25"	R 2 M	2	2	1	0	1
3260	3JTRM2	RAIL END MISMATCH > 0.25"	R 2 VH	0	0	0	0	0
3270	3JTTCB	TORCH CUT/ALTERED JOINT BAR	R 2 L	3	3	2	2	1
3300	3CBBRK	CAR BUMPER, BROKEN		3	3	4	2	1
330	3CBCOR	CAR BUMPER, CORRODED		3	3	4	3	2
3310	3CBCRB	CAR BUMPBER, CRACKED/BENT		3	3	4	2	1
3315	3CBIMP	CAR BUMPER, IMPROPER POSITION		3	3	4	3	2
3320	3CBLOS	CAR BUMPER, LOOSE		3	3	4	2	1
3325	3CBMIS	CAR BUMPBER, MISSING		3	3	4	2	1
3350	3CSBRK	CAR STOP, BROKEN		3	3	4	2	1
3355	3CSCOR	CAR STOP, CORRODED		3	3	4	3	2
3360	3CSCRB	CAR STOP, CRACKED/BENT		3	3	4	2	1
3365	3CSIMP	CAR STOP, IMPROPER POSITION		3	3	4	3	2
3370	3CSLOS	CAR STOP, LOOSE		3	3	4	2	1
3375	3CSMIS	CAR STOP, MISSING		3	3	4	2	1
3400	3DLBRK	DERAIL, BROKEN		3	2	4	2	1
3405	3DLCOR	DERAIL, CORRODED		3	3	4	3	2
3410	3DLCRB	DERAIL, CRACKED/BENT		3	2	4	2	1
3415	3DLIMP	DERAIL, IMPROPER POSITION		3	2	4	3	2
3420	3DLLOS	DERAIL, LOOSE		3	2	4	2	1
3425	3DLMIS	DERAIL, MISSING		3	2	4	3	2
3450	3GRR50	R5 - GAUGE ROD EFFECTS	R 5	3	2	4	3	2
3455	3GRBRK	GAUGE ROD, BROKEN	R 5	3	2	4	3	2
3460	3GRCOR	GAUGE ROD, CORRODED	R 5	3	2	4	3	2
3465	3GRCRB	GAUGE ROD, CRACKED/BENT	R 5	3	2	4	3	2
3470	3GRIMP	GAUGE ROD, IMPROPER POSITION	R 5	3	3	4	3	2
3475	3GRIST	GAUGE ROD, IMPROPER SIZE/TYPE		3	3	4	3	2
3480	3GRLOS	GAUGE ROD, LOOSE	R 5	3	2	4	3	2
3500	3GCRFL	GRADE CROSSING, ROUGH - LOW SEVERITY		3	2	4	3	2
3505	3GCRFM	GRADE CROSSING, ROUGH - MEDIUM SEVERITY		3	2	4	3	2
3510	3GCRFH	GRADE CROSSING, ROUGH - HIGH SEVERITY		3	2	4	3	2
3550	3HDR3L	R3L - HOLD DOWN DEVICE DEFECTS, LOW SEVERITY	R 3 L	3	3	4	3	2
3555	3HDR3M	R3M - HOLD DOWN DEVICE DEFECTS, MED SEVERITY	R 3 M	3	3	4	3	2
3560	3HDBRK	HOLD DOWN DEVICE, BROKEN	R 3 M	3	3	4	3	2
3565	3HDCOR	HOLD DOWN DEVICE, CORRODED	R 3 M	3	3	4	3	2
3570	3HDCRB	HOLD DOWN DEVICE, CRACKED/BENT	R 3 M	3	3	4	3	2
3575	3HDIMP	HOLD DOWN DEVICE, IMPROPER POSITION	R 3 L	3	3	4	3	2
3580	3HDIST	HOLD DOWN DEVICE, IMPROPER SIZE/TYPE		3	2	4	3	2
3585	3HDLOS	HOLD DOWN DEVICE, LOOSE	R 3 M	3	3	4	3	2
3590	3HDMIS	HOLD DOWN DEVICE, MISSING	R 3 M	3	2	4	3	2
3600	3ICIIV	INSULATED COMP., INSUF. INSUL. VALUE		3	2	4	3	2

