ARMY TM 5-627

NAVY NAVFAC MO-103

AIR FORCE AFJMAN 32-1047

TECHNICAL MANUAL

MAINTENANCE OF RAILROAD TRACKS

DEPARTMENTS OF THE ARMY, THE NAVY, AND THE AIR FORCE

30 April 1998

REPRODUCTION AUTHORIZATION/RESTRICTIONS

Conversion Factors for TM 5-627, Maintenance of Railroad Tracks

Multiply	By	To Obtain
degrees Fahrenheit	5/9	degrees Celsius or kelvins[1]
feet	0.3048	meters
inches	25.4	millimeters
pounds (mass)	0.454	kilograms
tons (2,000 pounds, mass)	907.1847	kilograms
yards	0.9144	meters

[1] To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the formula: C = (5/9)(F-32). To obtain kelvin (K) reading, use: K = (5/9)(F-32) + 273.15.

TECHNICAL MANUAL
NO. 5-627
NAVY MANUAL
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NO. 32-1047

HEADQUARTERS
DEPARTMENTS OF THE ARMY,
THE NAVY, AND THE AIR FORCE
Washington, D.C. 20332 *30 April 1998*

MAINTENANCE OF RAILROAD TRACKS

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This manual supersedes TM 5-627/MO-103,AFM 32-1047, dated January 1980.

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CHAPTER 1
INTRODUCTION

1-1. Purpose.

This manual prescribes the policy, criteria, and procedures for maintaining and repairing railroad track at military installations. It provides guidance for the selection, use, and installation of railroad materials and equipment and track components that will perform satisfactorily.

1-2. Scope.

This manual is a guide for maintenance of railroad track at military installations. Repair, modification, and minor construction procedures are presented within the limitation of maintenance personnel responsibilities. The maintenance methods and procedures prescribed herein have been established to protect Government property, with economical and effective expenditure of maintenance funds commensurate with the functional requirements and the planned future use of the facilities. This publication furnishes guidance for the maintenance forces in the field who will do the work and is designed for use in the performance of their work. Many track problems originate with faulty drainage or improper original construction. These problems must be solved prior to or during the repair or rehabilitation. Competent engineering assistance may be required to solve these problems when the determination of the cause of the deficiency is beyond the capability of the maintenance force. Early attention to maintenance problems reduces costly repair and adds to the efficiency of overall operations.

1-3. Related Publications.

The use of the methods and procedures described in this publication by personnel who have the responsibility for specifications, requisitions, procurement, inspection, storage, issue, application, and safety should assure uniform, economical, and satisfactory track maintenance and repair. If the information in this publication varies from that contained in the latest issue of Federal or Military Specifications, these Federal or Military Specifications shall apply. Appendix A lists pertinent regulations, manuals, and other significant publications referenced throughout the text. In case of doubt, advice concerning any procedure may be obtained from the addresses listed below. Also recommendations or suggestions for modification, or additional information and instructions that will improve the publication and motivate its use, are invited and should be submitted on DA Form 2028 (Recommended Changes to Publications and Blank Forms) to HQUSACE (CEMP-ET, Washington, DC 20314-1000.

1-4. Application.

This manual deals with railroad tracks; however, some of the information may apply to crane rail track. Railroad track applies to all track systems used by locomotives, railroad cars, or work equipment.

1-5. Cooperation and Coordination.

a. Intraservice Functions. Cooperation and coordination of track maintenance activities among the installation departments concerned should be continuous. Programs of properly planned and executed maintenance operations prevent undesirable interruptions of rail traffic on military installations. Measures for the protection of supplies in storage must be coordinated with the storage service primarily responsible for the care and preservation of stored items. Supply officers, through normal channels, provide standard items of materials and equipment for track maintenance.

b. Interservice and Interdepartmental Functions. Cooperation and coordination in conducting track maintenance activities are encouraged at all levels of command. Appropriate liaison should be established and maintained between major commands and installations in a geographical area. Cross-service assistance shall be provided as necessary in the interests of economy and maximum utilization of manpower and equipment.

1-6. Army Responsibility.

Staff, command, and technical responsibility for maintenance and repair of utility railroad track at Army installations will conform to assignments set forth in AR 420-10 and 420-72. The American Railway Engineering and Maintenance Association (AREMA) manual will be consulted on methods, tools, and procedures for railroad maintenance involving problems not covered herein and will be followed when not in conflict with current Army, Navy, or Air

Force directives. Inspection of track will conform to the guidelines established in TM 5-628/AFM 91-44.

1-7. Navy Responsibility.

a. Naval Facilities Engineering Command. The Naval Facilities Engineering Command (NAVFAC) provides technical guidelines and advice for inspection and maintenance of track and related accessories. The Commanders and Commanding Officers of NAVFAC's Engineering Field Divisions provide technical assistance in operations and maintenance matters to shore installations.

b. Commanding Officer. The Commanding Officer at each Naval and Marine Corps shore installation is responsible for providing safe track and an adequate maintenance program. Normally, these responsibilities are delegated to the Public Works Centers or Public Works Departments, as appropriate. Design standards shall be in accordance with MIL-HDBK 1005/6. Inspection and certification of track shall be in accordance with NAVFACINST 11230.1 and NAVFAC MO-103.9.

1-8. Air Force Responsibility.

a. Directives. Policy for the maintenance, repair, and minor construction of railroads and appurtenances is set forth in AFM 85-1 and AFM 86-1, Chapter 2.

b. Major Command Level. Each major command will:

(1) Insure that effective, preventive, and corrective track maintenance measures are established and accomplished at all installations under its jurisdiction.

(2) Provide qualified technical supervision for personnel engaged in these operations.

(3) Provide for training of personnel engaged in the maintenance of track and appurtenances.

(4) Make certain that Base Civil Engineer personnel engaged in direct field supervision of maintenance operations, or those who function independently of direct supervision, are technically competent and thoroughly familiar with the performance of all phases of this activity as outlined in this publication.

c. Air Force Installations. The Base Civil Engineer will:

(1) Plan, initiate, and supervise the execution of track maintenance.

(2) Insure that in-house track maintenance personnel are trained.

(3) Investigate the occurrence of and reasons for failures and accidents.

(4) Inspect and determine the effectiveness of safety measures.

1-9. Standards.

The standards or criteria contained in this manual have been developed by the Army, Navy, and Air Force with the concurrence and approval of the Under Secretary of Defense for Acquisition and Technology. Compliance with these standards is mandatory in order that the maintenance of track at military installations will be uniform, will adequately support the operational missions of the installations, and will permit interservice assistance and support, where possible, in the interest of efficiency and economy. The use of AREMA standards or standards of the railroad(s) serving an installation in lieu of Military Standards may be given consideration when such use would be to the advantage of the Government. Otherwise, the applicable Military Standards shall take precedence.

1-10. Policies and Criteria.

The extent of repair and maintenance of railroad track will be governed by the permanency of the installation, operational requirements, track classification, and category as described in TM 5-628/AFR 91-44, and MO-103.9. These Track Standards will normally satisfy operational needs of military installations. However, safety, efficiency, and economy will be the controlling factors. The Track Standards provide descriptions of tolerances and defects for guidance in overall track maintenance. Deviation from the standards may require immediate corrective action to provide for safe operations over the track involved. In general, on heavily used sections of tracks, work planning should start when a deficiency on a section of track exceeds one-half the allowable deficiency. Selection, installation, inspection, and maintenance of track shall be in accordance with referenced documents. In determining the extent and nature of Government maintenance, repairs, and rehabilitation of railroads on land that is held under lease, permit, or easement, the terms of such documents will be taken into account.

1-11. Engineering.

The need and accomplishment of major repairs and rehabilitation of existing railroads will be based on the determination of qualified engineers. The services of such technical personnel will be used to assist in the establishment of railroad maintenance programs.

1-12. Terms and Engineering Data.

A glossary of railroad terms is provided in Appendix B of this manual.

1-13. Active Track.

Active track is track used on a routine basis and during mobilization and emergencies. The principal tasks to be considered in maintaining active track are: renewing ties, ballast, rails, and accessories; raising, realigning, and regrading tracks; maintaining, oiling, and adjusting switches and tightening track bolts; controlling vegetation and cleaning ditches; and repairing bridges, trestles, and culverts. Overall maintenance policies and detailed guidance for maintaining these areas are covered in Chapters 2 through 6. A well-maintained track is shown in Figure 1-1.

1-14. Inactive Track.

Inactive track is track not routinely used but needed for mobilization and emergencies. When track is in an inactive status, the maintenance policies will be consistent with the anticipated future mission of the installation and the particular track involved.

1-15. Surplus Track.

Surplus track is track not routinely used or needed for mobilization and emergencies. This track should receive no maintenance except vegetation control.

Figure 1-1. Well-Maintained Track.

Useful material should be salvaged when such action is in the best interest of the Government.

1-16. Abandoned Track.

Abandoned Track is track not in service, disconnected from the operating tracks, and scheduled for removal.

1-17. Categories.

The term “track” includes rails, ties, rail accessories, switches, crossovers, ballast, roadbeds, and support structures. Also included for complete coverage of the track are criteria for the maintenance of slopes, ditches, road crossings, culverts, bridges, trestles, overpasses and underpasses, grade separations, tunnels, signals, snow protection, signs, and markings. Maintenance of track is based on condition standards by category of track established by paragraph 1-4 of TM 5-628/AFR 91-44 for Army and Air Force track, and paragraph 1-5 of MO-103.9 for Navy track.

1-18. Safety.

The Occupational Safety and Health Act (OSHA) guidelines and regulations make certain safety equipment and procedures mandatory. Safety precautions and safe maintenance practices are covered in the following publications:

a. Army EM 385-1-1.
b. Air Force AFM 127-101.
c. Navy EM 385-1-1.

CHAPTER 2

MATERIALS, TOOLS, AND EQUIPMENT

2-1. General.

Maintenance and repair of railroad track requires the use of special materials, tools, and equipment. It is important that personnel responsible for this maintenance be completely familiar with identification and nomenclature for purposes of use and requisitioning.

2-2. Material Nomenclature and Specifications.

In requisitioning track materials, it is important that proper details be given to obtain the exact material required. Figures 2-1 through 2-15 illustrate the most common track materials and present specification details required for drawing clear requisitions.

2-3. Stocks of Material.

Where deemed appropriate, it is recommended that the following quantities of material be stocked at a convenient location.

a. Ten full lengths of each weight and section of rail in use.

b. Ten pairs of joint bars of each weight and section of rail with the same punch as the rail in use.

c. Four compromise joints of the weight and section of rail in use.

d. One frog for each different size turnout and for each weight of rail in use.

e. One complete switch (including switch stand) and one pair of extra switch points for each weight of rail in use.

f. One set of guard rails and plates for each weight of rail in use.

g. One set of switch ties for the largest numbered turnout (usually No. 10) in use.

h. Twenty-five tons of size No. 4 ballast.

i. One hundred tie plates sized to fit each section of rail in use.

j. One keg of track bolts (1 by 5 1/2 inches).

k. One hundred crossties (7 inches by 9 inches by 8 feet-6 inches).

l. Five hundred tie plugs to fit 5/8- by 6-inch spike holes.

m. Two kegs of track spikes (5/8 by 6 inches).

n. Fifty gauge rods.

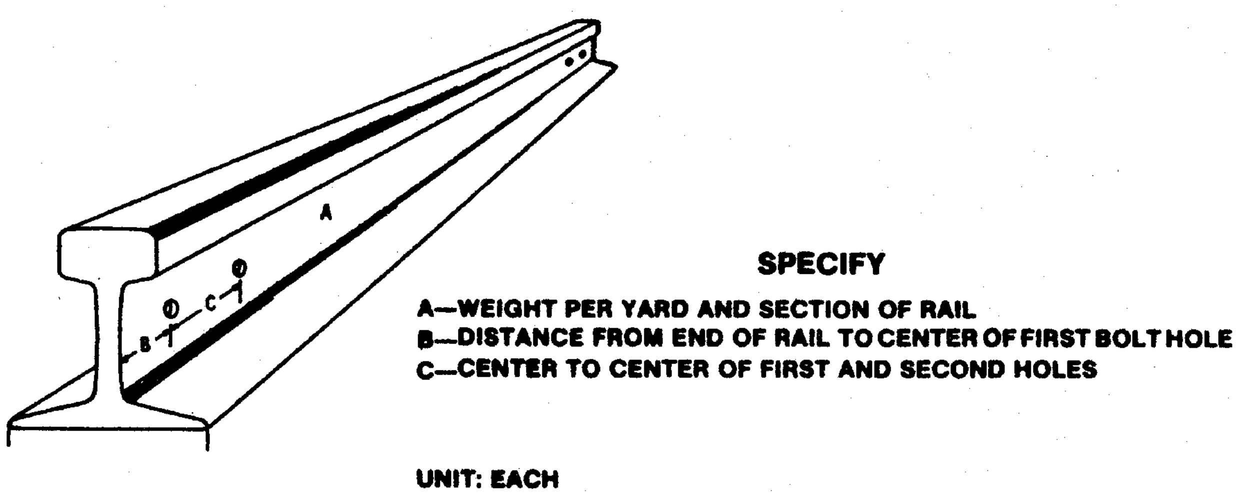


Figure 2-1. Rail Details.

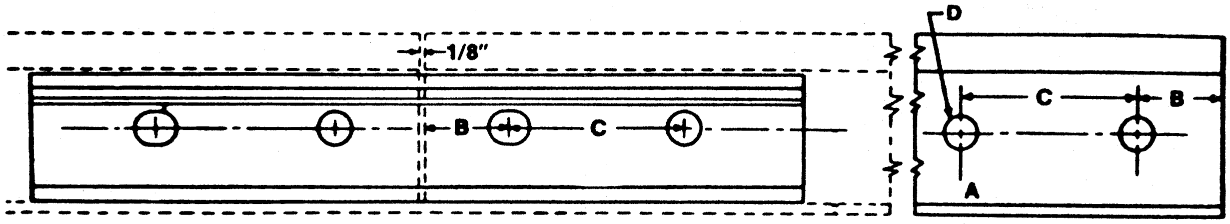


Figure 2-2. Joint Bar Details.

2-4. Storage of Material.

Stocks of material will be properly stored.

a. Rails and Track Accessories. Materials stored for future use should be segregated by weight, section, and size. Stored materials should be properly stored or stacked at least 10 feet from centerline of the nearest track. Store materials so that they will not interfere with movement of trains or personnel working in the area.

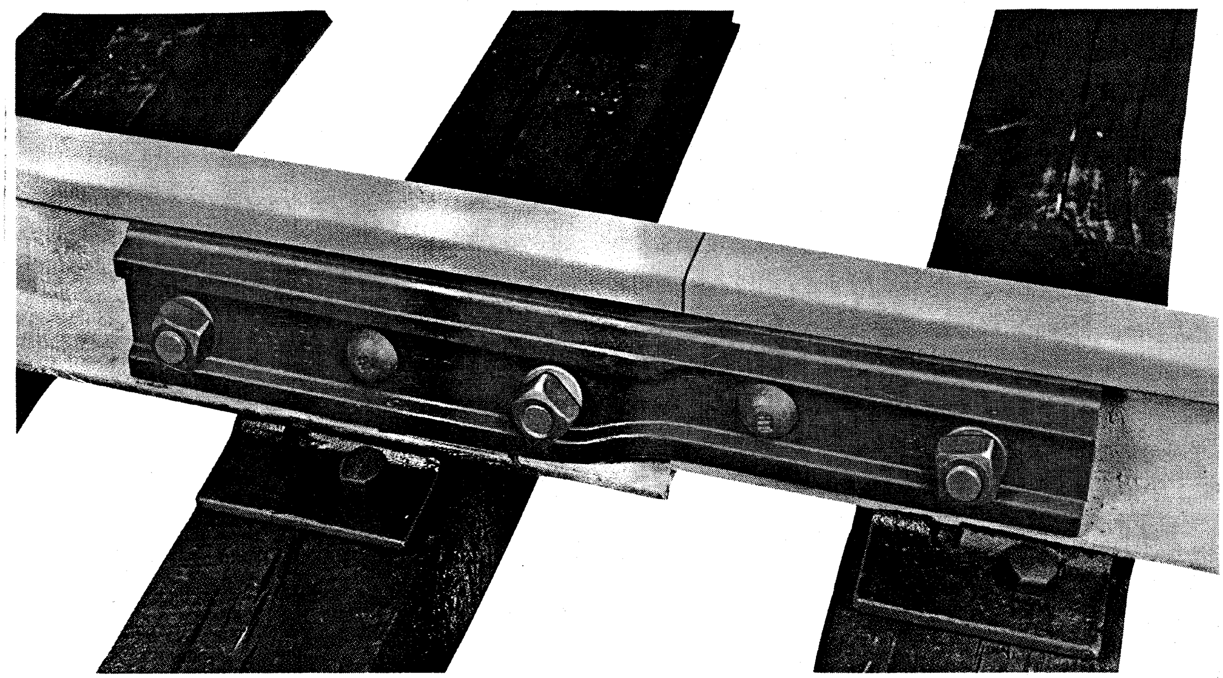
b. Wood and Concrete Ties. Segregate timber crossties according to size and type, and store by stacking on high, dry ground. Treated timber ties should be stacked edge to edge (Figure 2-16). Avoid handling ties with sharp instruments other than tie tongs. Keep ground in the storage area free of debris or vegetation for at least 2 feet around every stack of ties and clear of vegetation over 6 inches high within 10 feet of any stack; slope the ground so that water will not remain under the stacks or in their immediate vicinity. It is especially important that all decaying wood debris be removed and that fire prevention measures be observed around the storage area. Concrete ties should be stacked so they can be handled with a forklift or slings.

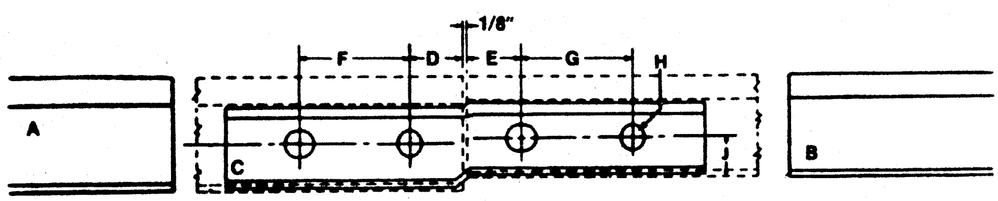
2-5. Requirements.

Proper tools and equipment should be provided in quantities consistent with the maintenance to be performed. In specific instances where additional or special tools and equipment are required, they should be procured through normal supply channels. Tools usually employed in track work are shown in Figure 2-17. A suggested list of tools for a four man maintenance track gang is shown below:

Spike Maul	4
Track Wrenches for 1-inch bolts	2
Track Wrenches for 3/4-inch bolts	2
Lining Bars	4
Claw Bars	2
Spike puller	1
Track Jacks (7-ton)	4
Clay Picks	4
Tamping Picks	2
Track chisel	1
Tie Tongs (2-man)	2
Tie Tongs (1-man)	4
Track Adz	1
Rail turner (fork)	3
Power Track Drill	1
Power Rail Saw	1
Rail Tongs (2-man)	4
Track Shovel	4
No. 2 Scoops	4
Ballast fork	2
Track Gage	1
Track Level	1
Claw Bar Extension (Roadmaster)	1
Rail Tongs (Crane type)	1
Tamper (Mechanical)	1
Sledge hammer	1
Rail bender	1

COMPROMISE JOINTS





C = LEFT HAND (LH) OR RIGHT HAND (RH) DEPENDING ON LOCATION OF LARGER RAIL VIEWED FROM CENTER OF TRACK (THIS IS A LEFT-HAND BAR)

SPECIFY

A—WEIGHT AND SECTION OF LARGER RAIL
B—WEIGHT AND SECTION OF SMALLER RAIL
C—LH OR RH
D—DISTANCE FROM END OF LARGER RAIL TO CENTER OF FIRST HOLE
E—DISTANCE FROM END OF SMALLER RAIL TO CENTER OF FIRST HOLE
F—DISTANCE CENTER TO CENTER OF FIRST AND SECOND HOLE, LARGER RAIL
G—DISTANCE CENTER TO CENTER OF FIRST AND SECOND HOLE, SMALLER RAIL
H—DIAMETER OF BOLT HOLES IN RAIL. IF DIFFERENT, SPECIFY SIZES

UNIT: EACH; INCLUDES INSIDE AND OUTSIDE BARS

Figure 2-3. Compromise Joint Details.

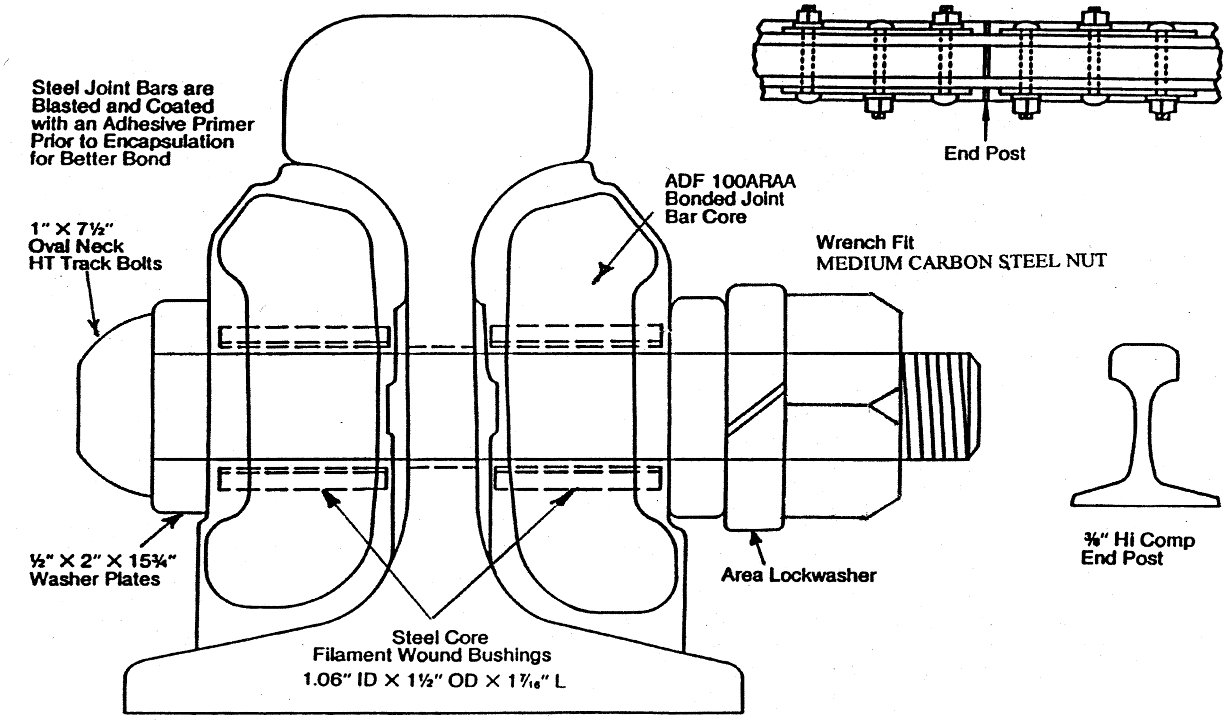


Figure 2-4. Insulated Joint Details.

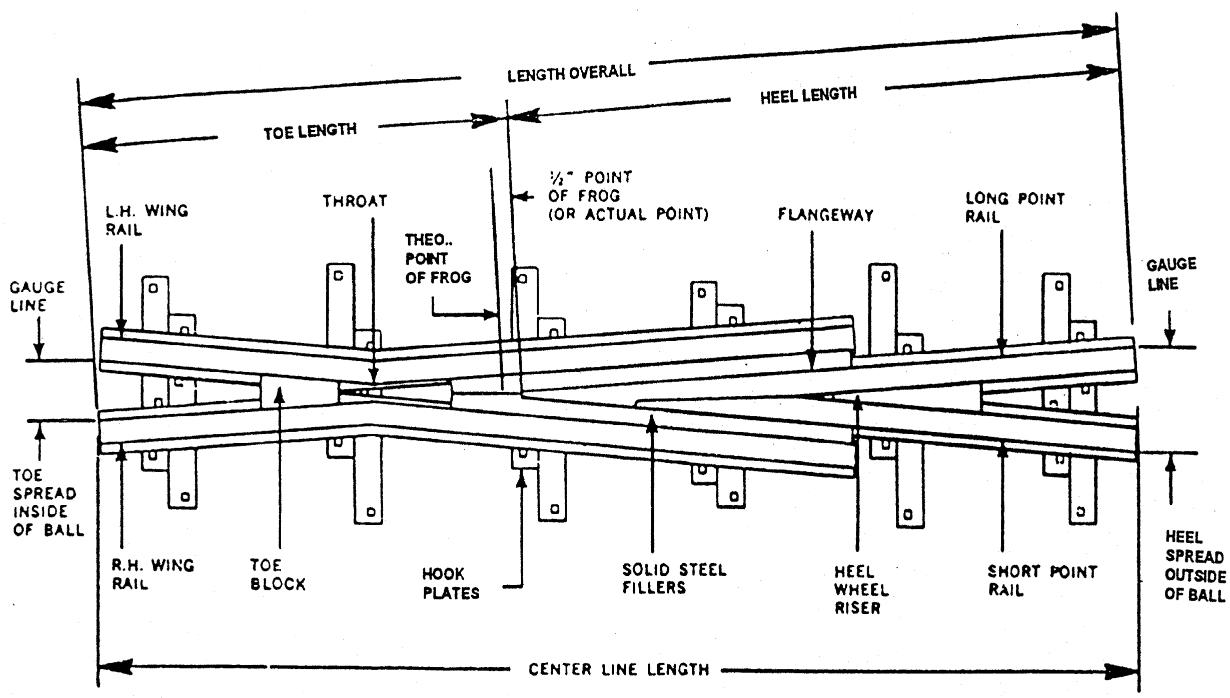
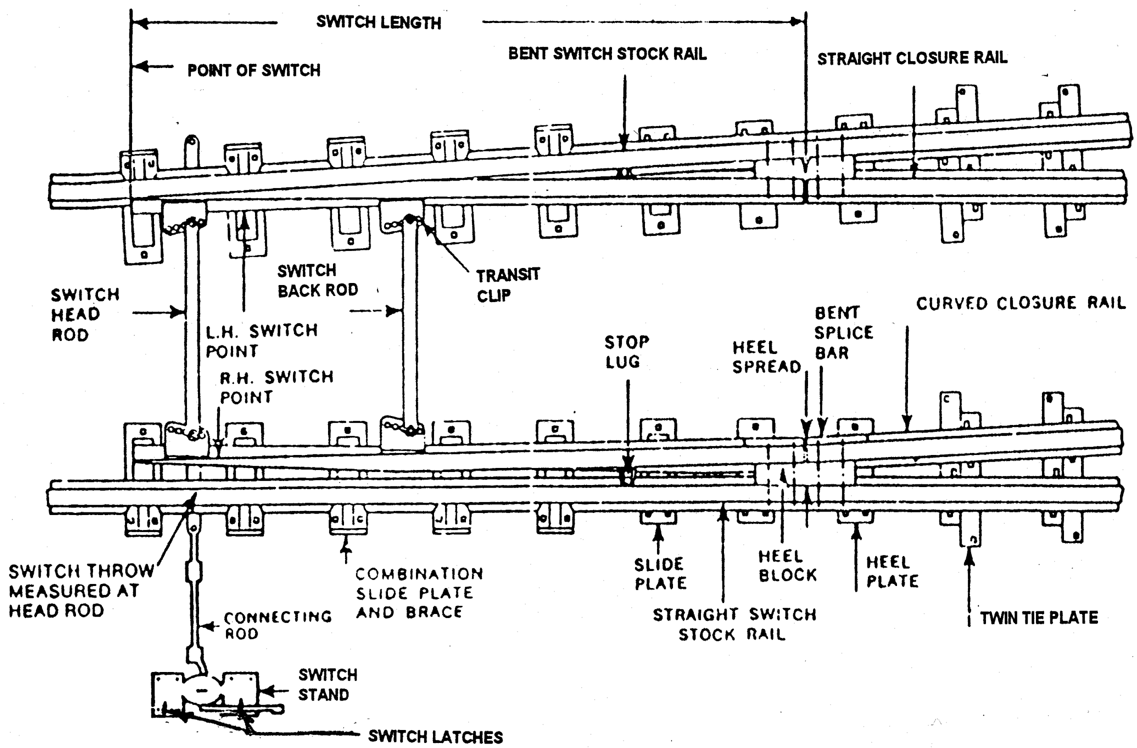
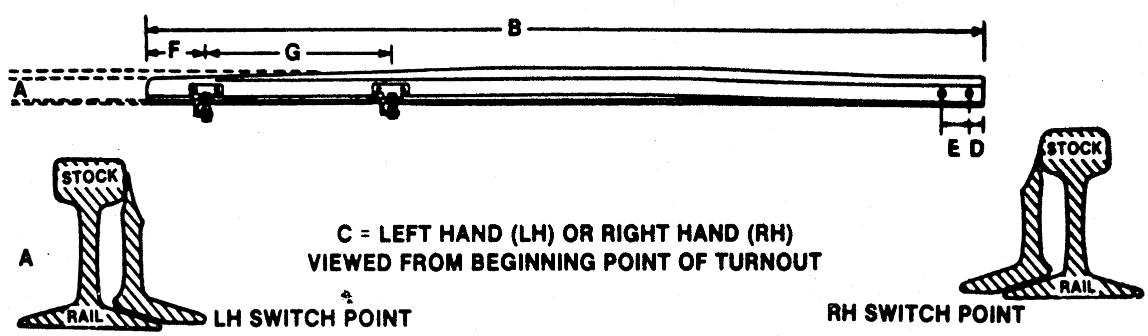


Figure 2-5. Frog Details.



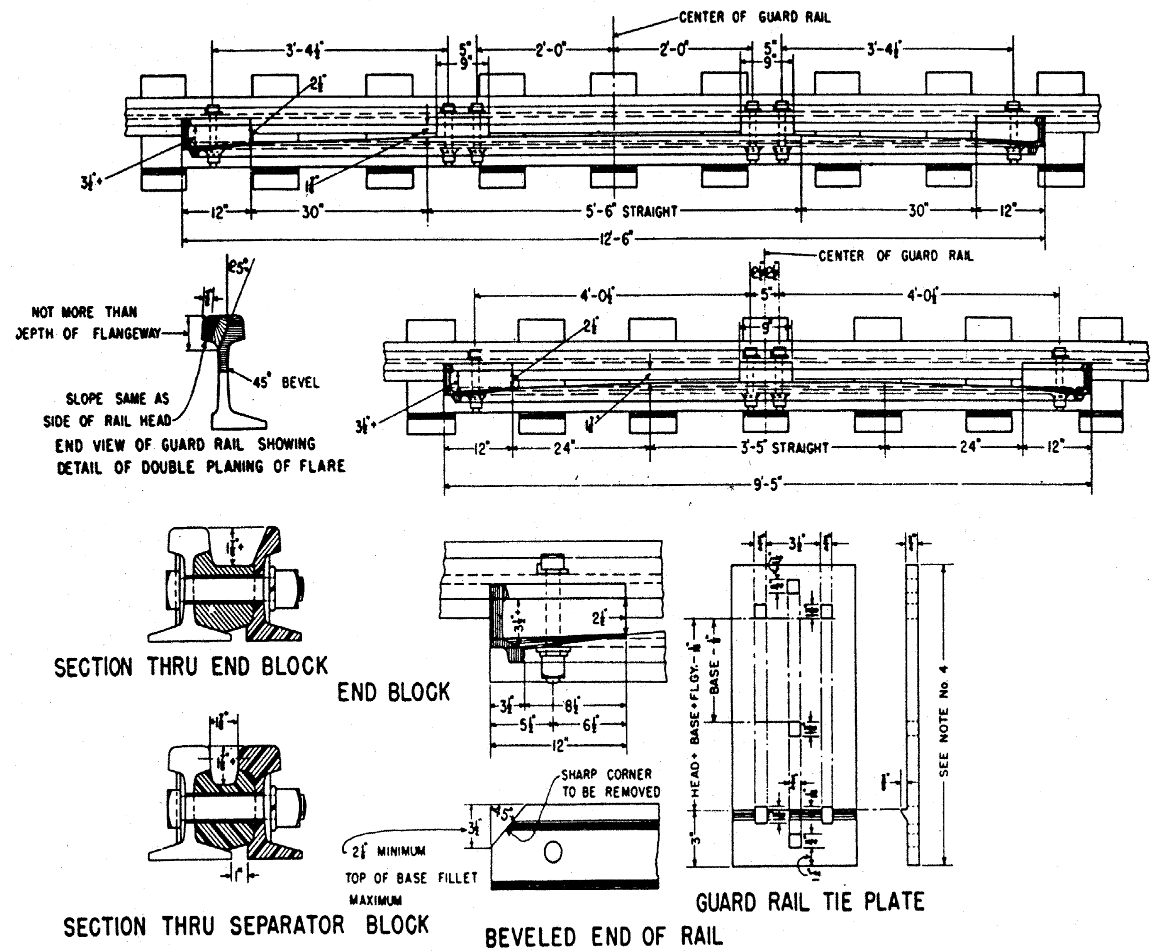


SPECIFY

A—WEIGHT AND SECTION OF STOCK RAIL
B—LENGTH OF POINT
C—LH OR RH
D AND E—DRILLING (OPTIONAL)
F—DISTANCE OF SWITCH ROD CLIP FROM TIP OF POINT
G—CENTER-TO-CENTER DISTANCE OF FIRST AND SECOND SWITCH ROD CLIPS

UNIT: EACH OR SET INCLUDING RH AND LH POINTS

Figure 2-6. Switch and Switch Point Details.



NOTES

1—GUARD RAILS shall be furnished to length called for and, unless otherwise specified, with accessories as illustrated in plan views and per notes below as follows:
Separator blocks and bolts per Note No. 2
End blocks and bolts per Note No. 3
Tie plates per Note No. 4

2—SEPARATOR BLOCKS may be of steel, cast iron or malleable iron, of suitable design.

3—END BLOCKS may be of cast iron as shown, steel or malleable iron, of suitable design.

4—PLATES—Shall be 7" x ¾" x 16" for rails less than 100 lb. per yd., and 8" x ¾" x 17" for rails 100 lb. per yd. and heavier, except when combined width of head and base exceeds 8⅝", plates shall be 18" long.

5—ALTERNATES.
(a) CLAMP GUARD RAILS — Clamps per Plan Basic No. 505 may be used instead of separator blocks and bolts in approximately the same locations, and shall be furnished when specified.
(b) RAIL BRACES—Approved type of guard rail braces to be furnished when required; purchaser shall specify details and state on which plates they are to be used.

6—For setting of guard rails, width of flangeway, guard check gage and guard face gage, see Plans Basic No. 502 and 790.

7—SPECIFICATIONS—See Appendix "A".
Bolt sizes and details shall be per Section 1402, Appendix "A".
Spike hole details not otherwise shown to be per Section 40, Appendix "A".

Courtesy of

American Railway Engineering and Maintenance Association

Figure 2-7. Guardrail Details.

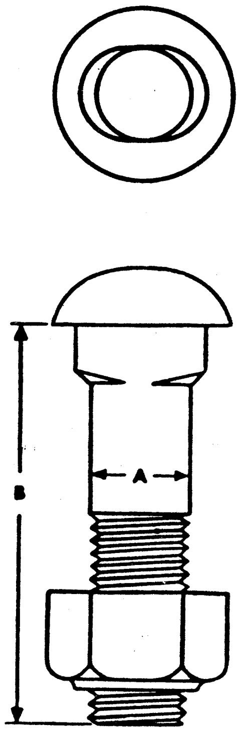


Figure 2-8. Track Bolt Details.

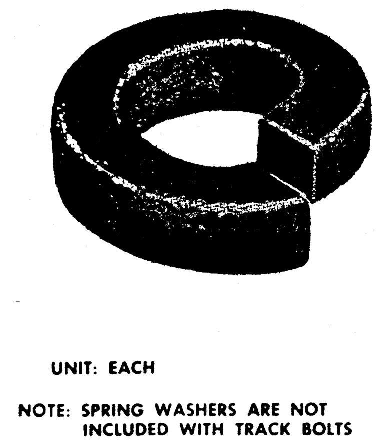
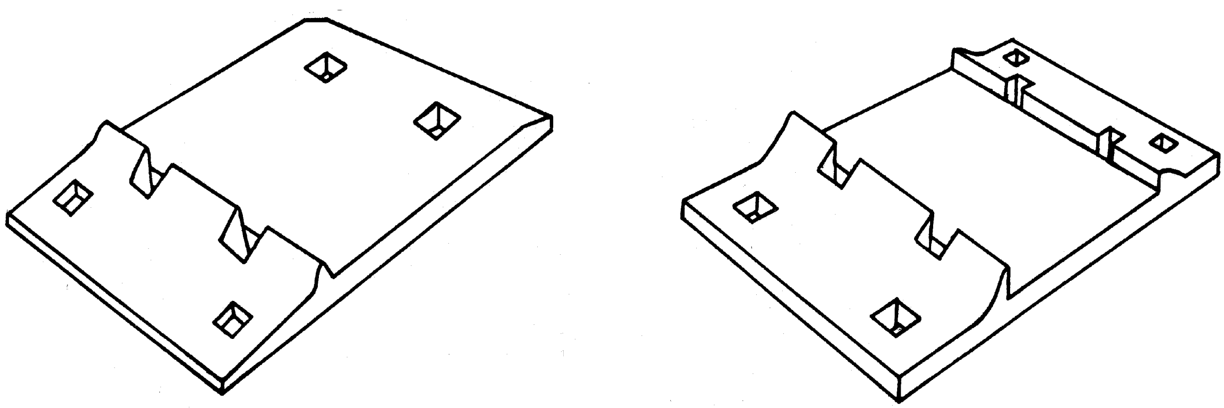


Figure 2-9. Spring Lock Washer Details.



Single shoulder tie plate.   Double shoulder tie plate

Figure 2-10. Tie Plate Details.

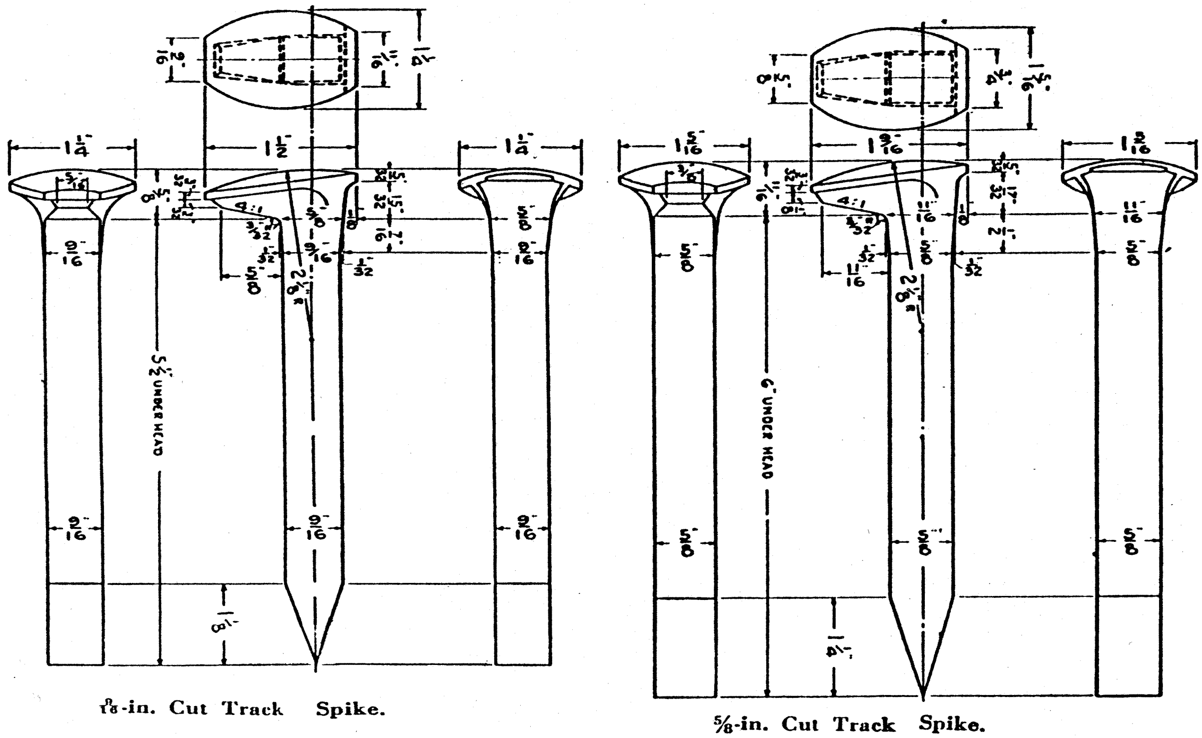


Figure 2-11. Track Spike Details.

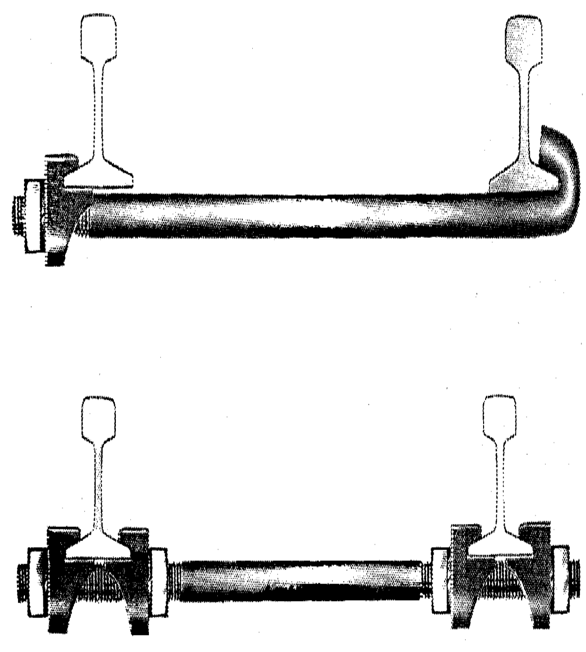


Figure 2-12. Gauge Rods.

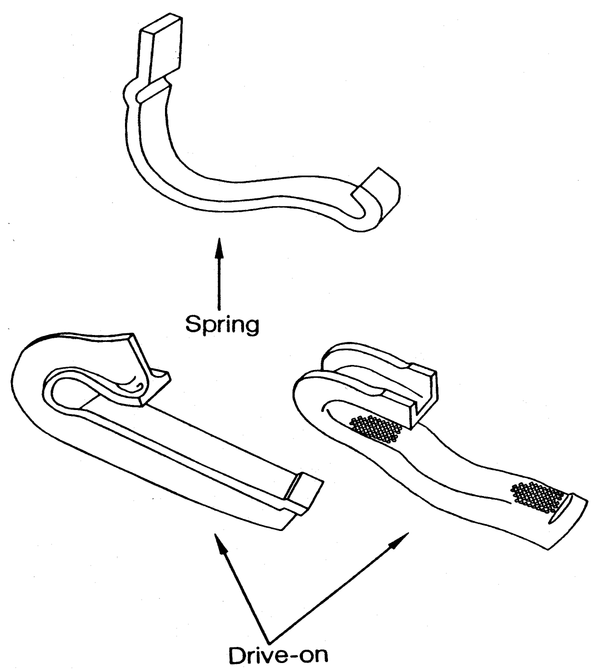


Figure 2-13. Typical Rail Anchor.

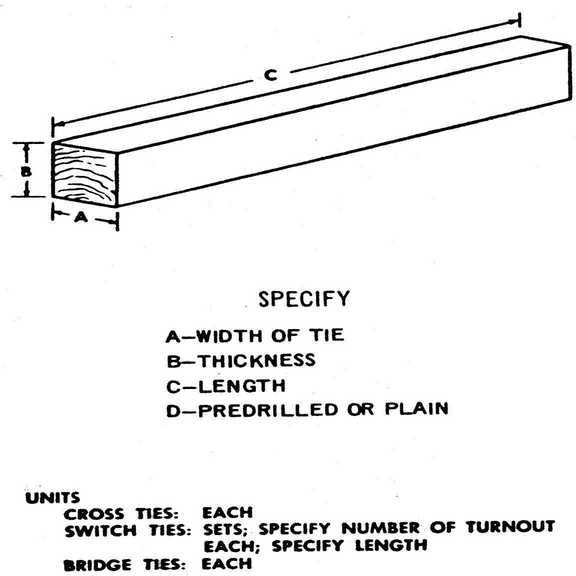


Figure 2-14. Switch, Cross, and Bridge Tie Details.

2-6. Care and Maintenance.

a. General. Tools and equipment shall be maintained in a constant state of good repair. They shall be kept free of rust and serviceable at all times. Cutting tools such as chipping hammers, drills, chisels, and saws must be kept sharpened and ready for use. Defective or worn-out tools and equipment should be repaired or replaced. Personnel handling, using, and storing tools and equipment must do so in an orderly workmanlike manner, adhering to all safety precautions. Railroad maintenance personnel should be constantly aware of rail traffic dangers to life and limb, not only from their own standpoint but from the standpoint of the transportation of personnel and passengers. Tools and equipment must be kept clear of the tracks except during actual in-hand use. When loaded on trucks, track cars, or trailers, tools must be placed so that they will not fall off when bumped or moved.

b. Power-Operated Equipment. Power-operated maintenance equipment and machinery shall be maintained as described in individual equipment manuals or in the manufacturer's instructions.

c. Special Tool and Equipment Maintenance Procedures. In areas where severe climatic conditions exist, special instructions will be given and provisions made for the handling of tools and equipment. This applies to arctic, tropic, and other severe climatic areas where intense cold, heat, or humidity affect the materials from which tools and equipment are made, as well as handling, storage, replacement, and repair. Adjustment shall be made in supplies and stocks to meet the local situation.

d. Storage. Tools shall be stored neatly in designated areas when not in use. Power tools or machinery shall be protected against severe weather and their accessories systematically stored for ready application.