Def. No.	Defect Code	Description	TSCI Indices	Army	German	FRA	Navy M.	Navy S.
				Standards Condition Levels				
3650	3RAR60	R6 - RAIL ANCHOR DEFECTS	R 6	3	3	4	4	3
3655	3RACOR	RAIL ANCHOR, CORRODED	R 6	3	3	4	3	2
3660	3RAIMP	RAIL ANCHOR, IMPROPER POSITION	R 6	3	3	4	2	3
3665	3RALOS	RAIL ANCHOR, LOOSE	R 6	3	3	4	2	3
3670	3RAMIS	RAIL ANCHOR, MISSING	R 6	3	3	4	2	3
3700	3RRBRK	RAIL CROSSING, BROKEN		3	2	0	2	1
3705	3RRCOR	RAIL CROSSING, CORRODED		3	2	4	2	1
3710	3RRCRB	RAIL CROSSING, CRACKED/BENT		3	2	0	2	1
3715	3RRLOS	RAIL CROSSING, LOOSE		3	2	0	2	1
3720	3RRWOR	RAIL CROSSING, WORN		3	2	0	2	2
3750	3SHBRK	SHIM, BROKEN		3	2	4	3	2
3755	3SHCOR	SHIM, CORRODED		3	2	4	3	2
3760	3SHCRB	SHIM, CRACKED/BENT		3	2	4	3	2
3765	3SHIMP	SHIM, IMPROPER POSITION		3	2	4	3	2
3770	3SHIST	SHIM, IMPROPER SIZE/TYPE		3	2	4	3	2
3775	3SHLOS	SHIM, LOOSE		3	2	4	3	2
3780	3SHMIS	SHIM, MISSING		3	2	4	3	2
3800	3S1BRK	SIGNALS, BROKEN		3	1	4	2	1
3805	3S1COR	SIGNALS, CORRODED		3	3	4	3	2
3810	3S1CRB	SIGNALS, CRACKED/BENT		3	3	4	3	2
3815	3S1IMP	SIGNALS, IMPROPER POSITION		3	3	4	3	2
3820	3S1IST	SIGNALS, IMPROPER SIZE/TYPE		3	3	4	3	2
3825	3S1LOS	SIGNALS, LOOSE		3	3	4	3	2
3830	3S1MIS	SIGNALS, MISSING		3	1	4	3	2
3835	3S1NFL	SIGNALS, NON-FUNCTIONAL		3	1	4	2	1
3850	3S2BRK	SIGNS, BROKEN		3	3	4	2	1
3855	3S2COR	SIGNS, CORRODED		3	3	4	3	2
3860	3S2CRB	SIGNS, CRACKED/BENT		3	3	4	3	2
3865	3S2IMP	SIGNS, IMPROPER POSITION		3	3	4	3	2
3870	3S2IST	SIGNS, IMPROPER SIZE/TYPE		3	3	4	3	2
3875	3S2LOS	SIGNS, LOOSE		3	3	4	3	2
3880	3S2MIS	SIGNS, MISSING		3	3	4	2	1
3885	3S2NFL	SIGNS, NON-FUNCTIONAL		3	3	4	3	2
3900	3SPBRK	SPIKE, BROKEN	R 3 M	3	3	4	3	2
3905	3SPCOR	SPIKE, CORRODED	R 3 M	3	3	4	3	2
3910	3SPCRB	SPIKE, CRACKED/BENT	R 3 M	3	3	4	3	2
3915	3SPIMP	SPIKE, IMPROPER POSITION	R 3 L	3	3	4	3	2
3920	3SPIST	SPIKE, IMPROPER SIZE/TYPE		3	3	4	3	2
3925	3SPLOS	SPIKE, LOOSE	R 3 M	3	3	4	3	2
3930	3SPMIS	SPIKE, MISSING	R 3 M	3	3	4	3	2
3950	3TPR40	R4 - TIE PLATE DEFECTS	R 4	3	3	4	3	2
3955	3TPBRK	TIE PLATE, BROKEN	R 4	3	3	4	3	2
3960	3TPCOR	TIE PLATE, CORRODED	R 4	3	3	4	3	2
3965	3TPCRB	TIE PLATE, CRACKED/BENT	R 4	3	3	4	3	2
3970	3TPIMP	TIE PLATE, IMPROPER POSITION	R 4	3	3	4	3	2
3975	3TPIST	TIE PLATE, IMPROPER SIZE/TYPE	R 4	3	3	4	3	2
3980	3TPLOS	TIE PLATE, LOOSE		3	3	4	3	2
3985	3TPMIS	TIE PLATE, MISSING	R 4	3	2	4	3	2
3990	3TPG20	TIE PLATES, ON < 8 OF 10 TIES ALONG RAIL		3		2	3	2
4100	4BSDTY	B1 - DIRTY (FOULED) BALLAST	B 1	3	2	4	3	2
4200	4BSVGB	B2L - VEG GROWING IN BALLAST/ROADWAY	B 2 L	3	3	4	3	2
4205	4BSVII	B2M - VEG INTERFERES WITH TRACK INSPECTION	B 2 M	2	0	0	1	1
4210	4BSVIM	B2H - VEG INTERFERES WITH TRAIN MOVEMENTS	B 2 H	1	0	0	0	0
4215	4BSVPM	B2VH - VEG PREVENTS TRAIN MOVEMENTS	B 2 VH	0	0	0	0	0
4300	7BSB3L	B3L - SETTLEMENT, LOW SEV.	B 3 L	3	3	3	3	2
4305	7BSB3M	B3M - SETTLEMENT, MED SEV.	B 3 M	2	2	2	2	1
4310	7BSB3H	B3H - SETTLEMENT, HIGH SEV.	B 3 H	1	1	1	1	1
4315	7BSB3V	B3VH - SETTLEMENT, VERY HIGH SEV.	B 3 VH	0	0	0	0	0
4350	7BSSLB	B3L - SETTLEMENT AT BRIDGE APPROACH, LOW SEV	B 3 L	3	3	3	3	2
4355	7BSSMB	B3M - SETTLEMENT AT BRIDGE APPROACH, MED SEV	B 3 M	2	2	2	2	1
4360	7BSSHB	B3H - SETTLEMENT AT BRIDGE APPROACH, HIGH SEV	B 3 H	1	1	1	1	1
4365	7BSSVB	B3VH - SETTLEMENT AT BRIDGE APPROACH, VH SEV	B 3 VH	0	0	0	0	0
4400	4BSHTB	B4 - HANGING TIES AT BRIDGE APPROACH	B 4	3	3	4	3	2
4500	4BSCBT	B5L - CENTER BOUND TRACK (CROSS TIE)	B 5 L	3	3	4	3	2
4505	4BSCBJ	B5M - CENTER BOUND TRACK (JOINT TIE)	B 5 M	3	3	4	3	2
4600	4BSPOE	B6L - PUMPING TIES (ONE END)	B 6 L	3	2	4	3	2
4605	4BSPBE	B6M - PUMPING TIES (BOTH ENDS)	B 6 M	3	2	4	3	2
4610	4BSPJE	B6H - PUMPING TIES (JOINT TIE AT JOINT END)	B 6 H	3	2	4	3	2
4700	7BSB7L	B7L - ALIGNMENT DEVIATION, LOW SEV.	B 7 L	3	3	3	3	2

Def. No.	Defect Code	Description	TSCI Indices	Standards Condition Levels Army	German	FRA	Navy M.	Navy S.
4705	7BSB7M	B7M - ALIGNMENT DEVIATION, MED SEV.	B 7 M	2	2	2	2	1
4710	7BSB7H	B7H - ALIGNMENT DEVIATION, HIGH SEV.	B 7 H	1	1	1	1	1
4715	7BSB7V	B7VH - ALIGNMENT DEVIATION, VERY HIGH SEV.	B 7 VH	0	0	0	0	0
4800	4BSB80	B8 - INSUFF CRIB AND/OR SHOULDER BALLAST	B 8	3	3	4	3	2
4805	4BSIBC	INSUFFICIENT BALLAST (CRIB)	B 8	3	3	4	3	2
4810	4BSIBL	INSUFFICIENT BALLAST (LEFT)	B 8	3	3	4	3	2
4815	4BSIBR	INSUFFICIENT BALLAST (RIGHT)	B 8	3	3	4	3	2
4900	4BSESS	B9L - EROSION OF BALLAST (SINGLE SHOULDER)	B 9 L	3	3	4	3	2
4905	4BSECS	B9M - EROSION OF BALLAST (CRIB & SHOULDER)	B 9 M	2	2	4	3	2
4910	4BSERM	B9H - EROSION OF BALLAST (RESTRICT MOVEMENT)	B 9 H	1	2	1	1	1
4915	4BSEWA	B9VH - EROSION OF BALLAST (WASHOUT)	B 9 VH	0	0	0	0	0
4950	4BSUNS	UNSTABLE SLOPE	B 10 M	3	3	4	3	2
4960	4BSEMB	EMBANKMENT EROSION	B 10 M	3	2	4	3	2
5000	5CUCOR	CULVERT, CORRODED	B 11 M	3	3	4	3	2
5005	5CUIST	CULVERT, IMPROPER SIZE/TYPE		3	3	4	3	2
5010	5CURFP	CULVERT, RESTRICTED FLOW (PARTIAL)	B 11 L	3	3	4	3	2
5015	5CURFM	CULVERT, RESTRICTED FLOW (MAJOR)	B 11 M	3	3	4	2	1
5020	5CUSCR	CULVERT, SCOUR	B 11 M	3	3	4	3	2
5025	5CUSTD	CULVERT, STRUCT. DETERIORATE	B 11 M	3	3	4	3	2
5050	5DIERO	DITCH, EROSION	B 10 M	3	3	4	3	2
5055	5DIRFL	DITCH, RESTRICTED FLOW	B 10 L	3	3	4	3	2
5070	5DISTD	DITCH, STRUCT. DETERIORATE	B 10 M	3	3	4	3	2
5100	5DRCOR	DRAIN, CORRODED	B 11 M	3	3	4	3	2
5105	5DRIST	DRAIN, IMPROPER SIZE/TYPE	B 11 L	3	3	4	3	2
5110	5DRRFP	DRAIN, RESTRICTED FLOW (PARTIAL)	B 11 L	3	3	4	3	2
5115	5DRRFM	DRAIN, RESTRICTED FLOW (MAJOR)	B 11 M	3	3	4	2	1
5120	5DRSTD	DRAIN, STRUCT. DETERIORATE	B 11 M	3	3	4	3	2
5150	5DSRFL	B11L - DRAINAGE STRUCTURE (RESTRICTED FLOW)	B 11 L	3	3	4	3	2
5155	5DSBFM	B11M - DRAINAGE STRUCTURE (BLOCKED FLOW)	B 11 M	3	3	4	2	1
5200	5SSCOR	STORM SEWER, CORRODED	B 11 M	3	3	4	3	2
5205	5SSIST	STORM SEWER, IMPROPER SIZE/TYPE		3	3	4	3	2
5210	5SSRFP	STORM SEWER, RESTRICTED FLOW (PARTIAL)	B 11 L	3	2	4	3	2
5215	5SSRFM	STORM SEWER, RESTRICTED FLOW (MAJOR)	B 11 M	3	2	4	2	1
5220	5SSSTD	STORM SEWER, STRUCT. DETERIORATE	B 11 M	3	2	4	3	2