2-7. Track Removal and Preparation of Materials for Storage or Shipment.

a. General. The work will consist of the removal of rail, angle bars, tie plates, spikes, compromise joints, insulated joints, turnouts, and other track materials (OTM). The work will also consist of the preparation of the removed materials for storage or shipment.

b. Inspection and Classification. Inspect track prior to removal and mark with yellow paint all materials that are to be salvaged for reuse in track construction or maintenance. Mark all other materials with red paint and classify as scrap for disposal by the proper authority.

c. Method of Removal. Track shall not be ripped up or shoved with a bulldozer or a forklift, but must be disassembled using spike pullers, bolt machines, bolt wrenches, and machines to lift the rail and turnout materials. Rail shall be handled with a crane with rail tongs or a forklift for loading to or unloading from trucks or rail cars. Never drop rails from cars or trucks. All materials are to be removed without bending, twisting, or damaging the materials. The method of disassembling should be left to the decision of the party doing the removal work. When in doubt, the safe course must be taken.

d. Preparation of Materials.

(1) *Relay Rail*. Relay rail must be removed from the track bed and stacked with the head up using 4- by 4-inch stacking strips between layers, as shown in Figure 2-18.

(2) *Angle Bars (Joint Bars)*. Pick up reusable bars and stack 50 to 80 pair of bars on a pallet and band with steel straps.

(3) *Compromise Joints*. Wire or bolt compromise joints together as they are removed from the rail. Stack the compromise joints on pallets and band with steel straps.

(4) *Insulated Joints*. Wire insulated joints together as they are removed from the track. Stack the insulated joints on pallets and band with steel straps.

(5) *Tie Plates*. Pick up reusable tie plates and stack 200 to 250 plates on a pallet and band with steel straps.

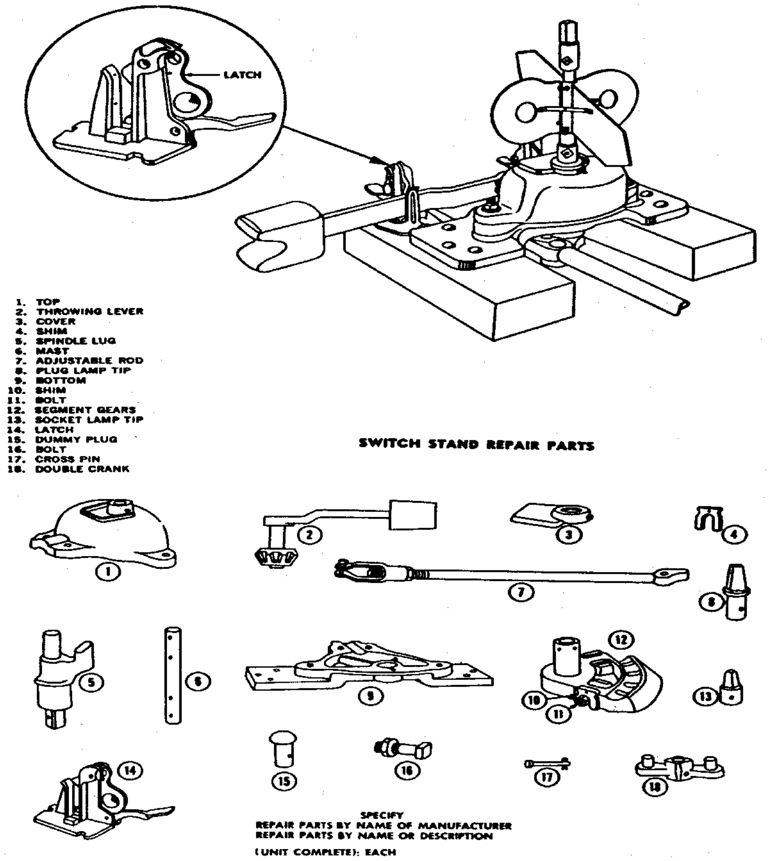


Figure 2-15. Switch Stand Details and Repair Parts.

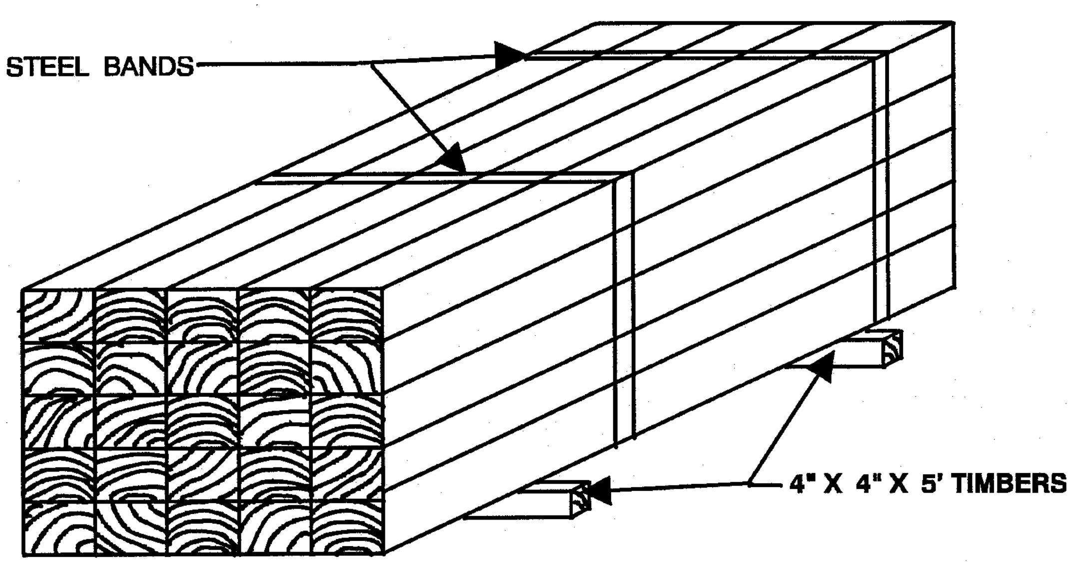


Figure 2-16. Crossties Bundled For Loading or Storage.

(6) *Track bolts, Nuts, and Nutlocks*. Classify as scrap and do not salvage for reuse. Used track bolts are worn and stretched and will not stay tight if reused.

(7) *Turnouts*. Switch points, frogs, and guardrails that are reusable will be marked with paint and identified by size. The switch points will be reversed (that is one point in one direction and the other point in the reverse direction) and then placed on a pallet. The guardrails will be placed between the points and the frog placed on top. The materials will be banded with metal straps to the pallet. All other turnout materials (plates, braces, fillers, switch stands, switch rods, connecting rods, etc.) will be placed in 55-gallon metal drums marked with the turnout identity number. The drums should have small holes near the bottom to let rainwater out.

(8) *Switch Ties*. Switch ties will be inspected and the reusable ties marked with paint. The switch ties will be stacked according to lengths and banded with metal straps. The number in each bundle will be determined by the capacity of the equipment that is available for loading or unloading.

(9) *Crossties*. Crossties will be inspected prior to the track removal. The reusable ties are to be marked with paint. The marked crossties will be stacked (5 wide and 5 high) and banded with steel straps. The bundles will be stacked on strips to allow loading with a forklift. Ties loaded onto trucks are to be loaded by bundles longitudinal with strips between layers of bundles. Ties loaded into gondola rail cars are to be loaded transverse to the car (crossways) so that ties can be unloaded with a car mounted machine, slings and a ground crane, or by hand.

(10) *Scrap Materials*. Scrap materials are to be disposed of by the proper authority. Scrap materials should be segregated at the time of removal and handled for disposal from the roadbed thus reducing handling expense.

e. Remarks. Properly stored and stacked materials are less hazardous to handle, but extra care must be taken when handling heavy materials such as rail, turnouts, and packaged (drums and pallets) track materials.

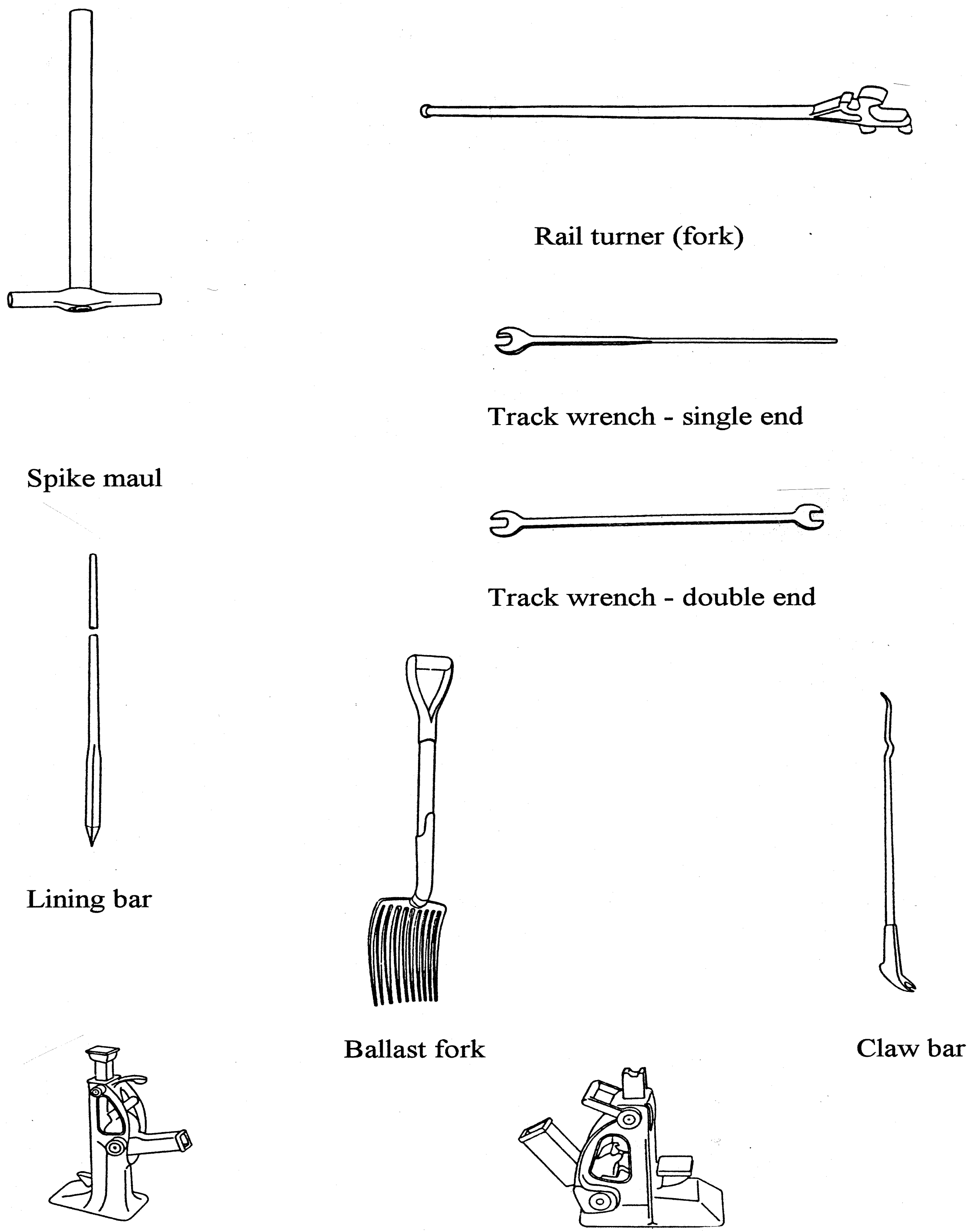
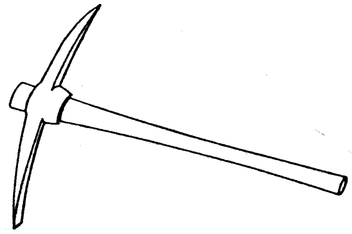
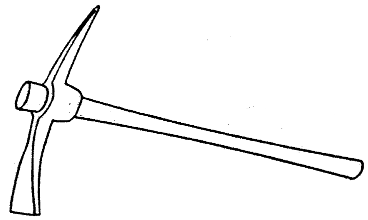


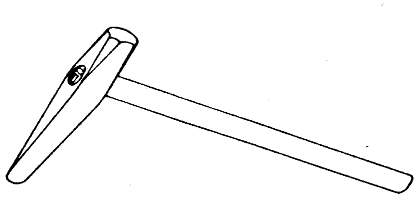
Figure 2-17. Track Tools. (Continued)



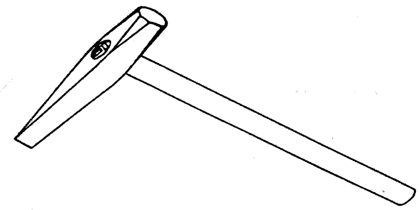
Clay pick



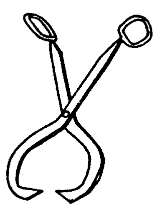
Tamping pick



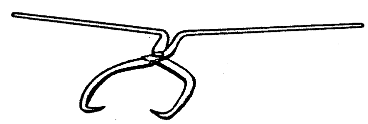
Round bit track chisel



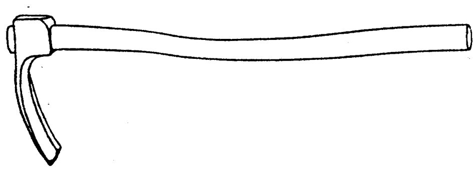
Square bit track chisel



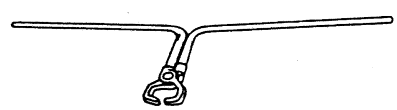
Tie tongs - one man



Tie tongs - two man

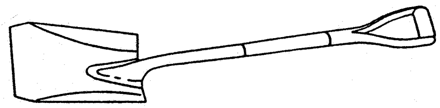


Track adze

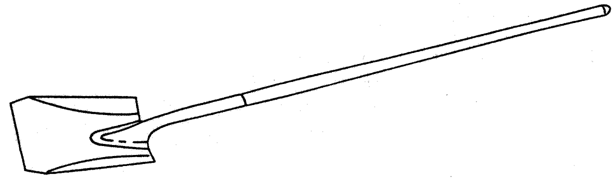


Rail tongs

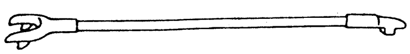
Figure 2-17. (Continued).



D handle track shovel

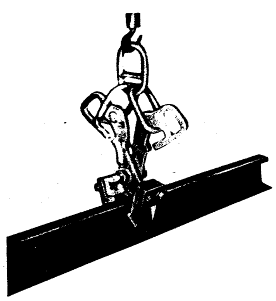


Long handle track shovel

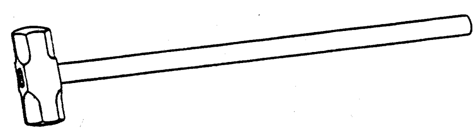


Track gage

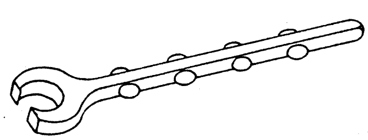
Track level



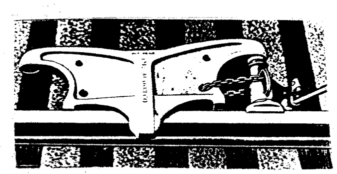
Rail tongs - crane type



Sledge hammer



Spike puller



Rail bender

Figure 2-17. (Concluded).

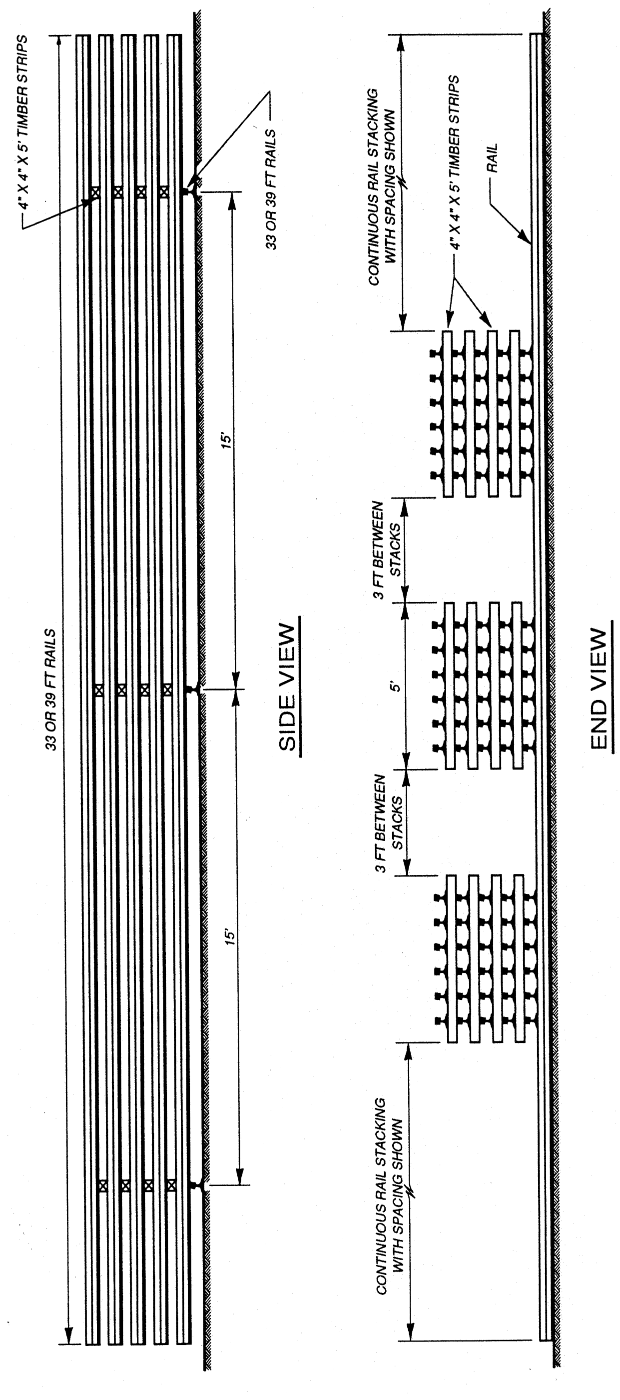


Figure 2-18. Rail Stacked for Loading or Storage.

CHAPTER 3

TRACK STRUCTURE ELEMENTS

3-1. Purpose.

To present methods and procedures for maintenance of track elements in a manner that complies with the policies set forth in Chapter 1.

3-2. Scope.

The criteria for repair, maintenance, and rehabilitation presented in this part of the manual pertain directly to elements making up the track structure.

3-3. Ballast.

a. Purpose of Ballast. Ballast is selected material placed on the roadbed for the purpose of holding the track in line and at the proper elevation. It provides uniform support for the track, anchors the track in place, drains water falling onto the roadbed, reduces heaving from frost, and retards the growth of vegetation. Economic factors as well as matching existing work will be considered in determining the type of ballast material for maintenance use.

b. Types, Sizes, and Application. Crushed stone, slag, or similar materials that have strength, durability, and permeability may be used if they conform to requirements for gradation, wear, chemical composition, and soundness. Coarse graduations, up to 2 1/2-inch maximum size, are to be used as conditions warrant.

c. Distribution of New Ballast. Except where the distribution of new ballast is needed for an intended raise out-of-face, the track is surfaced before distribution of new ballast.

(1) *Unloading Ballast.* Ballast is usually unloaded by dumping from hopper cars (Figure 3-1). A plow tie should be installed ahead of the trailing trucks of the car to be unloaded. It is unloaded by having one or more cars opened at a time, allowing the required amount of ballast material to flow out as the train is moved along slowly. Always unload the hopper doors away from the plow tie first. This allows the weight of the ballast over the plow tie to hold the plow tie and car on the rail. The hopper doors must be closed before the empty cars are released.

(2) *Spreading.* The unloaded material should be leveled by means of a ballast plow or spreader. Care must be taken to hold the established grade set for the new material. Hand methods require special attention to placement of ballast under the full tie length.

(3) *Tamping.* Ballast must be well packed with hand tools or machines.

(4) *Frogs, Guardrails, and Switches.* At turnouts, remove all excess ballast from frogs, guardrails, and the movable parts of switches.

(5) *Dressing the Ballast.* Ballast should be dressed to conform to the standard ballast section (Figure 3-2). Slopes shown are preferred; however, conditions may require different slopes. The portion of the subgrade outside the ballast line should be left with a full, even surface and the shoulder of an embankment clearly defined and properly dressed to the standard roadway section. Clean or rake the berm. Surplus ballast left over from trimming should be disposed of in an appropriate area.

(6) *Cleanup.* After the ballast is placed, track surfaced, and dressed, remove all materials, tools, and equipment used to perform the work. Install and secure promptly all stock guards, crossing planks, and similar facilities adjacent to or forming part of the track. Dispose of all rubbish and waste remaining from the operation. Do not litter the right-of-way.

3-4. Tie.

a. Purpose of Tie. The purpose of a tie is to:

(1) *Maintain Gage*.

(2) *Maintain Surface*.

(3) *Maintain Alignment*.

(4) *Distribute Load.* Distribute the load from the rail to the ballast and subgrade or a bridge substructure.

The inability of a tie to adequately perform any of the above functions constitutes a defective tie.

b. Types, Sizes, and Application.

(1) *Types.* The types of railroad ties are crossties, switch ties, rail crossing ties, and bridge ties.