5250	5TDRFL	B10L - TRACKSIDE DRAINAGE (RESTRICTED FLOW)	B 10 L	3	2	4	3	2
5255	5TDERO	B10M - TRACKSIDE DRAINAGE (EROSION)	B 10 M	3	2	4	3	2
6010	6SDYES	SWITCH DIFFICULT TO OPERATE		3	3	4	3	2
6020	6RWYES	RAIL WEIGHT OR SECTION CHANGE		3				
6030	6CAYES	DEBRIS IN CRIB AREAS		3	3	4	3	2
6040	6LNGOD	SURFACE AND ALIGNMENT (GOOD)		3	4	4	4	3
6050	6LNFAR	SURFACE AND ALIGNMENT (FAIR)		3	3	4	3	2
6060	6LNPOR	SURFACE AND ALIGNMENT (POOR)		3	3	4	2	1
6070	6DHDEF	DEFECTIVE HEAD BLOCKS		3				
6100	6TITOT	TOTAL DEFECTIVE OR MISSING SWITCH TIES		3			3	2
6110	6TIMX2	NUMBER OF 2-IN-A-ROW DEF SWITCH TIE CLUSTERS		3	0	4	3	2
6120	6TIMX3	NUMBER OF 3-IN-A-ROW DEF SWITCH TIE CLUSTERS		2	0	3	2	1
6130	6TIMX4	NUMBER OF 4-IN-A-ROW DEF SWITCH TIE CLUSTERS		1	0	1	1	0
6140	6TIMX5	NUMBER OF ≥5-IN-A-ROW DEF SWITCH TIE CLUSTERS		0	0	1	0	0
6150	6T9DEF	DEFECTIVE OR MISSING 9' SWITCH TIES		3		4	3	2
6160	6T0DEF	DEFECTIVE OR MISSING 10' SWITCH TIES		3		4	3	2
6170	6T1DEF	DEFECTIVE OR MISSING 11' SWITCH TIES		3		4	3	2
6180	6T2DEF	DEFECTIVE OR MISSING 12' SWITCH TIES		3		4	3	2
6190	6T3DEF	DEFECTIVE OR MISSING 13' SWITCH TIES		3		4	3	2
6200	6T4DEF	DEFECTIVE OR MISSING 14' SWITCH TIES		3		4	3	2
6210	6T5DEF	DEFECTIVE OR MISSING 15' SWITCH TIES		3		4	3	2
6220	6T6DEF	DEFECTIVE OR MISSING 16' SWITCH TIES		3		4	3	2
6230	6T9JNT	DEFECTIVE OR MISSING 9' SWITCH JT TIES		3		4	3	2
6240	6T0JNT	DEFECTIVE OR MISSING 10' SWITCH JT TIES		3		4	3	2
6250	6T1JNT	DEFECTIVE OR MISSING 11' SWITCH JT TIES		3		4	3	2
6260	6T2JNT	DEFECTIVE OR MISSING 12' SWITCH JT TIES		3		4	3	2
6270	6T3JNT	DEFECTIVE OR MISSING 13' SWITCH JT TIES		3		4	3	2
6280	6T4JNT	DEFECTIVE OR MISSING 14' SWITCH JT TIES		3		4	3	2
6290	6T5JNT	DEFECTIVE OR MISSING 15' SWITCH JT TIES		3		4	3	2
6300	6T6JNT	DEFECTIVE OR MISSING 16' SWITCH JT TIES		3		4	3	2
6310	6T9IMP	IMPROPERLY POSITIONED 9' SWITCH TIES		3		4	3	2
6320	6T0IMP	IMPROPERLY POSITIONED 10' SWITCH TIES		3		4	3	2
6330	6T1IMP	IMPROPERLY POSITIONED 11' SWITCH TIES		3		4	3	2
6340	6T2IMP	IMPROPERLY POSITIONED 12' SWITCH TIES		3		4	3	2
6350	6T3IMP	IMPROPERLY POSITIONED 13' SWITCH TIES		3		4	3	2

Def. No.	Defect Code	Description	TSCI Indices	Standards Condition Levels Army	German	FRA	Navy M.	Navy S.
6360	6T4IMP	IMPROPERLY POSITIONED 14' SWITCH TIES		3		4	3	2
6370	6T5IMP	IMPROPERLY POSITIONED 15' SWITCH TIES		3		4	3	2
6380	6T6IMP	IMPROPERLY POSITIONED 16' SWITCH TIES		3		4	3	2
6400	6STIMP	SWITCH STAND, IMP SIZE OR TYPE		3	0	4	3	2
6402	6STLOS	SWITCH STAND, LOOSE OR IMP POS		0	0	0	0	0
6404	6STDAM	SWITCH STAND, DAMAGED		3	3	4	0	0
6406	6STMIS	SWITCH STAND, MISSING		0	0	0	0	0
6410	6TLIMP	TARGET/LAMP, IMP SIZE OR TYPE		3	3	0	1	1
6412	6TLLOS	TARGET/LAMP, LOOSE OR IMP POS		3	3	4	3	2
6414	6TLDAM	TARGET/LAMP, DAMAGED		3	3	4	3	2
6416	6TLMIS	TARGET/LAMP, MISSING		3	0	0	3	2
6420	6GTIMP	GRND THROW LEVER, IMP SIZE OR TYPE		3		4	3	2
6422	6GTLOS	GRND THROW LEVER, LOOSE OR IMP POS		3		4	3	2
6424	6GTDAM	GRND THROW LEVER, DAMAGED		3		4	3	2
6426	6GTMIS	GRND THROW LEVER, MISSING		3		4	2	1
6430	6LLIMP	POINT LOCKS/LEVER LATCHES, IMP SIZE/TYPE		3	3	4	3	2
6432	6LLLOS	POINT LOCKS/LEVER LATCHES, LOOSE/IMP POS		3	2	4	3	2
6434	6LLDAM	POINT LOCKS/LEVER LATCHES, DAMAGED		2	2	0	0	0
6436	6LLMIS	POINT LOCKS/LEVER LATCHES, MISSING		2	3	0	0	0
6440	6JNIMP	JAM NUT, IMP SIZE OR TYPE		3		4	3	2
6442	6JNLOS	JAM NUT, LOOSE OR IMP POS		3		4	3	2
6444	6JNDAM	JAM NUT, DAMAGED		3		4	3	2
6446	6JNMIS	JAM NUT, MISSING		3		4	2	1
6450	6CRIMP	CONNECTING ROD, IMP SIZE OR TYPE		3	3	4	3	2
6452	6CRLOS	CONNECTING ROD, LOOSE OR IMP POS		0	0	0	0	0
6454	6CRDAM	CONNECTING ROD, DAMAGED		0	0	0	0	0
6456	6CRMIS	CONNECTING ROD, MISSING		0	0	0	0	0
6460	6SRIMP	SWITCH RODS, IMP SIZE OR TYPE		3	3	4	3	2
6462	6SRLOS	SWITCH RODS, LOOSE OR IMP POS		0	0	0	0	0
6464	6SRDAM	SWITCH RODS, DAMAGED		0	0	4	0	0
6466	6SRMIS	SWITCH RODS, MISSING		0	0	0	0	0
6470	6SCIMP	SWITCH CLIPS, IMP SIZE OR TYPE		3	3	4	3	2
6472	6SCLOS	SWITCH CLIPS, LOOSE OR IMP POS		0	0	0	0	0
6474	6SCDAM	SWITCH CLIPS, DAMAGED		0	0	0	0	0
6476	6SCMIS	SWITCH CLIPS, MISSING		0	0	0	0	0
6480	6RBIMP	CONNECTING ROD BOLTS, IMP SIZE OR TYPE		3	3	4	3	2
6482	6RBLOS	CONNECTING ROD BOLTS, LOOSE OR IMP POS		3	3	4	3	2
6484	6RBDAM	CONNECTING ROD BOLTS, DAMAGED		3	3	4	3	2
6486	6RBMIS	CONNECTING ROD BOLTS, MISSING		3	0	4	2	1
6490	6SBIMP	SWITCH ROD BOLTS, IMP SIZE OR TYPE		3		4	3	2
6492	6SBLOS	SWITCH ROD BOLTS, LOOSE OR IMP POS		3		4	3	2
6494	6SBDAM	SWITCH ROD BOLTS, DAMAGED		3		4	3	2
6496	6SBMIS	SWITCH ROD BOLTS, MISSING		3		4	2	1
6500	6BCIMP	CLIP BOLTS, IMP SIZE OR TYPE		3		4	3	2
6502	6BCLOS	CLIP BOLTS, LOOSE OR IMP POS		3		4	3	2
6504	6BCDAM	CLIP BOLTS, DAMAGED		3		4	3	2
6506	6BCMIS	CLIP BOLTS, MISSING		3		4	2	1
6516	6CKMIS	COTTER KEYS, MISSING		3	3	4	3	2
6520	6IFIMP	INSULATION FILLER, IMP SIZE OR TYPE		3		4	3	2
6524	6IFDAM	INSULATION FILLER, DAMAGED		3		4	3	2
6526	6IFMIS	INSULATION FILLER, MISSING		3		4	3	2
6534	6LSDAM	SWITCH POINT (LT), DAMAGED OR WORN		2	0	0	0	0
6535	6RSDAM	SWITCH POINT (RT), DAMAGED OR WORN		2	0	0	0	0
6540	6PLIMP	SWITCH POINT PROTECTOR (LT), IMP SIZE OR TYPE		3		4	3	2
6541	6PRIMP	SWITCH POINT PROTECTOR (RT), IMP SIZE OR TYPE		3		4	3	2
6542	6PLLOS	SWITCH POINT PROTECTOR (LT), LOOSE OR IMP POS		3		4	3	2
6543	6PRLOS	SWITCH POINT PROTECTOR (RT), LOOSE OR IMP POS		3		4	3	2
6544	6PLDAM	SWITCH POINT PROTECTOR (LT), DAMAGED OR WORN		3		4	3	2
6545	6PRDAM	SWITCH POINT PROTECTOR (RT), DAMAGED OR WORN		3		4	3	2
6546	6PLMIS	SWITCH POINT PROTECTOR (LT), MISSING		3		4	3	2
6547	6PRMIS	SWITCH POINT PROTECTOR (RT), MISSING		3		4	3	2
6550	6LPIMP	POINT RAIL (LT), IMP SIZE OR TYPE		0	0	0	0	0
6551	6RPIMP	POINT RAIL (RT), IMP SIZE OR TYPE		0	0	0	0	0
6552	6LPLOS	POINT RAIL (LT), LOOSE OR IMP POS		1	0	0	1	1
6553	6RPLOS	POINT RAIL (RT), LOOSE OR IMP POS		1	0	0	1	1
6554	6LPDAM	POINT RAIL (LT), DAMAGED		3	0	0	1	1
6555	6RPDAM	POINT RAIL (RT), DAMAGED		3	0	0	1	1
6556	6LPMIS	POINT RAIL (LT), MISSING		0	0	0	0	0
6557	6RPMIS	POINT RAIL (RT), MISSING		0	0	0	0	0