(2) *Sizes.* Crossties sizes are 7 inches by 9 inches by 8 feet-6 inches, 7 inches by 8 inches, by

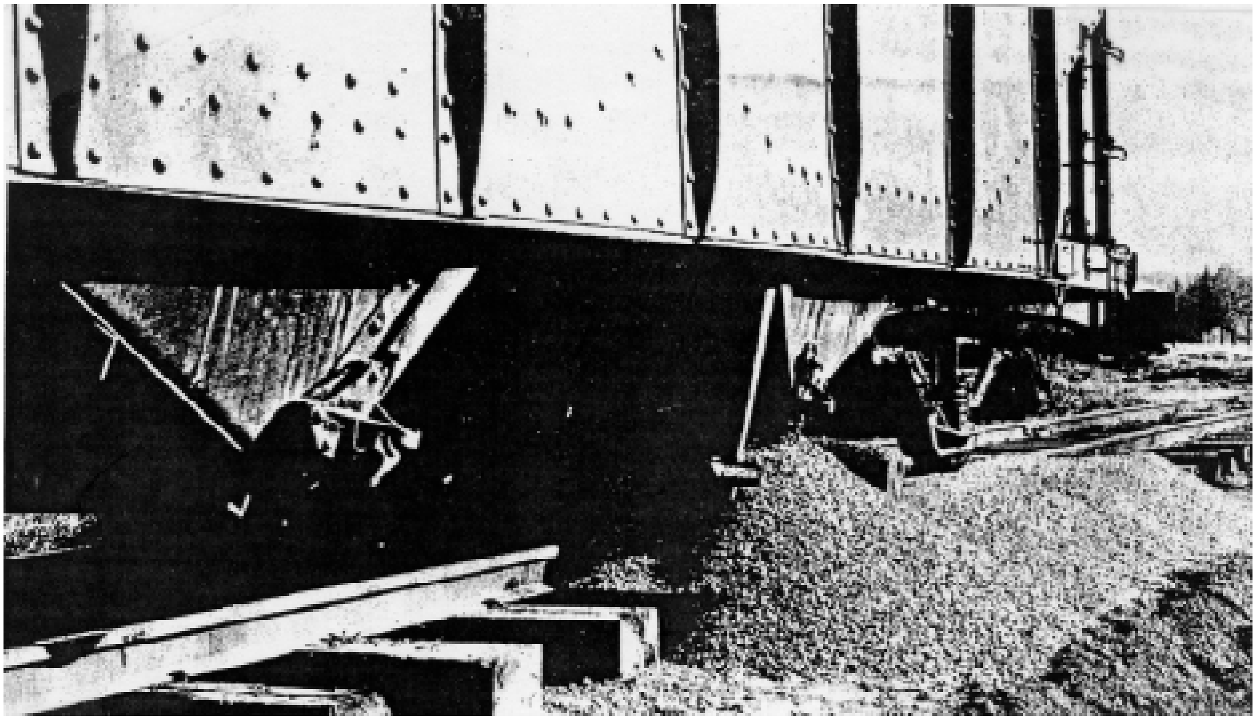


Figure 3-1. Distributing Ballast from Hopper Car.

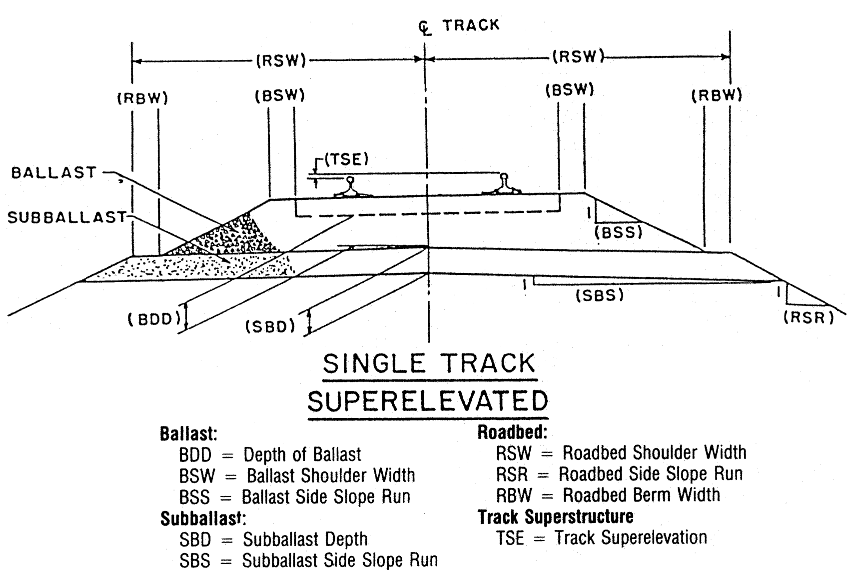


Figure 3-2. Standard Ballast Section.

8 feet-6 inches and 6 inches by 8 inches by 8 feet-6 inches. Special crossties are specified for special projects. Switch ties are 7 inches by 9 inches by various specified lengths. Rail crossing ties are 7 inches by 9 inches by various specified lengths. The size may be specified to comply with a particular kind of crossing. Bridge ties are of various sizes and lengths to provide structural components of open deck bridges.

(3) *Application.* Ties are to be installed to comply with the specified need. Ties should be replaced in kind and size unless otherwise specified.

3-5. Wood Ties.

Nearly all railroad track on military installations has been constructed using wood ties. The use of wood ties for most such track will be continued, but there are circumstances where the use of concrete ties may be warranted. The service life of wood ties depends on the kind of wood, the method of treatment, the mechanical protection afforded, the severity of use, and climatic conditions. Only treated wood ties are to be purchased or used. Ties used in maintenance and repairs must conform to specifications and should match the ties in existing adjoining work unless otherwise specified.

a. Handling Wood Ties. Broken, bruised, gouged, and otherwise damaged ties are the result of careless handling. Ties are not to be unloaded by dropping or throwing them onto rails, rocks, or hard or paved surfaces. Ties handled with tongs suffer less damage than ties handled with bars or sharp tools. The proper manner in which wood ties are to be stacked when they are not to be used immediately is shown in Figure 2-14.

b. Safety. Creosote is a skin irritant, and splinters are a constant hazard in the handling of ties. All personnel who handle ties must wear appropriate gloves, safety shoes, hard hat, long sleeve shirt, and eye protection. Other common hazards are the dropping of ties and other heavy objects and tripping over tools and supplies.

3-6. Ties Other than Wood.

Decisions on the use of ties other than wood are to be made by a qualified authority and shall be based on comparative cost estimates reflecting all factors. The longer in-use life of concrete ties may justify their use in areas where tie inspection and maintenance work entail pavement removal, or at critical locations where track maintenance work results in serious operational problems (i.e., crossings, paved streets, paved industrial areas).

a. Concrete. Specifications for concrete ties will be developed for individual installations by those responsible for engineering at the military installations or at the offices of higher echelons of the engineering elements of the Departments of the Army, the Navy, and the Air Force.

b. Other Material. Ties made of composite materials and other state-of-the-art materials leading to tie substitutes may be used as available and proven in service.

c. Handling Concrete Ties. Workmen must wear appropriate safety shoes and hard hats when handling ties. All ties shall be unloaded and loaded mechanically. Where ties must be stacked, they shall be stacked mechanically. No ties shall be loaded, unloaded, or stacked by hand. Because each concrete tie weighs between 500 and 750 pounds, all ties are to be moved from the unloading area or from stacks to the work sites by rail or truck. After the ties have been distributed, they are to be placed in their final position.

3-7. Tie Replacement and Reuse.

In general, ties should not be replaced until decayed or mechanically worn beyond serviceability for the purpose intended. However, where general track rehabilitation (ballast and rail removal) is under way, consideration should be given to replacing ties that are near the end of their serviceability so that the track need not be disturbed again in the near future. Installation of used ties is not recommended. Replacement usually is considered in the following order of priority: (1) running or access tracks, (2) classification yard, and (3) siding and storage tracks.

a. Spot Replacement. Spot replacement is the replacement of an occasional defective tie or a small group of ties from a length of track in which all the other ties are in satisfactory condition.

b. General Replacement. General replacement involves a larger number of ties (over 10 percent) from a length of track in which only occasional ties or small groups of ties are in satisfactory condition.

c. Identifying Defective Ties. Tie replacement will be made only after tie inspections have been completed and defective ties marked for removal. TM 5-628/AFR 91-44 and MO-103.9 describe defective ties. Due to the movable parts at switches, the switch ties must be maintained in better condition than the crossties. Only ties marked for removal will be replaced. Replacement ties shall be inspected prior to installation for compliance with applicable specifications and for damage or deterioration while in storage or while being handled.

d. Tie Spacing. Tie quantity and spacing is based on roadbed conditions, track category, rail size, anticipated load, and experience or engineering judgement. Installation criteria for new construction and reworking track should be specified for each section of track based on current design standards, need, and economics.

e. Spacing for Spot Replacement. For spot replacement of wood ties, spacings will not be changed. However, the face-to-face separation between ties shall be at least 10 inches, but less than 16 inches. Skewed ties shall be straightened.

f. Spacings for General Replacement. When replacing wood with wood ties, standard spacings should be as designed: 22 to 24 ties per 39 feet of running track, and 20 to 22 ties per 39 feet of low-use track. Tie-spacing gages will be used except where variations in wood tie cross sections and placement make its use impractical. Proper spacings for concrete ties are to be determined by a qualified engineer.

g. Skewed Ties. A skewed tie is one having an axis other than perpendicular to the rails (except turnout rails). Skew distance, as shown in Figure 3-3, is measured along the base of a rail on the gage side. Measurements of skew distance may be made while checking gage; however, a visual check at any track is adequate. Spotting ties that are over half the width of a tie out-of-line can be easily done while walking or riding over the track. Single skewed ties are not serious. Sections of track with skewed ties indicate a problem area that should be investigated.

h. Alignment of Ties. When placing standard length wood ties in double tracks, align the outside ends of ties. For three or more tracks, align the outside ends of ties with the outer tracks; align the ties of inner tracks the same as for single track. For single track, align the east ends of ties of north-south tracks, and the north ends of east-west tracks. Under-length wood ties shall be centered under the track.

i. Procedures for General Tie Replacement. Replacing ties out-of-face is accomplished by removing the rails, fittings, and ties. Grade ballast wind-rowing excess ballast for reuse. Reconstruct the track using new crossties. To replace ties that are marked for renewal involving a larger number (over 10 percent) use mechanical equipment (Tie Remover, Scarifier, Tie Handler, Tie Inserter, Spiker, and Ballast Regulator). An extra Tie Handler is needed to load and clean up old ties.

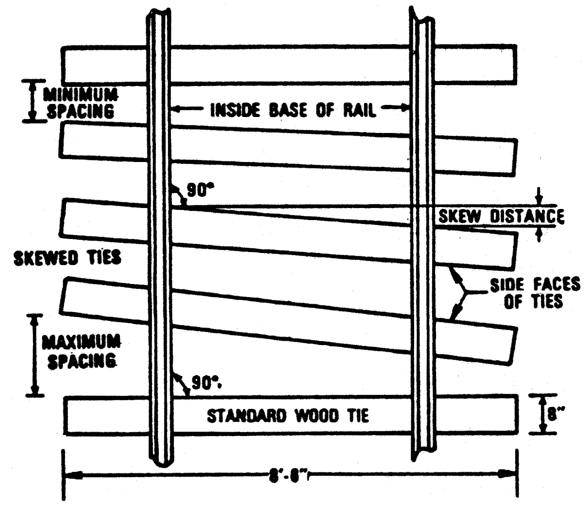


Figure 3-3. Railroad Tie Terminology and Identification.

j. Procedures for Spot Replacement. The following guidelines are applicable to the usual spot replacement programs:

(1) After removing spikes, remove sufficient ballast from the crib to permit easy removal of the tie. Pull the tie, and dress the roadbed.

(2) Insert the replacement ties, accurately spaced and at right angles to the rail.

(3) When replacement ties are wood, use the largest and best ties at rail joints. The distance from rail joint to the face of either adjacent wood tie shall not be more than 12 inches. Intermediate ties shall be evenly spaced.

(4) Wood ties shall be laid heart-side down.

(5) Spike wood ties to the rails at the proper gage. Fasten concrete ties to the rails after placing the bearing pads.

(6) Tamp ballast under the ties.

(7) Avoid raising the track because ballast may run under adjacent ties. Instead of raising track, remove a little more ballast from under the tie being removed to facilitate the placement of the new tie.

(8) Tamp under adjacent ties where one tie shows evidence of being cut by the rail base. The adjacent ties will then carry more of the load.

(9) Tie plates will be used on running or access track and heavy-use classification yard track. Tie plates are not required on temporary track except over bridges, trestles, or culverts and on curves sharper than 8 degrees (maximum radius 717 feet).

(10) Fill unused spike holes with treated soft wood plugs firmly driven into the holes. Salvage all sound ties, spikes, and tie plates for appropriate reuse. Dispose of unsound ties and unusable materials.

3-8. Rails and Accessories.

Design and specifications for rails and accessories should be in accordance with AREMA Manual (Chapter 2, section 1). In repair and maintenance work it is important to match existing design of materials and construction wherever it is economically justifiable. In cases of individual rail replacement, where the existing rail does not meet the standard criteria listed herein and where the remaining track is performing satisfactorily, the same size rail should be installed. Rails must be connected at the joints so that the rails will act as a continuous girder with uniform surface and alignment. Rails and accessories obtained from suppliers or storage should be inspected before they are placed in track.

3-9. Rail Sections.

Most of the existing substandard track at military installations consist of the 30- or 33-foot rails. Rails required for replacement of worn or substandard track should normally be 33 or 39 feet long unless there is sufficient justification for using the shorter rail. The 90-pound/yard RA-A section, in 33- or 39-foot lengths, is satisfactory for most military installations except when wheel loading or spacing of supports require heavier rail. Heavier rail sections will be routinely used only to meet minimum requirements of the serving railroad when their locomotives are used on the installation. When it becomes necessary to relay the existing 90-pound or lighter rails on running or access tracks, it is recommended to use 115-pound rail.

3-10. Rail Inspection.

All rails should be periodically checked. Some types of defects may be detected visually, and some by hitting the top of the rail with a hammer. An internal rail defect inspection shall be performed in accordance with TM 5-628/AFR 91-44 or MO-103.9.

3-11. Rail Failures.

Rails that are broken or damaged to the extent of being hazardous to traffic should be replaced immediately. This applies particularly to locations such as switches, trestles, and the like where derailment might occur. Broken rails must be replaced immediately in any part of a track.

3-12. Common Rail Defects.

Figure 3-4 shows the following types of rail defects. TM 5-628/AFR 91-44 and MO-103.9 give additional descriptions, acceptable limits, and remedial actions to be taken.

a. Transverse Fissure. A transverse fissure is a crosswise break in the railhead, starting from a center or nucleus inside the head and spreading outward. The broken rail shows a smooth area around the nucleus, which may be either bright or dark, round or oval.

b. Compound Fissure. A compound fissure is a horizontal split in the railhead that in spreading turns either up or down in the head.

c. Horizontal Split Head. A horizontal split head is a horizontal break beginning inside the head of the rail and spreading outward; it is usually indicated on the side of the head by a lengthwise seam or crack or by a flow of metal.

d. Vertical Split Head. A vertical split head occurs through or near the middle of the head. A crack or rust streak may show under the head close to the web, or pieces may split off the side of the head.

e. Crushed Head. A crushed head is a flattening or crushing down of the head.

f. Split Web. Split webs are lengthwise cracks extending into or through the web.

g. Piped Rail. A piped rail is a rail split vertically, usually in the web.

h. Broken Base. A broken base is a break in the base of the rail.

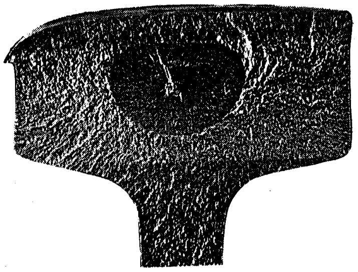
i. Square or Angular Break. Square or angular breaks are frequently caused by impact from flat or broken wheels.

j. Broken Base and Web (bolt hole break). A broken base and web is a break in the web extending to the base.

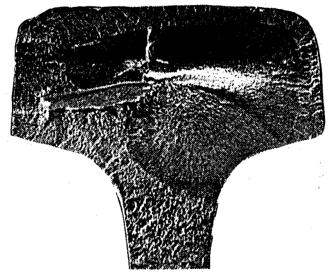
k. Other Defects. In addition to the defects listed above, flaking, slivers, flowing, engine burn, mill defects, bolt hole cracks, and top and side wear of the head are common defects.

3-13. Replacement of Rails.

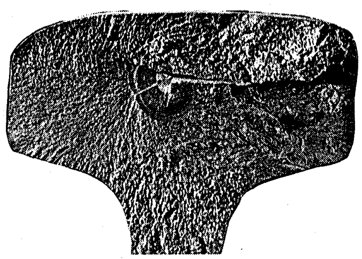
Where rails are to be replaced or interchanged, the following rules apply:



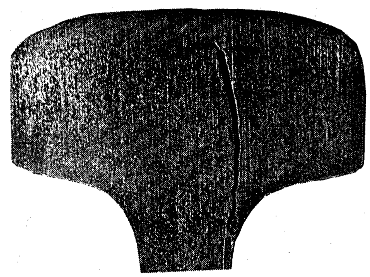
a. Transverse Fissure



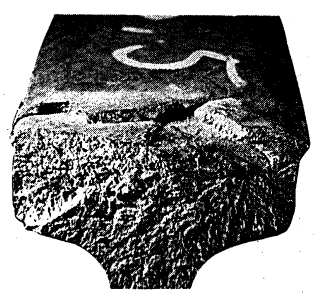
b. Compound Fissure



c. Horizontal Split Head

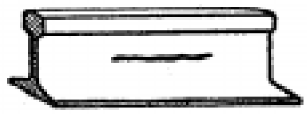


d. Vertical Split Head

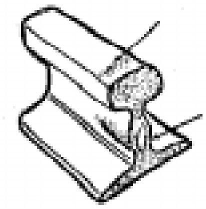


e. Crushed Head

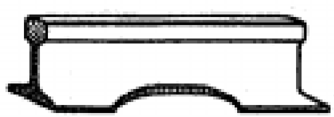
Figure 3-4. Types of Rail Failures (Continued).



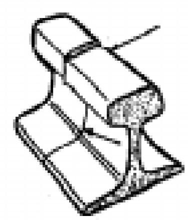
f. Split Web



g. Piped Rail



h. Broken Base



i. Square or Angular Break

Figure 3-4. Types of Rail Failures (Concluded).

a. Inspection. Before placing any rail in track, inspect it thoroughly for possible failures and defects.

b. Salvage. Do not place badly worn rails in running tracks; save them for use in storage tracks. Reject rail that cannot be straightened.

c. Curve-Worn Rails. Reset curve-worn rails with the worn side facing away from the gage side. On curves, use the worn rail as the low or inside rail.

d. Weight and Section. Match weight, section, and amount of wear of adjacent rails as closely as practicable. Do not connect rails with full heads to rails with worn heads where the gage of track of the joints would be altered appreciably. Build up joints with an electric welder to match rail ends.

e. Compromise Joints. When, by necessity, rails of different weights or sections are connected, use compromise bars to match the weights and sections of two rails (Figure 2-3). Compromise joints are either right-hand or left-hand. To determine which is needed, refer to Figure 2-3. Standing between the heavy rails and facing the light rails, the joint on the left is a left-hand compromise joint and the joint on the right is a right-hand compromise joint.

f. Length of Rail. Do not use rails less than 13 feet long.

g. Broken and Cracked Rails. Remove broken or cracked rails from track immediately. If it is not feasible to replace the broken rail at once, use a pair of fully bolted joint bars at the break as an emergency measure. Remove the broken or defective rail as soon as possible.

h. Drilling Bolt Holes. Drill the full number and correct size of bolt holes to coincide with the holes in the joint bars used. Hold joint bars in place with rail or C-clamps while the bolt holes are drilled to insure correct spacing.

i. Traffic Precautions. If a rail is unsafe, it should be closed and not reopened until repairs have been completed.

j. Cutting Rail. As soon as possible, remove rails that have been cut with an acetylene torch to make a temporary closure. Cut off at least 6 inches of the torch-cut end of the rail with a rail saw or cutting tool before using the rail in track again.

3-14. Welded Rail Replacement.

In continuous welded rail, the Army and Air Force require a minimum of 9 feet between welds or joints, and the Navy requires 10 feet. The method of welding shall be the preheated thermite process or another approved procedure. For the Army and Air Force, existing rail holes 6 inches from welds may be maintained as is, if there are no other potentially serious defects in the immediate area. The Navy specifies that all existing bolt holes be cropped before the rail is welded.

3-15. Handling and Replacing Rails.

Full flag protection and slow-order protection must be provided in cases where rail is being laid under traffic. Care must be taken in handling rails both in removing old rail for replacement and in delivering and placing new rail.

a. Precautions. Take care not to damage bolts, nuts, or rail anchors when removing rail from track. A crane should be used for handling rails.

(1) If there is danger of operating personnel falling over rails distributed along the track, report rail locations so they can be warned. Mark the obstructions with visible warning signs.

(2) In yards and station grounds, stack rails well out of the way of operating personnel and in a place convenient for distribution.

b. Distribution of Rail. Distribute rails so that they can be laid without unnecessary handling as follows:

(1) Place rails base down, parallel with the track and with sufficient bearing to prevent bending or swinging, except where there is a hazard of movement due to vibration. Rail left between or adjacent to tracks must be left lying on its side.

(2) Rails should be unloaded opposite the locations in which they are to be placed in the track, allowing suitable gaps for short lengths.

(3) Proper lengths of rail for road crossings, station platforms, bridges, and other special locations shall be unloaded in a safe and convenient location, where they will not constitute an obstruction.

(4) To minimize the cutting of new full-length rails, shorter rails should be distributed in proper places to provide for proper spacing at insulated joints and for connections to switches.

(5) No rail less than one-half rail length shall be used in main tracks, except that shorter rails not less than 13 feet long may be used for temporary closures and for connections within turnouts.

(6) Joints, turnouts, and fastenings should be unloaded and distributed concurrently with the rail, except small material which must be in the containers until the time of laying the rail.

3-16. Preparation for Laying Rails.

Bring grade to true line and elevation before laying new rail, particularly on curves that are out of line. No part of the track structure in use shall be removed until the replacement rail is ready to be installed.

a. Tie Plates and Bearings. Tie plates shall bear fully and uniformly on the ties, and the bearing on each tie shall be in the same place.

b. Curved and Straight Rails. When available, use a bender to precurve rails for sharp curves. Curvature must be uniform throughout the length of the rail. Straighten rails that have sharp crooks or bends.

c. Placement of Rail Accessories. Distribute bolts, spikes, tie plugs, tie plates, and rail anchors as close as possible to the site where they will be used shortly before rail is laid. Do not put such articles on the top of ties or in cribs when track is in use.

3-17. Steps in Laying Rails.

To prevent damage to the rails or fastenings by normal traffic, never lay more rails than can be properly secured during the day in which they are laid. Utilize mechanical devices to lay rails whenever possible. If this is not possible or practicable, extreme care must be exercised by personnel to preclude serious personal injury. Lifting and lowering of rails must be done with backs straight. A check list of the pertinent steps in rail laying follows:

a. Tie plates shall be installed and bear fully and uniformly on all ties.

b. Tamp loose ties to provide a good bearing under the new rail. Follow standards for spiking and bolting, and apply necessary rail anchors before permitting trains to pass over the rail.

c. See that insulated joints in the track circuit are spiked and supported as soon as possible, as insulating fibers are easily damaged.

d. Lay Rails One at a Time. To insure good adjustment, bring rail ends squarely together against suitable rail expansion gages, and bolt them before spiking. Under special conditions, certain departures from this plan are permissible. In areas of heavy traffic, when trains cannot conveniently be diverted to other tracks, stretches of rail not over 1,000 feet long may be bolted together and then lined into place. Proper allowance for expansion must be maintained; requisite rail expansion gages should remain in place until rails are set in final position.

e. Never use switch points to make temporary connections. This is a dangerous practice.

f. Provide holes for complete bolting of cut rails according to standard drilling practices and the following rules: (1) New holes must be drilled and not slotted or burned with a torch. They shall not be drilled between existing holes. (2) The distance from the end of a rail to the center of the first bolt hole should be at least twice the diameter of the hole. Blind end rails shall be drilled to match the punch of the joint bars used. Rail will not have other holes in the joint bar area.

g. Install standard metal, fiber, or wood shims between the ends of adjacent rails to insure proper space allowance for expansion, as indicated in the following table (Table 3-1):

h. Use a spike maul or a mechanical or pneumatic spike driver to drive spikes. Spikes must be vertical and square with the rail. Straightening spikes as they are driven decreases the holding power. Hold rail against gage when spiking.

i. For Army and Air Force track, use four spikes per tie on tangent track and curves with less than 4 degrees of curvature. For Navy track, use four spikes per tie on tangent track and curves of 6 degrees or less. Spikes shall be staggered so that all the outside spikes and inside spikes on the opposite end of the tie are in relatively the same position in the tie, i.e., spikes should be in a “V” pattern with the “V” pointing in the direction of heaviest traffic, as shown in Figure 3-5. Additional guidance is provided in TM 5-628/AFR 91-44 and MO-103.9.

j. On curves of Army and Air Force with more than 4 degrees of curvature (6 degrees for Navy track) and at other critical points, see Figure 3.5 for spiking patterns. See TM 5-628/AFR 91-44 and MO-103.9 for additional guidance.

k. Drive spikes down snugly but not tight against the rail. A space of approximately 1/8 inch should be left between the head of the spike and the base flange of the rail.