Def. No.	Defect Code	Description	TSCI Indices	Army	German	FRA	Navy M.	Navy S.
					Standards Condition Levels			
6560	6GPIMP	GAUGE PLATE, IMP SIZE OR TYPE		3		4	3	2
6562	6GPLOS	GAUGE PLATE, LOOSE OR IMP POS		3		4	3	2
6564	6GPDAM	GAUGE PLATE, DAMAGED		3		4	3	2
6570	6BLIMP	RAIL BRACES (LT), IMP SIZE OR TYPE		3	0	4	3	2
6572	6BLLOS	RAIL BRACES (LT), LOOSE OR IMP POS		3	3	4	3	2
6574	6BLDAM	RAIL BRACES (LT), DAMAGED		3	3	4	3	2
6576	6BLMIS	RAIL BRACES (LT), MISSING		3	0	4	3	2
6578	6BLFUN	RAIL BRACES (LT), < 4 FUNCTIONAL		1		4	3	2
6580	6BRIMP	RAIL BRACES (RT), IMP SIZE OR TYPE		3		4	3	2
6582	6BRLOS	RAIL BRACES (RT), LOOSE OR IMP POS		3		4	3	2
6584	6BRDAM	RAIL BRACES (RT), DAMAGED		3		4	3	2
6586	6BRMIS	RAIL BRACES (RT), MISSING		3		4	3	2
6588	6BRFUN	RAIL BRACES (RT), < 4 FUNCTIONAL		1		4	3	2
6590	6SLIMP	SLIDE PLATES, IMP SIZE OR TYPE		3	3	4	3	2
6592	6SLLOS	SLIDE PLATES, LOOSE OR IMP POS		3	3	4	3	2
6594	6SLDAM	SLIDE PLATES, DAMAGED OR WORN		3	3	4	3	2
6596	6SLMIS	SLIDE PLATES, MISSING		3	0	4	3	2
6600	6PTIMP	TURNOUT PLATES, IMP SIZE OR TYPE		3		4	3	2
6602	6PTLOS	TURNOUT PLATES, LOOSE OR IMP POS		3		4	3	2
6604	6PTDAM	TURNOUT PLATES, DAMAGED		3		4	3	2
6606	6PTMIS	TURNOUT PLATES, MISSING		3		4	3	2
6611	6TTIMP	TWIN TIE PLATES, IMP SIZE OR TYPE		3		4	3	2
6612	6TTLOS	TWIN TIE PLATES, LOOSE OR IMP POS		3		4	3	2
6614	6TTDAM	TWIN TIE PLATES, DAMAGED		3		4	3	2
6616	6TTMIS	TWIN TIE PLATES, MISSING		3		4	3	2
6620	6HLIMP	HEEL FILLERS (LT), IMP SIZE OR TYPE		3	0	4	3	2
6621	6HRIMP	HEEL FILLERS (RT), IMP SIZE OR TYPE		3	0	4	3	2
6622	6HLLOS	HEEL FILLERS (LT), LOOSE OR IMP POS		1	0	4	3	2
6623	6HRLOS	HEEL FILLERS (RT), LOOSE OR IMP POS		1	0	4	3	2
6624	6HLDAM	HEEL FILLERS (LT), DAMAGED		1	0	4	3	2
6625	6HRDAM	HEEL FILLERS (RT), DAMAGED		1	0	4	3	2
6626	6HLMIS	HEEL FILLERS (LT), MISSING		1	0	4	3	2
6627	6HRMIS	HEEL FILLERS (RT), MISSING		1	0	4	3	2
6630	6ELIMP	HEEL JT BOLTS (LT), IMP SIZE OR TYPE		3	3	4	3	2
6631	6ERIMP	HEEL JT BOLTS (RT), IMP SIZE OR TYPE		3	3	4	3	2
6632	6ELLOS	HEEL JT BOLTS (LT), LOOSE OR IMP POS		1	1	4	3	2
6633	6ERLOS	HEEL JT BOLTS (RT), LOOSE OR IMP POS		1	1	4	3	2
6634	6ELDAM	HEEL JT BOLTS (LT), DAMAGED		1	1	4	1	1
6635	6ERDAM	HEEL JT BOLTS (RT), DAMAGED		1	1	4	1	1
6636	6ELMIS	HEEL JT BOLTS (LT), MISSING		1	1	4	1	1
6637	6ERMIS	HEEL JT BOLTS (RT), MISSING		1	1	4	1	1
6640	6JLIMP	HEEL JT BARS (LT), IMP SIZE OR TYPE		3	3	4	3	2
6641	6JRIMP	HEEL JT BARS (RT), IMP SIZE OR TYPE		3	3	4	3	2
6642	6JLLOS	HEEL JT BARS (LT), LOOSE OR IMP POS		1	0	0	2	1
6643	6JRLOS	HEEL JT BARS (RT), LOOSE OR IMP POS		1	0	0	2	1
6644	6JLDAM	HEEL JT BARS (LT), DAMAGED		1	0	2	1	1
6645	6JRDAM	HEEL JT BARS (RT), DAMAGED		1	0	2	1	1
6646	6JLMIS	HEEL JT BARS (LT), MISSING		1	0	0	0	0
6647	6JRMIS	HEEL JT BARS (RT), MISSING		1	0	0	0	0
6650	6FGIMP	FROG (GENERAL), IMP SIZE OR TYPE		3	0	4	3	2
6652	6FGLOS	FROG (GENERAL), LOOSE OR IMP POS		3	0	4	3	2
6654	6FGDAM	FROG (GENERAL), DAMAGED		3	0	4	3	2
6656	6FGMIS	FROG (GENERAL), MISSING		0	0	0	0	0
6664	6PFDAM	FROG POINT, DAMAGED OR WORN		3	3	1	1	1
6674	6TSDAM	FROG TOP SURFACE, DAMAGED OR WORN		3		1	1	1
6684	6GLDAM	SG FROG GUARD FACES (LT), DAMAGED		3		4	3	2
6685	6GRDAM	SG FROG GUARD FACES (RT), DAMAGED		3		4	3	2
6690	6WRIMP	SP FROG WING RAIL, IMP SIZE OR TYPE		3		4	3	2
6692	6WRLOS	SP FROG WING RAIL, LOOSE OR IMP POS		3		4	3	2
6694	6WRDAM	SP FROG WING RAIL, DAMAGED		3		4	3	2
6696	6WRMIS	SP FROG WING RAIL, MISSING		0		0	0	0
6702	6SALOS	SP FROG SPRINGS & ASSEMBLIES, LOOSE OR IMP POS		3		4	3	2
6704	6SADAM	SP FROG SPRINGS & ASSEMBLIES, DAMAGED		3		4	3	2
6706	6SAMIS	SP FROG SPRINGS & ASSEMBLIES, MISSING		0		0	0	0
6710	6MPIMP	SWP FROG MOVABLE POINT, IMP SIZE OR TYPE		3		4	3	2
6712	6MPLOS	SWP FROG MOVABLE POINT, LOOSE OR IMP POS		3		4	3	2
6714	6MPDAM	SWP FROG MOVABLE POINT, DAMAGED		3		4	3	2
6716	6MPMIS	SWP FROG MOVABLE POINT, MISSING		0		0	0	0
6720	6FBIMP	FROG BOLTS, IMP SIZE OR TYPE		3	3	4	3	2

Def. No.	Defect Code	Description	TSCI Indices	Standards Condition Levels Army	German	FRA	Navy M.	Navy S.
6722	6FBLOS	FROG BOLTS, LOOSE OR IMP POS		3	2	4	3	2
6724	6FBDAM	FROG BOLTS, DAMAGED		3	2	4	3	2
6726	6FBMIS	FROG BOLTS, MISSING		3	0	4	1	1
6730	6FPIMP	FROG PLATES, IMP SIZE OR TYPE		3		4	3	2
6732	6FPLOS	FROG PLATES, LOOSE OR IMP POS		3		4	3	2
6734	6FPDAM	FROG PLATES, DAMAGED		3		4	3	2
6736	6FPMIS	FROG PLATES, MISSING		3		4	3	2
6740	6ULIMP	GUARD RAIL (LT), IMP SIZE OR TYPE		3	3	4	3	2
6741	6URIMP	GUARD RAIL (RT), IMP SIZE OR TYPE		3	3	4	3	2
6742	6ULLOS	GUARD RAIL (LT), LOOSE OR IMP POS		3	2	4	3	2
6743	6URLOS	GUARD RAIL (RT), LOOSE OR IMP POS		3	2	4	3	2
6744	6ULDAM	GUARD RAIL (LT), DAMAGED		3	2	4	1	1
6745	6URDAM	GUARD RAIL (RT), DAMAGED		3	2	4	1	1
6746	6ULMIS	GUARD RAIL (LT), MISSING		3	0	4	0	0
6747	6URMIS	GUARD RAIL (RT), MISSING		3	0	4	0	0
6750	6LGIMP	GUARD RAIL FILLER (LT), IMP SIZE OR TYPE		3	3	4	3	2
6751	6RGIMP	GUARD RAIL FILLER (RT), IMP SIZE OR TYPE		3	3	4	3	2
6752	6LGLOS	GUARD RAIL FILLER (LT), LOOSE OR IMP POS		3	3	4	3	2
6753	6RGLOS	GUARD RAIL FILLER (RT), LOOSE OR IMP POS		3	3	4	3	2
6754	6LGDAM	GUARD RAIL FILLER (LT), DAMAGED		3	3	4	1	1
6755	6RGDAM	GUARD RAIL FILLER (RT), DAMAGED		3	3	4	1	1
6756	6LGMIS	GUARD RAIL FILLER (LT), MISSING		3	0	4	0	0
6757	6RGMIS	GUARD RAIL FILLER (RT), MISSING		3	0	4	0	0
6760	6LBIMP	GUARD RAIL BOLTS (LT), IMP SIZE OR TYPE		3	3	4	3	2
6761	6GBIMP	GUARD RAIL BOLTS (RT), IMP SIZE OR TYPE		3	3	4	3	2
6762	6LBLOS	GUARD RAIL BOLTS (LT), LOOSE OR IMP POS		3	3	4	3	2
6763	6GBLOS	GUARD RAIL BOLTS (RT), LOOSE OR IMP POS		3	3	4	3	2
6764	6LBDAM	GUARD RAIL BOLTS (LT), DAMAGED		3	3	4	3	2
6765	6GBDAM	GUARD RAIL BOLTS (RT), DAMAGED		3	3	4	3	2
6766	6LBMIS	GUARD RAIL BOLTS (LT), MISSING		3	0	4	1	1
6767	6GBMIS	GUARD RAIL BOLTS (RT), MISSING		3	0	4	1	1
6770	6LCIMP	GUARD RAIL CLAMPS (LT), IMP SIZE OR TYPE		3		4	3	2
6771	6RCIMP	GUARD RAIL CLAMPS (RT), IMP SIZE OR TYPE		3		4	3	2
6772	6LCLOS	GUARD RAIL CLAMPS (LT), LOOSE OR IMP POS		3		4	3	2
6773	6RCLOS	GUARD RAIL CLAMPS (RT), LOOSE OR IMP POS		3		4	3	2
6774	6LCDAM	GUARD RAIL CLAMPS (LT), DAMAGED		3		4	3	2
6775	6RCDAM	GUARD RAIL CLAMPS (RT), DAMAGED		3		4	3	2
6776	6LCMIS	GUARD RAIL CLAMPS (LT), MISSING		3		4	3	2
6777	6RCMIS	GUARD RAIL CLAMPS (RT), MISSING		3		4	3	2
6780	6LUIMP	GUARD RAIL PLATES (LT), IMP SIZE OR TYPE		3		4	3	2
6781	6RUIMP	GUARD RAIL PLATES (RT), IMP SIZE OR TYPE		3		4	3	2
6782	6LULOS	GUARD RAIL PLATES (LT), LOOSE OR IMP POS		3		4	3	2
6783	6RULOS	GUARD RAIL PLATES (RT), LOOSE OR IMP POS		3		4	3	2
6784	6LUDAM	GUARD RAIL PLATES (LT), DAMAGED		3		4	3	2
6785	6RUDAM	GUARD RAIL PLATES (RT), DAMAGED		3		4	3	2
6786	6LUMIS	GUARD RAIL PLATES (LT), MISSING		3		4	3	2
6787	6RUMIS	GUARD RAIL PLATES (RT), MISSING		3		4	3	2
7000	6FFFDL	FROG FLANGEWAY DEPTH (LT) - FOULED		3		4	3	2
7010	6FFFDR	FROG FLANGEWAY DEPTH (RT) - FOULED		3		4	3	2
7020	6FWFDL	GUARD RAIL FLANGEWAY (LT) - FOULED		3		4	3	2
7030	6FWFDR	GUARD RAIL FLANGEWAY (RT) - FOULED		3		4	3	2
7500	6SGLFT	SWITCH POINT GAP (LT)						
7510	6SGRGT	SWITCH POINT GAP (RT)						
7520	6GSGAG	GAUGE AT SWITCH POINTS						
7530	6GJCR1	GAUGE AT JOINTS IN CURVED CLOSURE RAIL (1st)						
7540	6GJCR2	GAUGE AT JOINTS IN CURVED CLOSURE RAIL (2nd)						
7550	6FPPSS	GAUGE AT FROG POINT (LT)						
7560	6FPPTS	GAUGE AT FROG POINT (RT)						
7570	6FFWSS	FROG FLANGEWAY WIDTH (LT)						
7580	6FFWTS	FROG FLANGEWAY WIDTH (RT)						
7590	6FFDSS	FROG FLANGEWAY DEPTH (LT)						
7600	6FFDTS	FROG FLANGEWAY DEPTH (RT)						
7610	6FWWSS	GUARD RAIL FLANGEWAY WIDTH (LT)						
7620	6FWWTS	GUARD RAIL FLANGEWAY WIDTH (RT)						
7630	6CGCSS	GUARD CHECK GAUGE (LT)						
7640	6CGCTS	GUARD CHECK GAUGE (RT)						
7650	6GFFSS	GUARD FACE GAUGE (LT)						
7660	6GFFTS	GUARD FACE GAUGE (RT)						
8000	3GCWDF	GRADE CROSSING FLANGEWAY WIDTH (FOULED)						