Table 3-1. Space Allowance for Track Expansion.

33-ft Rail 160 joints per mile		39-ft Rail 135 Joints per mile		78-ft Rail 68 Joints per mile	
Rail Tempera-ture F°	Expansion Inches	Rail Tempera-ture F°	Expansion Inches	Rail Tempera-ture F°	Expansion Inches
Below -10	5/16	Below 6	5/16	Below 35	5/16
-10 to 14	1/4	6 to 25	1/4	35 to 47	1/4
15 to 34	3/16	26 to 45	3/16	48 to 60	3/16
35 to 59	1/8	46 to 65	1/8	61 to 73	1/8
60 to 85	1/16	66 to 85	1/16	74 to 85	1/16
Over 85	None	Over 85	None	Over 85	None

l. Gaging shall be done at least at every third tie when laying the second line of rail.

m. Install rail anchors (figure 3-6.) and gage rods, when required, before allowing traffic over new track.

n. When necessary to make a temporary connection for the passage of a train, the union shall be made with a rail of the section being renewed. The closure rail shall not be less than 13 feet long and shall be connected to the new rail by a compromise joint if the rails are of different sections. The connecting rail shall have a full number of bolts and the required number of spikes.

3-18. Rail Joints.

a. General Requirements. Rail joints should fulfill the following requirements:

(1) They should connect the rails so that they act as a continuous girder with uniform surface and alignment.

(2) Their resistance to deflection should approach that of the rails to which they are applied.

(3) Battered rail ends should be repaired by an approved method of welding and grinding.

b. Jointing. Lay rails so that the joints of one are opposite the middle of the other rail, with permissible variations as follows:

(1) Except through turnouts and at paved road crossings, the staggering of joints should not vary more than 30 inches from the center of the opposite rail, preferably not more than 18 inches.

(2) Do not locate joints within the limits of switch points, opposite guardrails, or within 6 feet of the ends of open deck bridges or trestles.

3-19. Bonded Rails.

Where highway or train signals are actuated through the track circuit, or where petroleum fueling facilities or ammunition loading points require grounding of rails, the rails must be bonded. The bonding may be applied to the outer side of the railhead, within the limits of the joint bars or outside of joint bars in the web of the rail.

a. Plug Type Bonds. For plug type bonding the following steps are required.

(1) Drill holes the size of lugs on the end of bond wires in the head or the center of the web of rail. Drive lugs into them to secure a firm fit.

(2) Do not disconnect bonding wires or reverse bonded rails without a Signal Maintainer present. In emergencies when a broken rail, switch, or frog needs immediate repair, make as tight a connection as possible, but notify the Signal Maintainer at the first possible opportunity.

b. Welded Bonds. Use approved methods for welding bonds in lieu of plug type bonds where it is more practical.

3-20. Cutting Rails.

Use either a tooth or an abrasive type rail saw for cutting rails. In cases of extreme emergency, rails may be cut with gas cutting torches by qualified operators, but torch-cut rails must be replaced as soon as possible. When rails are cut, suitable face, eye, and other body protection must be afforded in the form of goggles, face shields, gloves, and other protective devices to prevent injury. Manufacturers' instructions should be followed in the operation and maintenance of mechanical saws. General rules that apply are: keep the machine clean; inspect at regular intervals; use proper adjustment; and see that the railroad maintenance crew takes care in handling and operation.

3-21. Joint Bars.

a. Installation. Joint bars are installed with the full number of bolts, nuts, and spring washers. Joints must be bolted so that nuts alternate between the inside and outside of the track unless the joint bars are designed to be bolted with the nuts on one side (Webber type bars).

(1) Keep joints tightly bolted to prevent injury to the rail ends. Use a standard hand track wrench or a power wrench to tighten the track bolts.

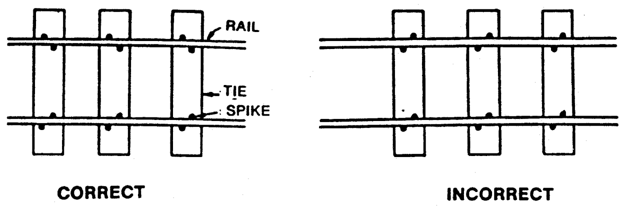
(2) Take up wear in fishing spaces of rail and joint bars by replacing bars.

b. Track Bolt Maintenance. The following practices are necessary to maintain track bolts:

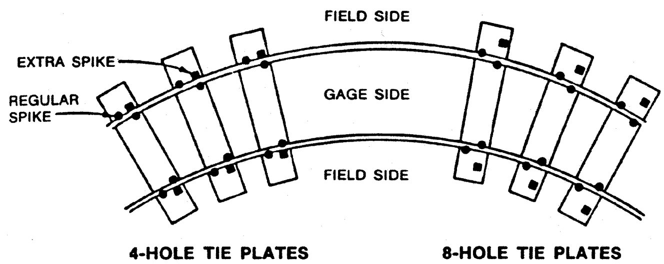
(1) In applying nuts on track bolts, the flat side of the nut should be placed next to the spring washer.

(2) The applied bolt tension should be within a range of 20,000 to 30,000 pounds per bolt for the initial tightening and within a range of 15,000 to 25,000 pounds of subsequent tightenings. Use mechanical torque wrenches set in accordance with manufacturer's instructions. Use a 42-inch track wrench with a 200-pound person on the wrench.

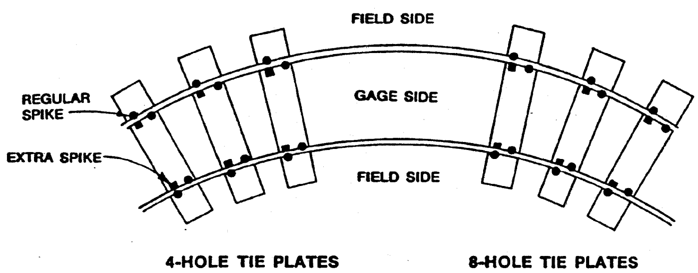
(3) Track bolts should be retightened as needed. Annual retightening of all bolts is recommended.



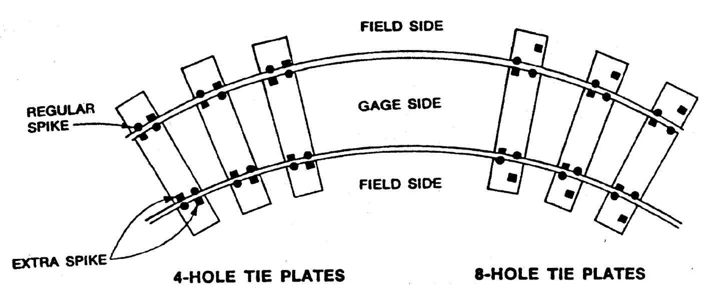
Spiking pattern for tangents and curves less than 4 degrees for Army and Air Force track, and tangents and curves of 6 degrees or less for Navy track



Spiking pattern for curves 4 degrees and greater for Army and Air Force track

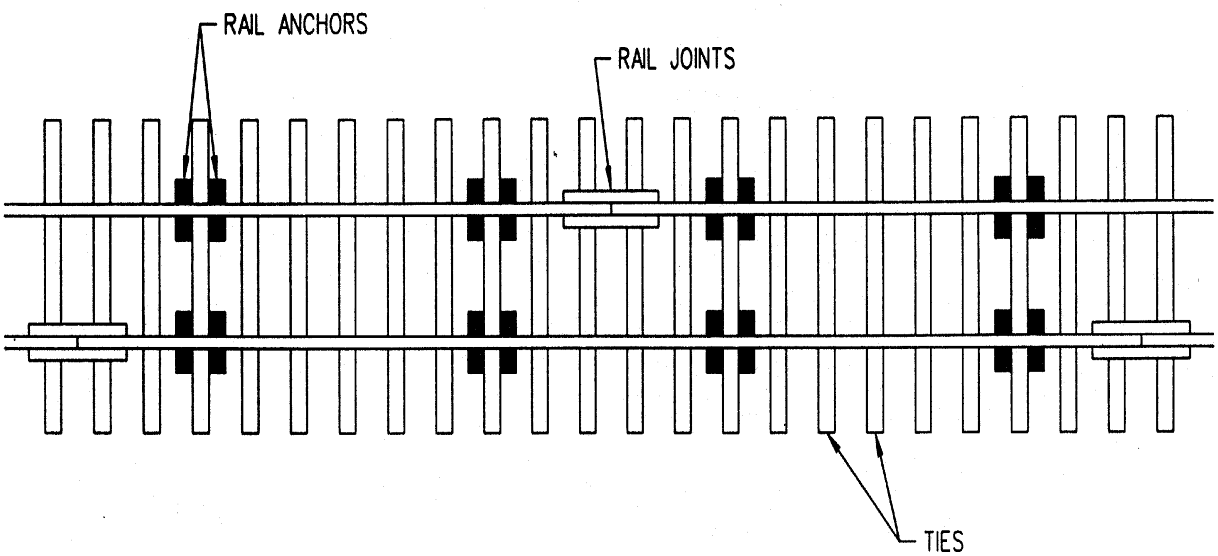


Spiking pattern for curves greater than 6 degrees but less than 16 degrees for Navy track

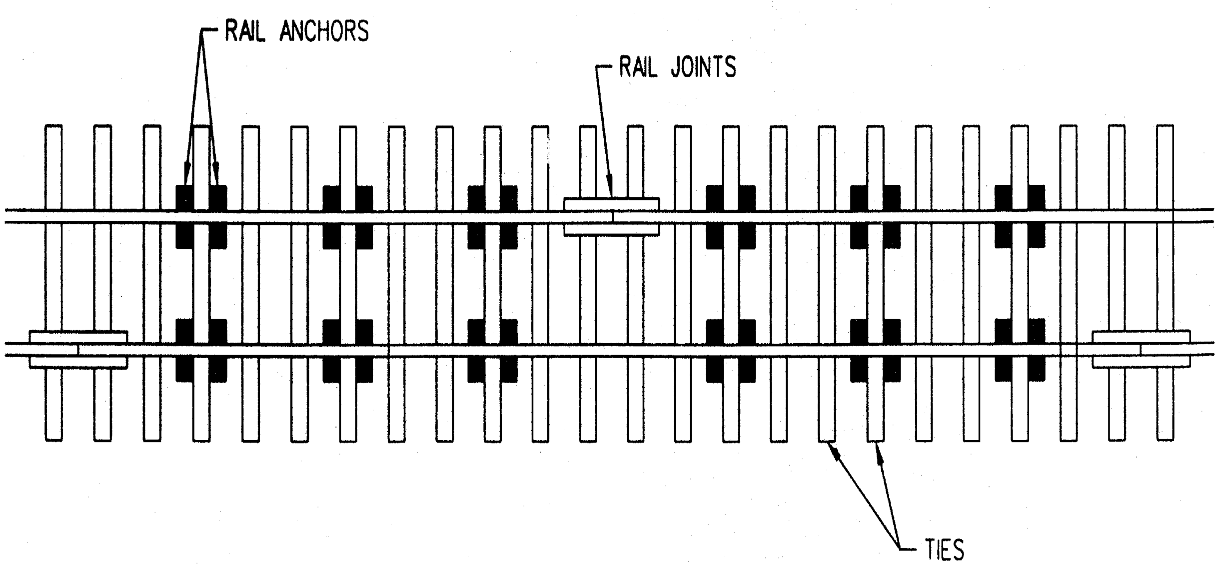


Spiking pattern for curves 16 degrees and greater for Navy track

Figure 3-5. Spiking Patterns.



A. Low Traffic Volumes



B. Large Traffic Volumes or on a Grade

Figure 3-6. Recommended Rail Anchoring Pattern.

3-22. Compromise Joints.

Compromise joints (Figure 2-3) are used wherever rails of different weights or sections are connected. The bars must conform to the weight and section of each rail at the connection. The maintenance of compromise joints is the same as for joint bars.

3-23. Spikes.

a. Specifications. All spikes used for replacement, repair, and rehabilitation shall conform to AREMA standards. They must be smooth and straight with well-formed heads, sharp points, and free from nicks or ragged edges.

b. Use. Standard 9/16-inch or 5/8-inch square cut spikes are to be used for all track spiking. Rail 90 pounds or less usually requires 9/16-inch by 5-1/2-inch spikes. Rail over 90 pounds usually requires 5/8-inch by 6-inch spikes. Shimming spikes are standard lengths plus the thickness of the shim taken at 1/2-inch intervals.

c. Location. Location of spikes shall be in accordance with Figure 3-5.

3-24. Bolts, Nuts, and Lock Washers (Nutlocks).

All joints will be fully bolted with the proper size, type, and number of bolts, nuts, and lock washers for the type of joint bar used. These items must conform to AREMA criteria. See Table 3-2 for standard bolt sizes, and Table 3-3 for spring lock washer sizes.

3-25. Rail Anchors.

a. General. Rail anchors are used in track that is subject to excessive movement from rail expansion due to temperature change or from traffic on steep grades. They must grip the base of the rail firmly and have full bearing against the face of the tie opposite the direction of creeping. The following general rules apply:

(1) At locations where rail anchors are required, ties shall be firmly tamped and the cribs filled to within 1 inch of the top of the ties.

(2) When the bearing of the rail anchor has been disturbed by removal of the tie, the anchor shall be removed and reset.

(3) Skewed ties shall be straightened before anchors are installed.

Table 3-2. Standard Track Bolt Sizes.

Track Bolt Size (Diameter × Length, in.)	Average Number (per 200-lb keg)	Rail Weights, lbs
3/4 × 3-1/2	275	60
3/4 × 4	260	65 - 70
7/8 × 4	178	80
7/8 × 4-1/2	168	85 - 90
1 × 5	118	90 - 119
1 × 5-1/2	111	90 - 119
1 × 6	105	Over 119

Table 3-3. Standard Spring Lock Washer Sizes.

Track Bolt Diameter, in.	Inside Diameter of Washer, in.	Average Number per Keg	Weight per Keg, lbs
3/4	13/16	1,500	165
13/16	7/8	1,500	192
7/8	15/16	1,000	188
15/16	1	750	150
1	1-1/16	750	175
1-1/16	1-1/8	750	192
1-1/8	1-3/16	750	200
1-1/4	1-5/16	500	15

b. Application. A minimum of eight rail anchors per 39 feet of rail are recommended to be installed as shown in Figure 3-6. It is important that the anchors be carefully applied and that they be in contact and remain in contact with the tie face. Additional anchors should be used as required. See TM 5-628/AFR 91-44 or MO-103.9 for additional information.

3-26. Gage Rods.

a. Gage rods are used to help maintain proper track gage but are not a substitute for good track maintenance and good tie conditions. Gage rods are sometimes used at the following locations:

(1) On sharp curves where there is difficulty holding the gage.

(2) In turnouts just ahead of the switch points and in the curved closure rails.

b. Spacing. Where gage rods are used in sharp curves, four rods should be installed for each rail length. Rods should be installed at evenly spaced intervals along the rail length, with specific attention made to rail joints on the outside rail of a curve.

c. Application. Gage rods should be installed at right angles to the rail with the jaws firmly gripping the base of the rail.

d. Maintenance.

(1) Gage rods shall be kept tight while maintaining the proper track gage.

(2) Bent or broken gage rods shall be replaced where the track conditions warrant their continued use.

3-27. Turnouts and Crossovers.

a. General. The number of the frog in a turnout designates the size of the turnout and generally establishes (1) length of switch points, (2) lead distances, (3) radius of lead curve, (4) length of the closure rails, and (5) number, length, and spacing of ties.

b. Replacement. For purposes of maintenance, the No. 8 turnout with a straight split switch, low switch stand, and solid manganese self-guarded frog is considered standard for replacement purposes. However, a self-guarded frog cannot be installed in a curved track. Weight factors of switching equipment, installation layout, and site conditions determine the size of a turnout. No. 8 and No. 10 turnouts are often used and will meet most requirements.

c. Crossovers. A crossover consists of two turnouts with track between, and it connects two adjacent and usually parallel tracks.

d. Location. Turnouts are located on tangent track wherever possible to minimize wear on switch points, frogs, and guardrails. When a turnout is from the inside of a curve, the degree of curvature of the turnout is approximately its normal degree plus the degree of curvature of the main line; if from the outside, the degree of curvature of the turnout is the difference between these two. Thus, if a No. 8 turnout (with a degree of curve of 12°24'23") is installed on the inside of a 4-degree curve, the curvature through the turnout is equal to 12°24'23" plus 4 degrees, or 16°24'23". Safety against derailment and economy in maintenance require that turnouts be located so that the total curvature does not exceed 14 degrees. It is considered poor policy to install turnouts in mainline curved track.

e. Switches. Lengths of switch points are adopted as standard for various turnouts. Because loose or broken switch rods or connecting rods are serious defects and could cause derailment, all switch rods and connecting rods require close inspection as follows:

(1) Match switch points to weight and section of stock rail. When points are renewed, renew stock rail to secure a proper fit. Connect points to the operating rod to provide ample flangeway between the open point and the stock rail. Check both switch points for this adjustment. The correct throw of the switch is 4-3/4 inches, with an allowable minimum limit of 3-1/2 inches or according to switch design. All switches in paved areas should be adjusted to provide the maximum throw of 5-1/2 inches. Provide all vertical bolts on switch connections with cotter pins, and place the bolts with nuts facing up. Center the slide and heel plates on the tie to provide a uniform bearing for the switch point.

(2) If switch point protectors are used, the bolts should be checked regularly and retightened as necessary or the protector will not provide adequate protection for the switch point. When wear makes repairs necessary, manufacturer's instructions should be followed.

(3) Check each switch to determine that it operates freely, that points fit accurately, and that rods are not obstructed by the ties or ballast. Keep all operating mechanisms clean and thoroughly lubricated. Keep the switch free of ice, snow, and debris at all times.

(4) Maintain surface, line, and gage throughout. Keep the gage side of the main track point in line with the gage side of the stock rail in advance of the point. Bend the stock rail with a rail bender at the proper place so that the point fits snugly against the rail when closed. Table 3-4 gives data on bends of stock rails for different lengths of switch points.

f. Switch Stands. The switch-operating mechanism consists of a hand-operated switch stand with throw lever and a connecting rod. The switch stand is placed on two headblock ties at the point of switch. The switch stand is located on the right side of the track with respect to the normal direction of traffic. The switch stand is installed and maintained according to the following requirements.

(1) A hand lever operates parallel to the track. Throw of stand is adjustable from 3-1/2 to 5-1/2 inches; the adjustment is made so that each switch point has a throw of 4-3/4 inches. Throw of switch points should be a minimum of 3-1/2 inches.

(2) Colored targets and/or distinctly shaped targets are provided to indicated switch points clearly at locations where such indications are necessary.

Table 3-4. Offsets for Bending Stock Rail.

Length of Switch Point, ft	Distance of Bend Ahead of Switch Point, in.	Perpendicular Offset from Original Line at 10 ft from Bend, in.
30	7-3/8	1-7/8
22	5-1/2	3-1/8
16.5	8-1/4	3-5/8
15	4-1/16	3-7/8
11	5-1/2	5-5/8

(3) For night operations, switch targets are red and green reflectors mounted on the spindle. Green indicates switch normal and red indicates switch reversed. Some switch yard operations use yellow or white in lieu of green.

g. Railroad Frogs. When it is necessary to purchase new frogs, solid manganese self-guarded or rail bound manganese frogs should be purchased; however, any supply of rigid bolted frogs on hand can be used. The above frogs should be used unless a variation is specifically authorized by a higher authority. Rigid frogs are preferred for all locations because of their maintenance-free characteristics. Self-guarded frogs must have guardrails installed when they are used in turnouts out of curved track. Existing spring frogs should be replaced with standard rigid frogs when replacement is required. When using standard bolted frogs, guardrails shall be installed to protect the frog point and assist in the prevention of derailments. Railroad frogs are installed in the following manner:

(1) The frog number corresponds to the turnout number.

(2) The frog is the same weight and section as the rails throughout the turnout.

(3) All frogs are fastened to switch ties by hook plates or frog plates and fully spiked. Spikes will be kept tight; all bolts must be tight, and any broken bolts shall be replaced immediately.

(4) Correct line, surface, and gage shall be maintained.

h. Guardrails. Guardrails are not required with solid manganese self-guarded frogs, except under special circumstances. Guardrails may be either 9 feet 5 inches, or 12 feet 6 inches as shown in Figure 2-7.

i. Guardrail Placement. Requirements for guardrail placement are:

(1) The gage of guardrails at frogs must be checked frequently. Normally, the distance from the gage line of the frog to the flangeway face of the guardrail is 4 feet 6-5/8 inches (guard check gage); however, if curvature through turnout exceeds 8 degrees, the distance must be 4 feet 6-3/4 inches regardless of track gage. The distance between the guard line of the guardrail and the guard line of the frog (guard face gage) will not exceed 4 feet 5 inches.

(2) Ends of guardrails are beveled to prevent loose or dragging objects from catching or fouling the rail.

(3) The centerline of the guardrail should be located 6 inches ahead of the point of frog as shown on the standard turnout plan.

j. Derails. Derails must be kept in good operating condition. Frequent observations should be made to see that the clearance point has not changed because of shifting or movement of tracks. Derails are painted a bright chrome yellow to make them clearly visible.

k. Clearance Marker. Where derails are not used, a chrome yellow strip 10 inches wide should be painted across the web and base of each rail of the connecting track at the clearance point, or other distinctive markers should be used (Figure 3-7). The markings or markers must be located at sufficient distance (15 feet from center to center of tracks) to provide adequate clearance between standing or moving trains, or at road crossings to prevent standing trains or cars from reducing the crossing sight distances.

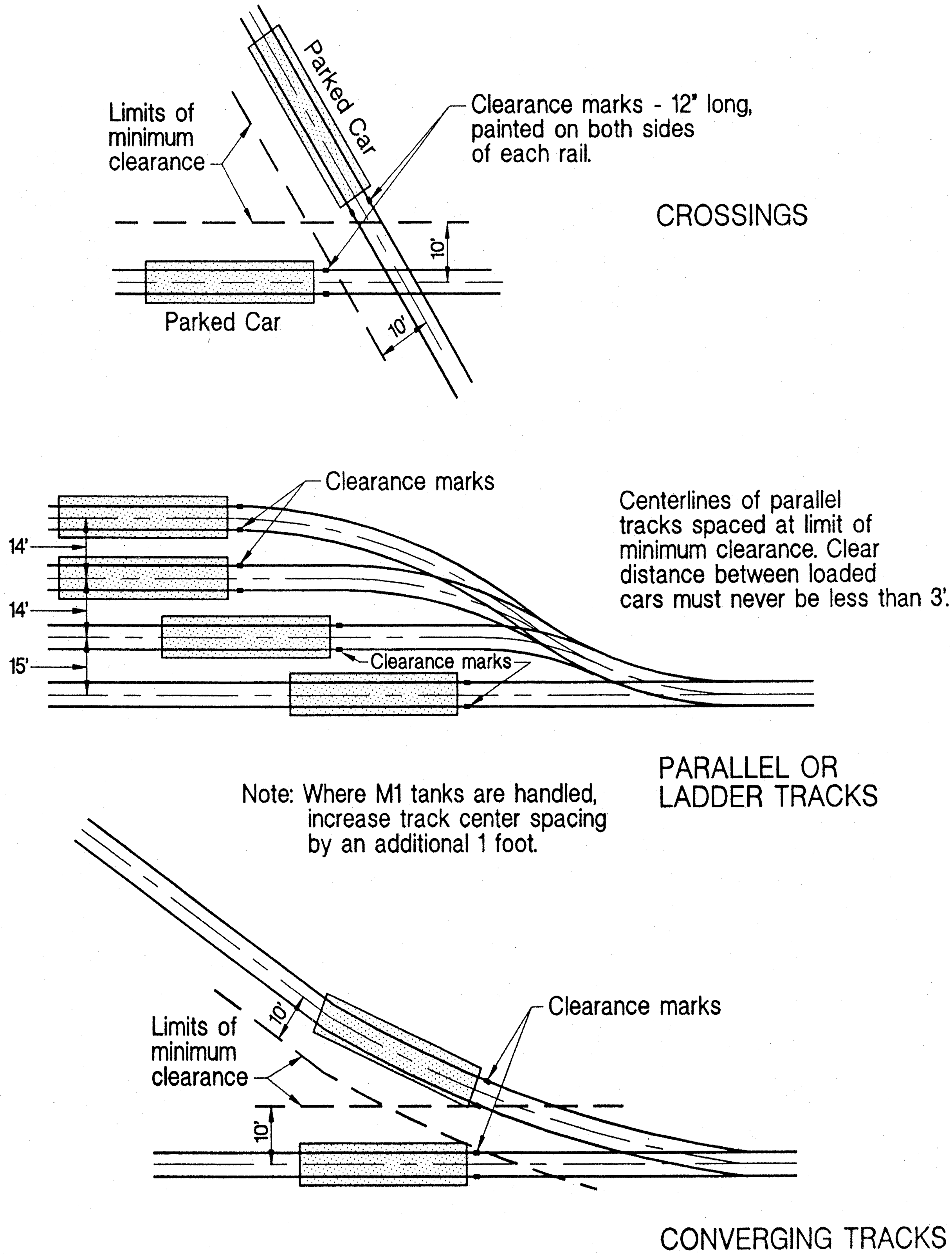


Figure 3-7. Locations of Clearance Markers.

CHAPTER 4

SPECIFIC MAINTENANCE OPERATIONS

4-1. Lining Track.

Track is aligned at the same time it is surfaced.

a. Horizontal Alignment. Existing systems not conforming to grade and curvature standards may be maintained as is, provided a record is on file describing each deviation from the standard and necessary operating restrictions. Restrictions shall be tailored to each specific situation and may include such items as maximum speed and maximum car/engine combination. To assist cars in tracking and to reduce wear on sharp or substandard curves, it is suggested that the rails be lubricated.

b. Tangents. On tangent track the line rail is brought to correct line. The other rail is brought to line by correcting to the proper gage.

c. Curves. Lining of track on curves is more complicated because the curve must be uniform throughout its length.

(1) All curves shall have a designated degree of curvature. Curves on Army and Air Force track with a degree of curvature greater than 12°30' or turnouts less than No. 7, and on Navy track with a degree of curvature greater than 16 degrees or turnouts less than No. 5, must be approved by a higher authority than the installation. Spirals shall have a smooth transition.

(2) Compound or reverse curves should be provided with easements or spirals from one curve into the other. A tangent distance of 50 feet between curves should be provided.

(3) String lining is used for determining the degree of curvature and locating and correcting irregularities in the alignment of existing curves. A transit should be used in laying out new work or when making major changes in an existing track layout.

4-2. Surfacing Track.

a. General. All tracks shall be maintained to correct surface elevation. Surfacing out-of-face refers to raising the track structure to a new grade. Spot surfacing refers to raising low spots to the original uniform surface. Correct surfacing means that a plane across the top of the rails at right angles to the rails is level on tangents and has the correct superelevation on curves. The track level is used to check surfacing work.

(1) Pay special attention to surface and line of track at ends and approaches to bridges, trestles, and culverts; through turnouts and road crossings; and at platforms.

(2) Before raising track during hot weather, be sure that rails will not warp or buckle. Consider the amount of rail openings at joints, tightness of bolts, position of rail anchors and amount of ballast in cribs and at ends of ties. Where there is danger of buckling, loosen track joints in both directions from the danger point to allow for expansion.

(3) On curved tracks with superelevation, the outside rail shall be higher than the inside rail. On curved track in industrial areas traveled at low speeds, superelevation is not required.

b. Hand Jacking. Place the first pair of jacks approximately 10 feet ahead of starting point of the rise. Place the second pair of jacks 10 feet ahead of the first pair of jacks. Raise both sets of jacks to give an even grade from the starting point to the second jacks. Tamp the ties to a point approximately halfway between the jacks. Then, move the first pair of jacks about 10 feet ahead of the second pair of jacks and raise the rail at that point. Tamp the ties halfway between the jacks. Bring the second rail to proper surface at the same time the first rail is raised, using a track level to level the two rails. CAUTION: Jacks must be placed ahead of rail joints to prevent strain on joint bars.

c. Out-of-Face Surfacing. In raising or surfacing track, the inner rail on curves and the line rail on tangents are the grade rails. Bring them to surface with the aid of the spot board, or refer them to grade stakes. Bring the second rail to surface with the aid of the track level.

(1) Bring both rails to grade, tamp ties, set tie plates, gage track, and drive spikes fully before jacks are moved ahead.

(2) Place track jacks in cribs between the ties outside the rail, and set them true vertically. If jacks are to be placed between rails, set them in trip position and provide flag protection.

4-3. Tamping.

Systematic and uniform tamping is of great importance in maintaining correct surface and line.

a. Tools. Pneumatic, electric, gasoline, or other mechanically operated or hand tampers may be used for tamping. The type of tool varies somewhat for different materials as follows:

(1) For broken stone, crushed and washed gravel, or slag ballast, use a tamping pick or bar, ballast spade, or power tamper. Power equipment will be fitted with a tool having an end similar to a tamping pick face or vibratory tool.

(2) For gravel, chats, or chert ballast use a shovel, ballast fork, ballast spade, tamping pick, tamping bar, or power tamper. For heavy traffic, a tamping pick, tamping bar, or power tamper should be used. With a power tamper use a tamping tool with a tamping end of sufficient area. For light traffic, shovel tamping is sufficient.

(3) For spot tamping picks, ballast forks, ballast spades, shovels, tamping bars, or power tampers may be used.

b. Methods. After the track has been raised on jacks to a true surface, pack ballast firmly under the ties. Tamp so that a tight bearing is obtained between the tie and the raised rail without disturbing the surface. The following tamping methods apply:

(1) *Tool Positioning.* Regardless of the kind of ballast or the kind of power tamper used, two tamping tools must always be worked opposite each other on the same tie. Start power tampers from a vertical position, and use them directly against the sides of the tie to be tamped. Work downward past the bottom corner, after which the tools may be tipped down to force the ballast directly under the tie.

(2) *Tamping Distances.* In tamping ties, 8-foot crossties should be tamped from 12 inches inside the rail to the end of the tie, 8-foot 6-inch crossties should be tamped from 15 inches inside the rail to the end of the tie, and 9-foot crossties should be tamped from 18 inches inside of the rail to the end of the tie.

(3) *Cautions.* Omit tamping at the center of the tie, between the stated tamping limits. This center area should be filled lightly with a ballast fork. Both sides of the ties must be tamped simultaneously, and tamping inside and outside the rail should be done at the same time.

4-4. Gage.

Check gage of track out-of-face annually and spot check gage frequently when the volume of traffic or local conditions warrant. Gage for railroad track is measured between the heads of the rails at right angles to the rails in a plane 5/8 inch below the top of the railhead.

a. Railroad Track. The standard gage of 4 feet 8-1/2 inches is used for tangent track and on curves up to 8 degrees. On curves over 12 degrees, the gage is increased 1/8 inch for each increment of 2 degrees to a maximum of 4 feet 9 inches by moving the inside rail. The rate of change from standard to widened gage is 1/4 inch in 31 feet along the spiral curve or tangent adjacent to the curve, unless physical conditions do not permit the normal transition. The 1/4 inch in 31 feet rate of change from standard gage to widened gage for curves is a design standard and not track inspection criteria.

b. Limiting Factors for Corrective Maintenance. Allowable deviations and operating restrictions are provided in TM 5-628/AFR 91-44 and MO-103.9.

c. Procedure for Regaging. The standard track gage is used in correcting gage. It will be checked frequently and replaced when it shows a variation of 1/8 inch or more. All spike pulling and driving is done on the rail opposite the line rail. The gage is not removed until all spikes have been driven. Spikes are pulled with a standard claw bar or spike puller. At switches, frogs, and guardrails where the claw bar will not fit between rails, the spike puller extension is used. Treated tie plugs are driven in all spike holes before respiking. Corrections to gage shall not be made by striking the head of the driven spike toward the rail. Spikes shall be removed, rail lined to gage, and spikes redriven.

4-5. Spiking.

Spiking will follow the standards set forth in paragraph 3-17 *i* and *j*.

4-6. Turnout Relay and Installation.

Turnouts are placed and maintained in accordance with standard plans and the following rules:

a. Locate point of frog and point of switch.

b. Relocate any main-track rail joints that come within the limits of switch point or guardrail.

c. Cut the lead rails, bearing in mind that the turnout lead is longer than the main-track lead.

d. First, put in headblocks and gage plate or two side plates. Then put in all ties for the switch point and frog and their slide plates, braces, heel plates, and guardrail plates. The plates and braces for the unbroken line or rail are lined and fully spiked in position, whereas those on the turnout side are held in place temporarily.

e. Bend a rail for the turnout stock rail according to paragraph 3-27*e*(4).

f. Couple the stock rail, main-track switch point (heel block to be placed later, if used), lead rails, and frog on the ends of ties on the turnout side, doing such cutting and drilling as may be necessary to complete the main track from the point of the switch to the heel of the frog.

g. Take out the old main-track rail. Set the turnout parts in the following order: (1) place stock rail and switch point, (2) place the lead rail and frog, (3) make connections at the heel of the frog and at the stock rail, (4) spike frog to exact gage at the heel and the toe point, (5) place joint bars and tighten bolts, and (6) complete spiking from the frog to the heel of the switch point.

h. Do not permit train movement over main track until the guardrail has been correctly placed and spiked, all switch plates on the turnout side have been fully spiked in correct position, the switch point has been spiked against a stock rail, and the free end of the stock rail fastened to prevent movement.

i. In applying the switch plates on the turnout side: (1) make sure that the gage is 12 inches ahead of the switch point, and (2) put slide plates on tie where switch point begins to taper.

j. Adjust stock rail so that it does not bind against switch point and cause it to open. (To test this, operate the switch point and see that point touches the stock rail first.) Spike these slide plates, and install and spike remaining slide plates and braces working each way from the center.

k. When putting on slide plates, use a bar (not a pick), and do not attempt to draw the gage with a spike.

l. Put in the remaining switch ties, and line and surface main track.

m. Couple switch point for the turnout lead, set lead rails, and spike turnout lead to proper line for turnout curve.

n. Complete the work by setting the remaining guardrail, setting and adjusting the switch-operating mechanism, checking the line, gaging, spiking, and surfacing.

4-7. Shimming Track.

a. *General*. Heaving of track in winter and spring months is generally an indication of poor drainage or poor ballast conditions, which must be corrected as soon as frost leaves the ground. Until the cause can be eliminated, heaving can be corrected temporarily by using shims to raise the rails on either side of the high spot, thus providing an easy grade. The length of this temporary raise is called the runoff. NOTE: Criteria for maximum runoff are contained in TM 5-628/AFR 91-44 and MO-103.9.

b. *Methods*. When shimming is necessary, it will be done so as to provide easy and safe runoff gradients. When one side of the track is heaved more than the other, proper cross level will be restored when shims are installed. Care must be taken on curves to maintain proper curve elevation. Heaved ties will not be adzed or otherwise cut to lower their height; shimming under ties is prohibited except in an emergency, in which case the shims shall be removed, and the condition otherwise taken care of as soon as possible.

c. *Rules for Shimming and Bracing*. When installing shims, the track level and gage will be used to insure proper gage and surface.

(1) Before a shim is placed on a tie, all spike holes in that tie must be plugged with treated wood tie plugs. The tie shall be free of ice, snow, and other obstructions within the area of the shim, and full bearing of the shim on the tie shall be provided.

(2) Two shims of the same length will not be used together under one rail on a tie. One 12-inch shim may be used on top of a 24-inch or a 3-foot 6-inch shim. One 24-inch shim may be used on top of a 3-foot 6-inch shim. One 12-inch shim may be used on top of a 24-inch shim that has been placed on top of a 3-foot 6-inch shim. Where possible, use only one shim. Where two shims are required, the lower shim must be of maximum thickness. Where three shims are required, the two lower shims shall each be of maximum thickness.

(3) When tie plates with special shallow base patterns or with shallow ribs on their bases are in use, they should be installed on top of shims. When tie plates with deep ribs on their bases are in use, they should not be installed on top of shims. Shims shall never be installed on top of tie plates.

(4) In all cases where a 12- or 24-inch shim or a 12-inch on top of a 24-inch shim is installed, all spikes used shall be long enough to provide a minimum penetration of 4 inches in the tie. In all cases where a 3-foot 6-inch shim is installed, it will be properly and independently spike to the tie with 7-1/2-inch shimming spikes. In all cases where a 12- or 24-inch shim is installed on top of a 3-foot 6-inch shim, all spikes through the shorter shims shall be long enough to go through the 3-foot 6-inch shim and have a minimum penetration of 1 inch in the tie.

d. *Precautions*.

(1) Driving shims at an angle between the spikes weakens the track and is prohibited. Shims shall be placed squarely on top of the tie and the spikes driven through the holes provided.

(2) Wood or other types of rail braces should not be used where shimming is done on tangent track or on curved track equipped with shoulder tie plates of a type that is to be used on top of shims. Where shimming is done on curved track not yet equipped with tie plates or equipped with shoulder tie plates of a type that will not be used on top of shims, wood or other approved rail braces shall be installed with the shims.

e. Reestablishing Normal Surface. As the frost leaves the ground and the heaved places return to their proper level, the shimming may be reduced from time to time in order to maintain proper surface. When the frost has left the ground, all shims shall be removed without delay from the track and any imperfect surface corrected. Removed shims and shimming spikes should be carefully preserved for future use.

4-8. Street Crossings and Paved Areas.

Prompt attention must be given to correcting deficiencies as they occur at crossings and around tracks in paved areas. The maintenance of the track bed and track will be the same as that outlined in the preceding chapters and sections, except that inspection will be more difficult and additional maintenance is required for the paving, planking, etc., to insure smooth and safe operation of vehicles in the area. Because track maintenance in paved areas is more costly and time-consuming, materials supporting and contained in the track structure must have as low a maintenance potential as possible. For that reason, materials that will resist deterioration and changes in grade and gage are recommended.

4-9. Drainage.

Drainage is critical. It can present more problems at crossings than at other points on a railroad. Catch-basins, gutters, ditches, pipe drains, and/or culverts, as appropriate, must be provided to intercept and divert both surface and subsurface water at depressed or downhill crossings. Base materials underlying tracks and pavement must be of appropriate, well-graded, granular materials. Pavement surfaces must be adequately crowned and sloped to direct water into the catch-basins and ditches.

4-10. Ballast.

Ballast under a properly maintained pavement or crossing normally requires little or no maintenance. However, if the ballast is not installed properly on a good foundation in the beginning, or if the surface over the ballast permits infiltration of water, silt, and other debris, the ballast can become fouled and interfere with the drainage. If the track through the crossing is not well ballasted, or if the ballast is fouled, the ballast and subballast should be removed to at least one foot below the bottom of the ties, not less than one foot beyond the ends of the ties, and to the extent fouled in each direction away from the crossing and replaced in accordance with criteria set forth in Chapter 3.

4-11. Ties.

The condition of crossties under crossings or pavement cannot be determined without removing the crossing materials or paving. If untreated ties were originally installed, they may be seriously damaged by insect attack or decay in a short period of time. The first indication of tie failure may be settling of the rails or paving or a change in track gage. When tracks are torn up to replace the ties, it not only interferes with train operations, but also with the use of the area or crossing by vehicular traffic. When the track has been uncovered for repairs, the track in the crossing or paved area should be brought up to proper condition. Drainage and ballast should be investigated and replaced or restored before the new ties are installed. Also, all of the ties should be replaced at this time. New treated wood ties are to be installed through the crossing and 30 feet on each side of the crossing.

4-12. Rail.

Bolted rail joints should not fall within a crossing. Where crossing widths and rail lengths are such that joints have to be included, they shall be properly welded. The nearest bolted joints should be at a minimum of 20 feet outside of the crossing. Every precaution must be taken to insure adequate and continuing bonding of rail through the crossing. All rail and metal fittings used within a crossing shall be given a coating of an approved rust inhibitor. Rail shall be gaged and lined accurately and double spiked to the ties. The ballast under the track shall be solidly tamped to bring the track to grade. If concrete ties are used, the rails will be firmly fastened to the ties and the track then brought to grade.

4-13. Crossing Surfaces and Materials.

a. General. Crossing surfaces must be as smooth as possible, and the materials selected for this purpose must be suitable for the type of traffic using the crossing. Although it may be desirable to match the material and texture of approach pavements, consideration must be given to a material and an installation that is economical to maintain and that will have a long service life. Materials such as portland cement concrete or hot-mix bituminous asphalt concrete are economical to install, but are costly to remove and replace. Wood plank and prefabricated materials may be a little more costly to install, but are removable and reusable. Further, because they are easily removed and replaced, they facilitate the inspection and maintenance of the track. In plank-type crossings, the flangeways are often open down to the ties, which exposes the subgrade and ballast to the water, silt, and debris that flow to this opening. Regardless of the materials used, 2-1/2-inch flangeways must be provided for tangent and nominally curved track. On curves over 8 degrees, the flangeways must be widened to 2-3/4 inches. Elastic (rubber) and concrete crossing pads are available and should be considered for installation in areas of medium to heavy traffic or where small-wheeled vehicles use the crossing.

b. Street and Highway Crossings. Street or highway crossings should be at least 8 feet wider through the crossings than the width of the approach pavements. When the crossing has to be repaired or replaced and the crossing is the same width as the approach pavements, the crossing width should be extended 4 feet on each side. The additional width is necessary to reduce the hazards of vehicles running off the sides of the crossing. The most frequently used crossing materials are listed below:

(1) *Asphalt.* Where traffic is light, the entire crossing may be constructed of hot-mix bituminous asphalt concrete. In every light traffic area the flangeways may be formed by running the locomotive wheels through the hot mix after it has been placed and rolled. Some finishing may be required to smooth the material that has been shoved out of the flangeway. However, at crossings with a high volume of traffic or heavy truck traffic, a flangeway guard is needed to protect the edges of the asphalt section between the rails. The guard may be constructed of wood. Metal flangeway guards may be fabricated from used rail or purchased from commercial sources.

(2) *Precast Sectional Concrete.* This type of material provides a long-lasting surface for all volumes of traffic. Several types of precast concrete crossings are available on the market. Special care must be taken to insure even support throughout the length of each pad.

(3) *Solid Sectional Timber.* This type of crossing has been successfully used for many years. Treated timber will last for a long time, but may require retightening of lag screws from time to time as they will become loose as the timbers flex under traffic.

(4) *Blastomeric (Rubber).* This type of material provides a smooth riding, durable, and maintenance-free crossing. This type of crossing, as well as other prefabricated types, is salvageable and can be reused. Rubber crossings are often not the best choice for locations where traffic includes significant numbers of heavy trucks (as at Army Material Command installations) or where there are typically several annual snow removal operations. The passage of many heavy trucks often leads to rutting in the tire paths, and snow plow blades often tear into the rubber, accelerating surface deterioration.

4-14. Track in Paved Area.

The type of vehicular traffic, in particular the size of wheel and type of tire, determines the type of material and construction used adjacent to and between rails in paved industrial areas. Normally asphalt pavements are used with flangeway guards appropriate for the vehicular traffic. Where small-wheeled, solid-tired vehicles are used, a rubber flangeway filler is recommended. Flangeways may also be formed by placing used rail on its side with the head against the web of the running rails.

4-15. Signs and Signals.

Crossing sign and signal maintenance must be given a high priority to assure legibility and visibility.

a. Highway Crossing Signs and Signals. Standard highway-railway grade crossing signs and crossing signals are shown in Figure 4-1, typical grade crossing signs in Figure 4-2, and location of signs and signals in Figure 4-3. For details of appropriate types of crossings and signals see Department of Transportation (DOT) Manual on Uniform Traffic Control Devices, Bulletin No. 6 of the Association of American Railroads (AAR) (Railroad-Highway Grade Crossing Protection), and Chapter 9 of AREMA Manual.

b. Maintenance of Signal Circuits. Electric and/or electromechanical signal inspection and maintenance should conform to AREMA, AAR requirements and to manufacturer's recommendations. Circuit continuity checks, battery water level observations, trickle charger operating tests, relay point checks, light bulb tests, and related checks and inspections must be made periodically as specified or required by the installation's maintenance program or the serving railroad. Test and inspection records must be kept showing date, name of inspector, and defects noted. Indicated defects must be corrected promptly.