Def. No.	Defect Code	Description	TSCI Indices	Army	German	FRA	Navy M.	Navy S.
8010	3GCWDN	GRADE CROSSING FLANGEWAY WIDTH (NOT FOULED)						
8020	3GCDPF	GRADE CROSSING FLANGEWAY DEPTH (FOULED)						
8030	3GCDPN	GRADE CROSSING FLANGEWAY DEPTH (NOT FOULED)						
8040	3RRWDF	RAIL CROSSING FLANGEWAY WIDTH (FOULED)						
8050	3RRWDN	RAIL CROSSING FLANGEWAY WIDTH (NOT FOULED)						
8060	3RRDPF	RAIL CROSSING FLANGEWAY DEPTH (FOULED)						
8070	3RRDPN	RAIL CROSSING FLANGEWAY DEPTH (NOT FOULED)						
9500	7GOGAG	GAUGE						
9510	7GOLEV	CROSS LEVEL	B 3					
9520	7GOALG	ALIGNMENT	B 7					
9530	7GOPRF	PROFILE	B 3					
9540	7GOWRP	WARP (CROSS LEVEL DIFFERENCE)	B 3					
9550	7GORDS	RAIL DISPLACEMENT						

USACERL DISTRIBUTION

Chief of Engineers
ATTN: CEHEC-IM-LH (2)
ATTN: CEHEC-IM-LP (2)
ATTN: CECG
ATTN: CERD-M
ATTN: CECC-P
ATTN: CERD-L
ATTN: CECW-P
ATTN: CECW-PR
ATTN: CEMP-E
ATTN: CEMP-C
ATTN: CECW-O
ATTN: CECW
ATTN: CERM
ATTN: CEMP
ATTN: CERD-C
ATTN: CEMP-M
ATTN: CEMP-R
ATTN: CERD-ZA
ATTN: DAEN-ZCM
ATTN: DAEN-ZCE
ATTN: DAEN-ZCI

CECPW
ATTN: CECPW-F 22060
ATTN: CECPW-TT 22[illegible]
ATTN: CECPW-ZC 22060
ATTN: DET III 79906

US Army Engr District
ATTN: Library (40)

US Army Europe
ATTN: AEAEN-EH 09014
ATTN: AEAEN-ODCS 09014
29th Area Support Group
ATTN: AERAS-FA 09054

INSCOM
ATTN: IALOG-I 22060
ATTN: IAV-DEH 22186

USA TACOM 48397
ATTN: AMSTA-XE

Defense Distribution Region East
ATTN: DDRE-WI 17070

US Army Materiel Command (AMC)
Alexandria, VA 22333-0001
ATTN: AMCEN-F
Installations:
ATTN: DEH (19)

FORSCOM
Forts Gillem & McPherson 30330
ATTN: FCEN
Installations:
ATTN: DEH (23)

6th Infantry Division (Light)
ATTN: APVR-DE 99505
ATTN: APVR-WF-DE 99703

National Guard Bureau 20310
ATTN: Installations Div

Fort Belvoir 22060
ATTN: CETEC-IM-T
ATTN: CECC-R 22060
ATTN: Engr Strategic Studies Ctr
ATTN: Australian Liaison Office

USA Natick RD&E Center 01760
ATTN: STRNC-DT
ATTN: DRDNA-F

TRADOC
Fort Monroe 23651
ATTN: ATBO-G
Installations:
ATTN: DEH (20)

US Army Materials Tech Lab
ATTN: SLCMT-DEH 02172

USARPAC 96858
ATTN: DEH
ATTN: APEN-A

SHAPE 09705
ATTN: Infrastructure Branch LANDA

Area Engineer, AEDC-Area Office
Arnold Air Force Station, TN 37389

HQ USEUCOM 09128
ATTN: ECJ4-LIE

AMMRC 02172
ATTN: DRXMR-AF
ATTN: DRXMR-WE

CEWES 39180
ATTN: Library

CECRL 03755
ATTN: Library

USA AMCOM
ATTN: Facilities Engr 21719
ATTN: AMSMC-IR 61299
ATTN: Facilities Engr (3) 85613

USAARMC 40121
ATTN: ATZIC-EHA

Military Traffic Mgmt Command
ATTN: MTEA-GB-EHP 07002
ATTN: MT-LOF 20315
ATTN: MTE-SU-FE 28461
ATTN: MTW-IE 94626

Fort Leonard Wood 65473
ATTN: ATSE-DAC-LB (3)
ATTN: ATZA-TE-SW
ATTN: ATSE-CFLO
ATTN: ATSE-DAC-FL

Military Dist of WASH
Fort McNair
ATTN: ANEN 20319

USA Engr Activity, Capital Area
ATTN: Library 22211

Norton AFB 92409
ATTN: Library

US Army ARDEC 07806
ATTN: SMCAR-ISE

Engr Societies Library
ATTN: Acquisitions 10017

Defense Nuclear Agency
ATTN: NADS 20305

Defense Logistics Agency
ATTN: DLA-WI 22304

US Military Academy 10996
ATTN: MAEN-A
ATTN: Facilities Engineer
ATTN: Geography & Envr Engrg

416th Engineer Command 60623
ATTN: Gibson USAR Ctr

USA Japan (USARJ)
ATTN: APAJ-EN-ES 96343
ATTN: HONSHU 96343
ATTN: DEH-Okinawa 96376

Naval Facilities Engr Command
ATTN: Facilities Engr Command (8)
ATTN: Division Offices (11)
ATTN: Public Works Center (8)
ATTN: Naval Constr Battalion Ctr 93043
ATTN: Naval Civil Engr Service Center (3) 93043

8th US Army Korea
ATTN: DEH (12)

US Army HSC
Fort Sam Houston 78234
ATTN: HSLO-F
Fitzsimons Army Medical Ctr
ATTN: HSHG-DEH 80045
Walter Reed Army Medical Ctr 20307

Tyndall AFB 32403
ATTN: HQAFCESA Program Ofc
ATTN: Engrg & Srvc Lab

USA TSARCOM 63120
ATTN: STSAS-F

American Public Works Assoc. 60637

US Army Envr Hygiene Agency
ATTN: HSHB-ME 21010

US Gov't Printing Office 20401
ATTN: Rec Sec/Deposit Sec (2)

Nat'l Institute of Standards & Tech
ATTN: Library 20899

Defense Tech Info Center 22304
ATTN: DTIC-FAB (2)

244
10/93

This publication was reproduced on recycled paper.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1993—3510-S/80077

END

FILMED

DATE: 1-94

DTIC