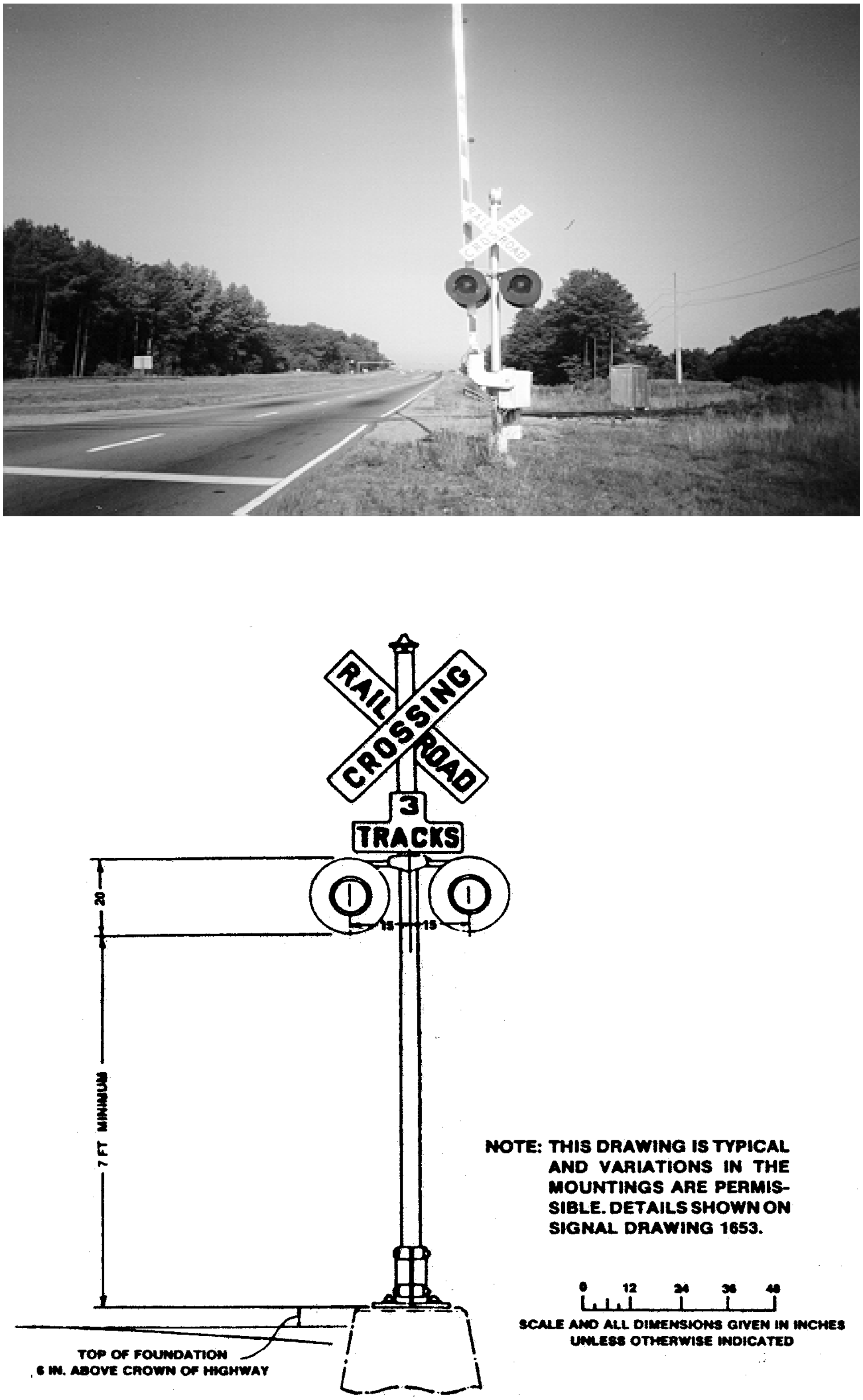


Figure 4-1. Highway Crossing Signal, Flashing-Light Type.

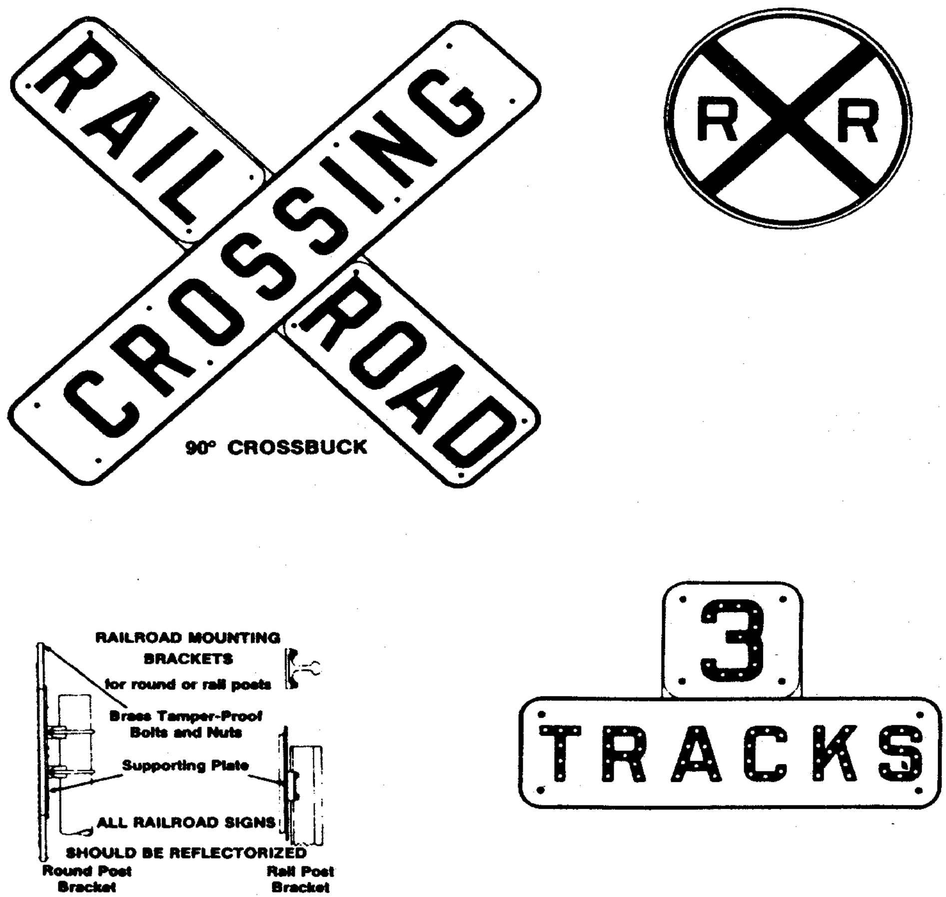


Figure 4-2. Typical Grade Crossing Signs.

c. Signal Cables. Signal cables are buried along and under the track at signal locations. Cables should be buried at toe of ballast between instrument housing and signals in the track circuit system territory, at interlocking plants, and at switches equipped with electric locks, as well as automatic block signal locations. Maintenance employees working on roadbed at these locations should be informed by signal forces as to exact locations of these cables. Machine operators must exercise care to avoid damage to underground cables at these locations. In case of doubt as to location of cables, do not excavate within signal territory until the cables are located.

4-16. Maintenance of Roadbed.

Good drainage is the single most important factor in roadbed maintenance. To provide maximum support for the track structure, subgrades should be kept as dry and stable as possible. Poor drainage not only affects the roadbed and the underlying earth structure (Figures 4-4 and 4-5) but also the side cuts and other track side areas. Where drainage deficiencies occur that cannot be corrected by normal maintenance practices, engineering assistance will be requested. TM 5-820-4/AFJMAN 32-1016 will be used for the design and construction of drainage structures, except as modified in TM 5-850-5/AFJMAN 32-1046. Open ditches and pipe drains shall be maintained to function at maximum capacity. Weed control and efficient methods of ice control and snow removal are important factors in conjunction with water runoff. Inadequacies in the original system shall be corrected as they become evident.

4-17. Inspection and Repair.

Prompt correction of defects is necessary for the economical maintenance of drainage systems. The object is to preserve the original track and roadbed section by

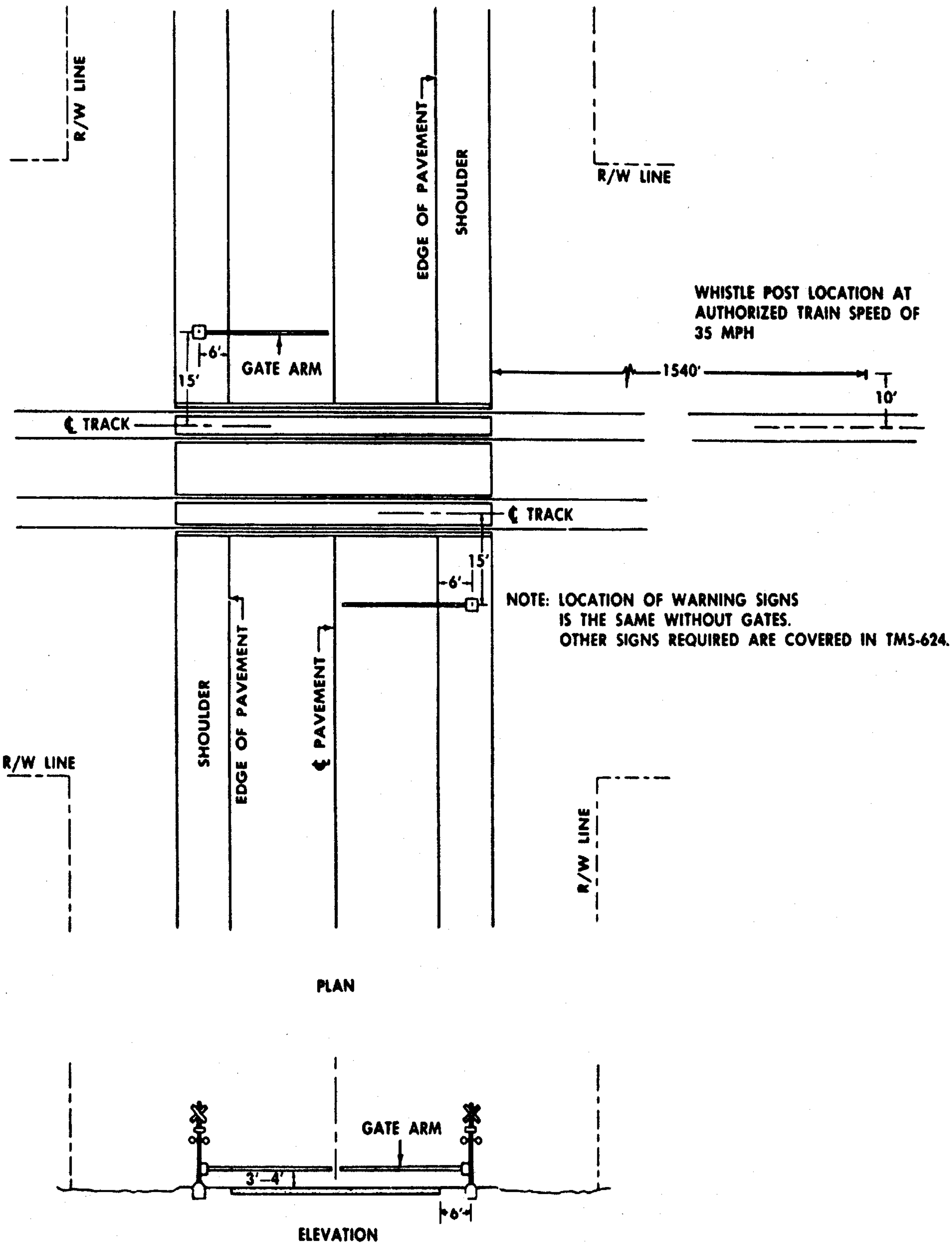


Figure 4-3. Location of Warning Signs and Signals.

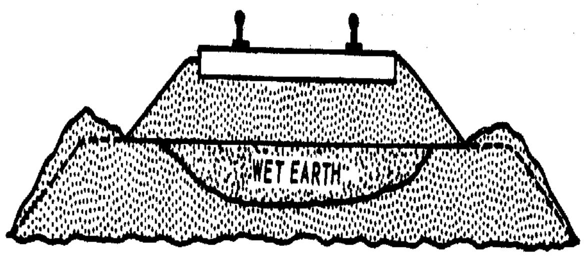


Figure 4-4. Effect of Water Pocket Under the Middle of Ties.

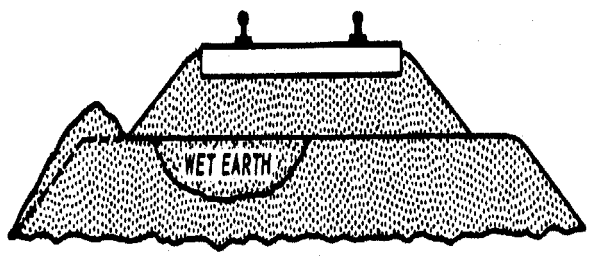


Figure 4-5. Effect of Water Pocket Under One End of Ties.

preventing obstructions that tend to divert or impede the flow in the drainage system. Emergency repairs to drainage systems must be made when onditions require such action, but a general program of repairing and cleaning should be conducted as needed.

4-18. Subsurface Drainage.

Water falling on ballast soon soaks through to the subgrade. Impervious subgrade not properly graded so the water will drain off to the side ditches will cause pools to form, which soften the subgrade, resulting in low spots in the summer and possible heaving in the winter. Poorly drained subgrades are reflected in poor track surface. Resurfacing or raising track instead of providing proper subsurface drainage is only a temporary measure. The only remedy to eliminate wet spots is to reshape the subgrade so water will flow toward the ditches. Subsurface drains, often in the form of underground pipes, are used in places where ditches will not work well - especially in large flat areas. They are also sometimes required to collect water from ditches and carry it to an outlet or stream. Subsurface drainage can also be used as an addition to ditches to promote drainage in poorly draining areas or in poorly draining subgrades.

4-19. Surface Drainage.

All surfaces must be sloped toward the drainage systems, and slopes maintained to minimize erosion during runoff. Drainage ditches and structures shall be kept in condition to dispose of runoff quickly. Obstructions that cause water to remain in pools shall be removed. Erosion of ditch sides and bottoms can be controlled by lining them with native grasses or by check dams, riprap, or pavement.

a. Ditch Maintenance. Where ditch maintenance is a constant problem because of faulty design or construction, permanent measures may be required. For example, if the gradient is unsuitable, the ditch may scour (too steep) or may accumulate silt (too flat). Unchecked growth of vegetation obstructs water flow and raises the water level in the ditch. This water can penetrate and soften the roadbed or restrict the drainage of the roadbed. Some soil wears away readily, and the slopes are eroded by rainfall and undermined by the flow of water in the ditch unless the gradient is correct and the streambed clear. Erosion of the ditch side slopes increases the silting in the ditch. Therefore, the side slopes must be stabilized or flattened to reduce erosion. Maintenance and repair measures must be determined to fit the existing conditions.

b. Erosion. Erosion occurs when the velocity of water or wind on the slope of an embankment or ditch dislodges the soil particles from these areas and carries them away. The degree to which the velocity affects the ditch and side slopes depends upon the stability of the soil or the protection it has been given by additional stabilization. Loose, sandy, or silty soils are easily eroded at almost any velocity. Such soils must be stabilized by vegetative cover, riprap, or concrete blankets. Riprap or concrete blankets must be extended below the ditch bottom to prevent undermining. The most satisfactory solution to erosion control is to flatten the slope to reduce the velocity of the water to keep erosion to a minimum and yet prevent unacceptable silting.

c. Lack of Drainage. When drainage is inadequate, unwanted water remains in the roadbed long enough to soften the subgrade. Dirty ballast can reduce the drainage of water as effectively as a stopped drain. Improperly shaped subgrade or pockets that have developed in the subgrade can impound water to the detriment of the track system. Subdrains may become clogged, or buildup of silt in adjacent ditches will reduce the flow of water from beneath the track structure.

d. Corrective Measures. Where it can be used effectively, off-track power equipment provides more economical results for cleaning of intercepting and drainage ditches than other methods. Handwork may be necessary where equipment is not available or where conditions prevent access of mechanical equipment.

4-20. Storm Pipe Drains.

a. A regular program of maintenance of pipe drains should be conducted. As-built record plans must be current regarding changes in the system. Limits of covered drains shall be marked with adequate signs to facilitate inspection and maintenance.

b. Routine Maintenance.

(1) *Ditches.* Ditches shall be kept clean, with adequate width and grade to insure proper drainage. Side banks should be maintained with sufficient slope that the material involved will not slide. Ditches should be maintained free of vegetation, debris, and other obstructions. Irregularities in alignment and grade tend to cause silting and scouring and should be avoided.

(2) *Culverts.* Screens on culverts shall be kept in place to prevent small animals from entering pipes. When silting occurs, the screen shall be removed and the opening cleaned. Special care should be given to culverts to make certain that stoppage does not occur.

(3) *Overflow.* Occasionally, drainage pipes discharging near bridges and culverts are subject to overflow or backwater during high water. Inspection should be made as soon as water recedes and if necessary the pipe drainage system flushed.

4-21. Soft Spots and Water Pockets.

Soft spots and water pockets exist in localities where soil conditions are unfavorable to satisfactory maintenance, particularly in clay. They will be found in both fills and cuts, but more generally in clay cuts. In soft spots, the ballast generally has settled into the roadbed, forming a trough or pockets under the track. This condition usually causes the subballast and roadbed to be pushed out laterally and raised (Figure 4-4), thus forming walls that prevent the water from draining from the track. This condition invariably results in water pockets. If surfacing and tamping track have no permanent effect in correcting soft spots and water pockets, an engineering study should be conducted to find a solution.

4-22. Slides.

a. General. Slides usually occur in unconsolidated material but may occur in open faces of rock formations. Gravity is a primary cause, supplemented by lubricating water, undermining (natural or artificial), clay-type material, certain types of geological structures that increase load and, in the case of rock slides specifically, by joint planes, fault planes, schistose structure, or strata dipping toward an open face. In the latter cases, slides are often accentuated by clay seams in partings of the rock. Where embankments are subjected to hydrostatic head for a length of time sufficient to saturate the embankment, slides may occur suddenly and without warning, particularly if the material is disturbed, as by spreading operations.

b. Corrective Measures. Each slide shall be considered an individual problem. The cause of the slide should be determined by thorough and expert examination of the soils, drainage conditions, and geological conditions related to the slide under the direction of an engineer. The prevalence of unstable material will be ascertained in order to arrive at a decision as to economic preference between the removal of sliding material and the application of suitable control methods. The removal or prevention of the cause of a slide is as important as the restoration of the roadway.

4-23. Vegetation Control.

The elimination of vegetation from areas where it is not required for erosion control is essential to economical maintenance of tracks, as well as to the appearance of the roadway. Vegetation should be controlled or eliminated to at least the limits of the ballast section to minimize the danger of fire. Proper visibility of traffic signals must be maintained. Dirty ballast permits the growth of weeds that interfere with drainage and shorten the life of ties. The remedy is to clean the ballast by using approved herbicides to eliminate vegetation from ballast and other areas of the roadway. Consult a specialist in this field for the best material and method to use. Weeds along the roadway can be controlled by mowing or by using herbicides. NOTE: It is mandatory that personnel handling herbicides be certified.

4-24. Snow and Ice Control.

Snowfall in amounts sufficient to obstruct railroad traffic or hinder operations can be expected at northern installations. Ice and packed snow can be a problem at crossings and in industrial areas where the tracks are in the pavement.

a. Snow Plan. A plan should be prepared in advance of the snow season in conjunction with the snow plan for installation roads. The plan must contain data on materials, manpower, and procedures to be used under varying storm conditions.

b. Snow Fences. Snow fences keep snow from drifting onto the roadbed in localities where heavy snowstorms are frequent. Effective placement of snow fences can be assured by keeping records of locations where drifts have occurred during the winter season.

c. Snow and Ice Removal. Snow and ice will be removed promptly from switches, frogs, guardrails, and flangeways at highway crossings. Also, snow and ice will be removed promptly from loading platforms, track scales, turntables or transfer tables, and from any other places where personnel or property may be endangered.

d. Chemical Control. Snow and ice control chemicals, sodium chloride (salt), calcium chloride, and urea, are effective in melting ice and packed snow. The lowest temperatures at which these chemicals are effective under field conditions are: sodium chloride +20 degrees Fahrenheit (-7 degrees Celsius), urea +25 degrees Fahrenheit (-4 degrees Celsius), and calcium chloride -20 degrees Fahrenheit (-29 degrees Celsius).

e. Snow-Melting Heaters. Snow-melting heaters may be used to advantage. At switches where serious snow and ice conditions are expected over long periods, oil or electric snow-melting pots or switch heaters may be used. Electrical switch heaters are not recommended because of the high operating cost.

4-25. Roadway Cleanup.

All materials removed and waste must be cleared from the work site at the close of the work day. The items cleaned up are to be properly disposed. The right-of-way at the work site must be left in a safe and orderly condition. If material, equipment, or tools are left or the work area is disturbed, a bad footing order must be issued to advise operating personnel or other personnel of the hazard that exists.

CHAPTER 5
STRUCTURES

5-1. General.

This chapter provides guidance for maintaining structures that are a part of the track system and some that may affect railroad operations. Bridges, trestles, and box culverts are used for water crossings, pedestrian walkways, roadways, other tracks, and drainage systems. Tunnels and cuts are used to penetrate hills or pass under bridges and other structures. The ensuing paragraphs of this chapter describe effective, preventive maintenance and/or the corrective measures appropriate for the several types of deficiencies usually encountered.

5-2. Supporting Substructures.

Bridges, trestles, and culverts shall be inspected using designated procedures and checkpoints.

5-3. Bridges and Culverts.

Railroad bridges may be constructed of steel, concrete, masonry, or wood. Steel bridges may be through-truss, through-panel girders, deck truss, or deck panel girder types. These bridges may be open deck or ballast deck. As far as the bridge structure is concerned, maintenance procedures are generally the same for all types. However, track maintenance will differ between the open deck and ballast deck bridges.

a. Open Deck Bridge. On an open deck bridge, bolts that secure ties to the stringers may work loose as the bearing areas of the ties on the stringers become worn, as the ties swell and shrink with moisture changes, or as rot or insect damage develops. Loose bolts on a number of adjacent ties can result in excessive gage and alignment deficiencies. Figure 5-1 shows an open deck pile trestle.

b. Ballast Deck Bridge. A ballast deck bridge is maintained in the same manner as on a regular roadbed. The only extra maintenance required in the track is to keep the drain holes unplugged and free draining.

5-4. Inner Guardrails.

On structures and approaches, inner guardrails are installed to guide equipment and prevent it from leaving the rail. Maintaining inner guardrails requires that loose spikes be replaced or redriven and track bolts be tightened. These maintenance operations should be performed at least annually.

5-5. Structure Drainage.

Periodic inspection of the weep holes near the bases of structures will reveal those that have become plugged and ineffective. A small wrecking bar or smaller tool should be sufficient to unplug the weep holes. The following measures should be taken for weep holes that frequently become plugged. If the plugging material is earth, sand, or debris carried into the hole from behind the structure, a screen should be inserted at the rear of the weep hole. To prevent plugging of the weep holes by animals or birds who enter from the front face of the structure, a screen should be placed across the front of the hole.

5-6. Structure and Approach Track.

Adequate and effective maintenance of track on structures and structure approaches is as essential as the maintenance of the structures. Poor track maintenance can cause excessive vibration and undue stresses in structures and can result in disastrous derailments.

5-7. Maintenance and Repairs.

All maintenance and repairs must be performed by an experienced bridge foreman and under the direction of a bridge engineer.

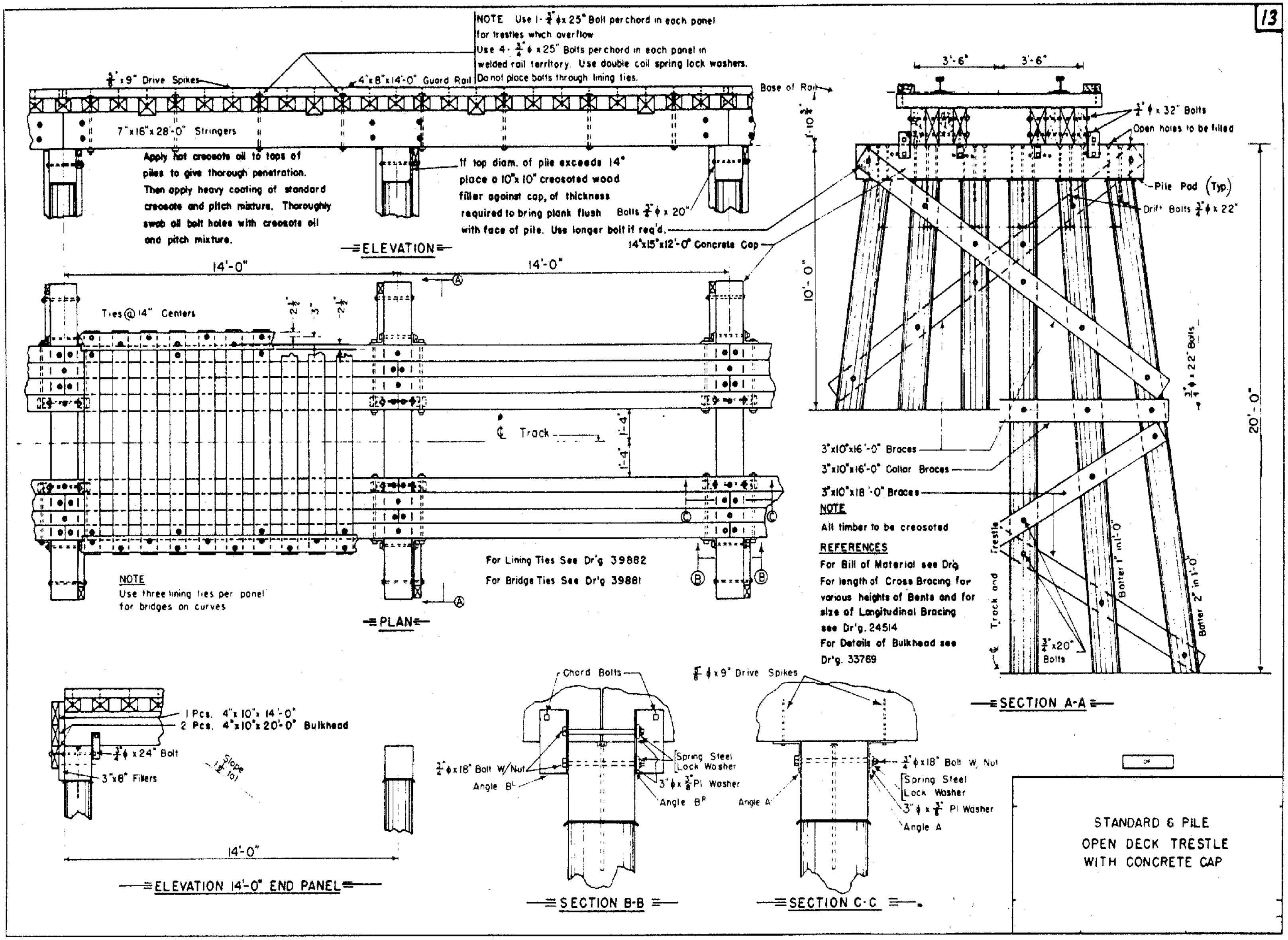


Figure 5-1. Open Deck Timber Pile Trestle.

CHAPTER 6

SAFETY

6-1. Safety First.

Constant presence of mind to insure safety to themselves and others is the primary duty of all personnel. In cases of doubt or uncertainty, the safe course must be followed.

6-2. Safe Condition of Tools, Equipment, and Clothing.

a. Personnel must exercise care to avoid injury to themselves and others. They must observe the condition of equipment and tools used in performing their duties, and when found defective, put them in safe condition or report the defects to the proper authority.

b. Personnel must wear proper clothing including appropriate protective equipment for work being performed. They must not wear red garments or other outer garments which may be mistaken for signals.

6-3. Dangerous Positions.

a. Personnel must not place themselves in dangerous positions and must warn others not to do so. Personnel must not get on or off moving equipment, except in case of emergency.

b. Personnel must not remain near the track when trains are passing. Where there are two or more tracks, they must, when practical, stand outside and clear of all such tracks. They must not stand close to switches while trains are approaching or passing, and must not rely on others to notify them of the approach of trains but must expect the movement of trains at any time on any track in either direction.

6-4. Fixed Structures.

Fixed structures that impair safe clearance are listed below in the general order of prevalent hazards.

a. *Side Clearance*. Platforms of 3 feet 8 inches in height must be 6 feet 2 inches from the center of the track and all other side clearances must be 8 feet 6 inches from the center of the track.

(1) *Gates*. At many installations, track may pass through boundary perimeter and/or security fences. Gates should open to provide 8 feet 6 inch of side clearance on straight track and a compensated 8 feet 6 inch of side clearance on curved track. CAUTION: Gates should be securely fastened in open position to prevent them from swinging toward the moving train, striking the locomotive and/or cars or a riding trainman.

(2) *Curves*. The side clearances will have to be increased in areas of switches and curves. The sharpness of the curve and the overhang of the longest cars brought onto the installation will determine the increase in clearance required. The side clearances must be increased as follows:

Car Length, ft	Increase of Side Clearance Per Degree of Curve, in.
0 to 62	1-1/2
62 to 89	3

b. *Overhead Clearances*. Pipe trestles, bridges, elevator bins, chutes, and other overhead structures must meet the clearance criteria as specified in TM 5-628/AFR 91-44 or MO-103.9. Equipment used to load or unload cars must be raised to a safe clearance prior to train movements. Suitable devices must be installed to keep this equipment in a raised position at a safe clearance when not in use.

c. *Restrictions*. Any location that does not provide proper side or overhead clearance must be protected with advanced warning signs noting that obstructions will not clear personnel riding on the side or top of cars. Also, an order should be issued to warn of such obstructions.

6-5. Safety Warnings and Signs.

a. *Installation of Warnings and Signs*. When hazards exist because of inadequate clearances, construction work, blind corners or approaches, proximity of flammable or explosive storage, heavy vehicle or pedestrian traffic, crossings, and any other condition that would jeopardize operations, people, or property, appropriate warning signs or signals shall be posted or installed. Signs may be fixed and installed at proper clearances from the track or may be portable and temporary. Signs must be standard blue signs or metal flags unless otherwise prescribed. Typical signs say "STOP", "DERAIL", "STOP-TANK CAR CONNECTED", and "DANGER-MEN WORKING."

b. Clearance Markings for Crossings, Turnouts, and Ladder Tracks. Clearance markers shall be painted on rails of adjacent tracks where the minimum clearance is reduced. Chrome yellow paint shall be used. The marker shall be 12 inches long and painted on both sides of each rail at the clearance point. Figure 3-7 shows the location of typical clearance markers. In paved areas, a 12- by 24-inch yellow marker shall be painted between the tracks at the clearance point.

c. Whistle and/or Ring (Bell) Signs. These are usually shop fabricated by painting a large “W” on a diamond-shaped sign. Whistle signs should be placed at least 900 feet in advance to arriving at the crossing, or as specified in applicable state or municipal requirements. Where no such requirements exist, AREMA standards should be used.

APPENDIX A
REFERENCES

A-1. Government Publications

Department of Defense

Departments of the Army, the Air Force, and the Navy

AFM 85-1	Resources and Work Force Management
AFM 86-1, Chap 2	Programming Civil Engineering Resources
AFM 127-101	Ground Accident Prevention Handbook
AR 420-10	General Provisions, Organization, Functions, Personnel
AR 420-72	Surface Areas, Bridges, Railroads, and Associated Structures
CE 804	Guide Specification for Military Construction; Railroads
EM 385-1-1	General Policy, Safety Office Functions, and Program Elements
NAVFAC DM 5.6	Civil Engineering, Trackage
NAVFAC DM 5.7	Wide Gage Portal Crane Trackage
NAVFAC INST 11230.1	Inspection, Certification, and Audit of Crane and Railroad Trackage
NAVFAC MO-322	Inspection of Shore Facilities
NAVFAC MO-103.9	Navy Railroad Trackage Field Assessment Manual
TM 5-628/AFR 91-44	Railroad Track Standards
TM 5-820-4/AFJMAN 32-1016	Drainage for Area Other than Airfields
TM 5-850-2/AFJMAN 32-1046	Railroad Design and Rehabilitation
MIL-HDBK-1005/6	Trackage

U.S. Department of Transportation, Federal Highway Administration: Manual of Uniform Traffic Control Devices for Streets and Highways, 400 7th Street S.W., Washington, DC 20590

A-2. Nongovernment Publications

American Railway Engineering and Maintenance Association, Manual for Railway Engineering, 50 F Street N.W., Washington, DC 20001

American Railway Engineering And Maintenance Association, Portfolio of Trackwork Plans, 50 F Street N.W., Washington, DC 20001.

Association of American Railroads, 50 F Street N.W., Washington, DC 20001.

APPENDIX B

STRINGLINING

B-1. Introduction.

Correcting alignment on a curve is much more complex than correcting alignment on tangent track. On a tangent, locations can be moved as needed without affecting the track adjacent to the spot being lined. This is not the case for a curve, where except for the smallest corrections, moving the track in one spot requires compensating movements elsewhere on the curve.

a. Stringlining is a method for taking alignment measurements around a curve, using a length of string, and using an arithmetic procedure to make adjustments to those measurements so that the curve can be smoothly relined. Even though stringlining is done with simple tools, with the required curve adjustments figured using a pencil and paper, the method is as accurate as any available - and it produces excellent results. Successfully applying it, though, does require some study and practice as it is a trial and error process requiring knowledge of the method and good judgment.

b. There are several different methods for figuring the required adjustments for correcting curve alignment. One is given in chapter 5 of the AREMA manual. Two methods, the Bartlett method and Bracket method, are described below. Regardless of the method used, the basic principles are the same, as is the procedure for measuring the original (uncorrected) curve alignment.

B-2. Making Alignment Measurements.

Alignment measurements are made using a stringline and a ruler, as illustrated in Figure B-1. A 62-foot string is often used for convenience, as with that length every inch of mid-ordinate measure equals 1 degree of curvature. However, the 31-foot string may help achieve better accuracy and should always be used for short curves. With a 31-foot string, every 1/4 inch of mid-ordinate equals 1 degree of curvature.

a. As shown in Figure B-1, the ends of the string are held on the gage face of the outside rail (5/8 inch down from the top of the rail), while at the center of the string, a measurement is made with a ruler from the string to the gage face of the rail. This measurement, from the center of the string to the rail, is referred to as a mid-ordinate, or more simply, just ordinate. The sharper the curve at a given location, the larger the mid-ordinate measurement will be.

b. Especially for measuring at the beginning of a curve, where the track may be too far inward, it is common practice to attach the string to wooden handles, with the string ends 1 inch from the rail. If this is done, the 1-inch offset must be subtracted from every mid-ordinate measurement, or a ruler modified with a 1-inch offset must be used.

c. To prepare for collecting curve alignment measurements, mark the measurement locations along the curve as follows. Begin near one end of the curve at a point which is clearly at least 60 feet back into the tangent (not quite into the curve or spiral) if using a 62-foot string, or at least 30 feet back into the tangent if using a 31-foot string. With a lumber crayon, mark a line on the rail at this point and label it as station 0. Have two people hold ends of a 15 1/2-foot length of tape measure, and from station 0, mark and number stations all the way around the curve until clearly at least 60 feet (or 30 feet) into the tangent at the other end. All alignment measurements will be taken at the numbered stations.

d. For the Bartlett method, set up a form with columns labeled as shown in Figures B-2 through B-9. For the Bracket method, use the form shown in Figure B-10. List the station numbers in column 1 and write the mid-ordinate measurements in column 2. If using a 62-foot string when taking mid-ordinate measurements, measuring to the nearest 1/4 inch is usually good enough for most work on military track (lower speed). If using a 31-foot string, measurements should be taken to the nearest 1/8 inch.

e. If using a 62-foot string, the string ends will be 4 stations apart when making measurements; with a 31-foot string, the ends will be 2 stations apart. With one end of the string held at station 0 and the 62-foot end at station 4 (or 31-foot end at station 2), begin taking mid-ordinate measures and recording them on the form. With a 62-foot string, the first measurement will be recorded at station 2. Move the ends of the string one station forward, and repeat the process until the mid-ordinate measure at all stations has been recorded.

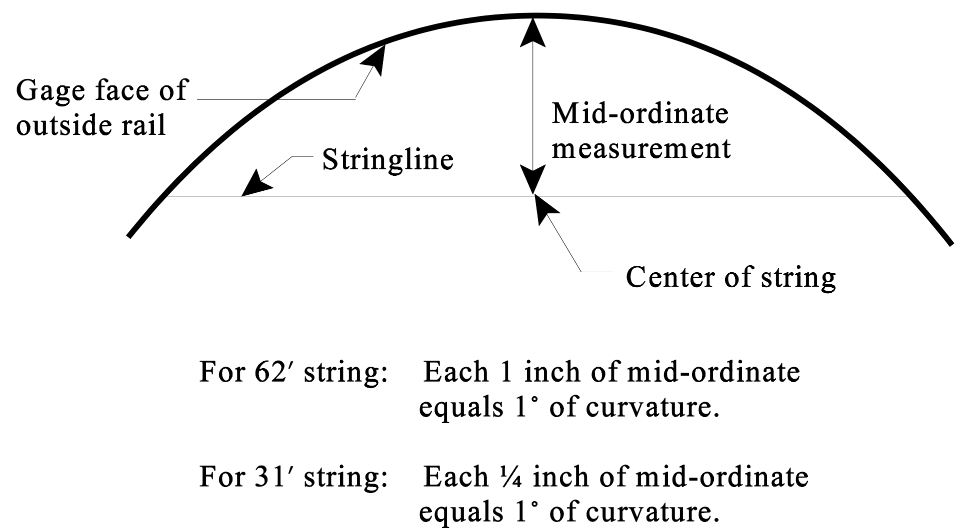


Figure B-1. Measuring Curve Alignment With a Stringline.

f. Note that near the beginning of a curve, the track is nearly tangent, and the actual alignment may allow the track to be too far inward, producing a negative mid-ordinate reading; this is normal. Record such readings on the form, keeping the negative sign.

g. While measuring ordinates, note in the far right column (Remarks) locations of road crossings, turnouts, bridges, or other locations where the track either cannot be moved, or where movement needs to be limited because of limited side clearances.

B-3. Calculations (Bartlett Example).

The objective of the calculations is to produce the best set of revised ordinates (column 5) giving the most uniform curve possible. In a perfect curve, all the values (between spirals) would be the same at each station, but in practice, there will usually have to be some variations. The method is described using an example. Calculations are done in the following steps:

a. Convert ordinate measurements to units and produce cumulative unit count. To make calculations much easier, the mid-ordinate measurements in inches and fractions are converted to units. If recorded to the nearest 1/4 inch, use 1/4 inch as the unit to convert the measurements: thus a 1 1/4-inch measurement in column 2 becomes 5 units in column 3 and a 2 inch measurement becomes 8 units. Then produce a running cumulative total of the ordinates in the next column. Your form should now look like the one shown in Figure B-3. In the example, note the string length recorded (62 feet), the size of the curve units (1/4 inch), and that the center of High Street crossing is located at station 15, which means that the track at this station cannot be moved (without tearing out the crossing).

b. Estimate the beginning and ending station of the full curve. By inspection, look at the values of the original ordinates in column 3 and estimate the stations where the full curve begins and ends. In Figure B-3, it appears that the entry spiral ends (and full curve begins) at station 5 and that the curve ends (and exit spiral begins) at station 21.

c. Determine the coverage ordinate value in the curve. Add the ordinate values at the stations within the full curve and divide by the number of stations within the curve. In the example, ordinate values for stations 5 through 21 are added - this is done easily by taking the cumulative value at station 21 (283) and subtracting the cumulative amount up to station 4 (6), giving a total of 277. The total of 277 units is divided by the total of 17 stations to get an average of 16.3.

STRINGLINE NOTES **Date:** **Location:**

	Ord.	Curve Units (in.) 1/4						Half	Full Throw	
Sta.	Meas.	Orig.	Cum.	Rev.	Cum.	Diff.	Sum	Throw	(Inches)	Remarks

Figure B-2. Bartlett Stringline Form.

STRINGLINE NOTES				**Date:** 2/25/95			**Location:** Example Curve			
	Ord.	Curve Units (in.) 1/4						Half	Full Throw	
Sta.	Meas.	Orig.	Cum.	Rev.	Cum.	Diff.	Sum	Throw	(Inches)	Remarks
1										62-foot string
2	- 1/4	-1	-1							
3	0	0	-1							
4	1 3/4	7	6							
5	4	16	22							
6	6 1/4	25	47							
7	5 1/2	22	69							
8	2 3/4	11	80							
9	3	12	92							
10	4 1/2	18	110							
11	4 3/4	19	129							
12	3 1/2	14	143							
13	3	12	155							
14	3 3/4	15	170							
15	4 1/4	17	187							Center of High Street Crossing.
16	4	16	203							
17	3 1/2	14	217							
18	5	20	237							
19	3 1/2	14	251							
20	4	16	267							
21	4	16	283							
22	2	8	291							
23	1 1/4	5	296							
24	0	0	296							
25	- 1/4	-1	295							
26	1/2	2	297							

Figure B-3. Bartlett Stringline Example: Stage 1.

d. Produce the first trial curve (with spirals). In column 5 write the average curve value, in the nearest whole number, at the stations in the full curve. Then, estimate values for producing a smooth spiral at each end (a uniform increase or decrease in curvature) and write these values in the beginning and ending stations. This is done according to the following rule: The sum of the ordinates in the revised curve must equal the sum of the ordinates in the original curve.

e. If this rule is not obeyed, rail would have to be either added or cut out of the curve to restore its alignment. When done, your form should appear as in Figure B-4. In the example, the full curve (station 5 to station 21) uses 16 units at 17 stations, or a total of 272 units. As all stations in the original curve used 297 units, this leaves 297 minus 272 or 25 units with which to form the spirals on the revised curve. Thirteen of these units were used at stations 3 and 4, and the remaining 12 at stations 22 and 23.

f. Note that while the track cannot be moved at High Street, the revised mid-ordinate there need not be the same as the original; this is because the track off either end of the crossing can move, which would change the ordinate measurement at the center of the crossing. For longer crossings where the track cannot move even at stations on either side, those original ordinate values must be kept as the revised values.

g. *Choose Maximum Throw.* Decide the maximum amount you are willing to move the curve at any station once the curve solution is done. In practice, 6 inches to 8 inches is a good limit to start with. In the example, 8 inches (or 32 units) is chosen.

h. *Begin Calculations.* Do the calculations for the first 4 or 5 stations, as follows, referring to Figure B-5. Create the revised ordinate cumulative values and record them in column 6. Then subtract the revised ordinates from the original ordinates and record the result in column 7, keeping any negative signs produced.

i. Follow the arrows to produce the sum and half throw; these values are initially set at zero. At each station, the new sum value is produced by adding the sum in the previous station to the difference at that station. The new half throw is produced by adding the sum and half throw at the previous station.

j. *Check the Actual Throw.* For the example, the maximum desired throw was given as 8 inches or 32 units. To avoid exceeding this limit, the maximum half throw value must be kept to 16 units. Referring to Figure B-5, the half throw at station 6 is -20 units, which would require a full throw at that point of -40 units or 10 inches inward. As the maximum throw is exceeded, we must back up and change some of the revised ordinates to lower the throw.

k. Since the half throws are too large in a negative direction, it means that the revised ordinates are too much larger than the original ordinates. In Figure B-6, this is fixed by subtracting 2 units from station 3 and adding them to station 23 (to keep the total number of units in the curve the same). Making this change brings the half throw at station 6 down to -14, and the calculations continue until once again the throw is exceeded at station 13.

l. *Adjust Revised Ordinates to Limit Throw.* In most stringline problems, revised ordinates will need to be changed as the solution proceeds to keep throws within desired limits. The art to the process is deciding which stations to change. To keep the curve smooth, adjacent stations are best kept within one unit, except in the spirals. Also, it is best not to have adjacent stations alternating back and forth by 1 unit.

(1) If the half throw is too large in the <u>positive</u> direction, <u>add</u> units to the revised ordinates at one or more lower station numbers (and subtract from higher numbers to keep the total ordinates unchanged). If the throw is too large in the <u>negative</u> direction, <u>subtract</u> units to the revised ordinates at one or more lower station numbers (and add to higher numbers to keep the total ordinates unchanged).

(2) The difference in the station numbers between the point where units are added and subtracted, multiplied by the change in the units, equals the total change in half throw produced. For example, if the ordinate at station 12 is increased by 1 unit and the ordinate at station 20 is decreased by 1 unit (to keep the total the same), the half throws at station 20 and all following stations will decrease by 20 minus 12 or 8 units. If station 12 had been increased by 2 units and station decreased by 2 units, the total change in half throws from station 20 onward would be 16 units.

(3) Adjustment of an ordinate at a station changes the throws at all following stations. Thus, it is best to avoid changing ordinates much farther back in the curve than calculations have progressed to if that part of the curve is smooth and the throws are small.

(4) In the example, changes are needed to keep the half throws no larger than 16 (positive or negative) and to force a zero throw at station 15 (because the track at High Street crossing cannot be moved). The three rules above are used to produce the results shown in Figure B-7. One unit was added to the ordinates at stations 8 through 10 (which were changed from 16 to 17), and one unit was subtracted

STRINGLINE NOTES **Date:** 2/25/95 **Location:** Example Curve

Sta.	Ord. Meas.	Curve Units (in.) 1/4 Orig.	Cum.	Rev.	Cum.	Diff.	Sum	Half Throw	Full Throw (Inches)	Remarks
1										62-foot string
2	- 1/4	-1	-1	0						
3	0	0	-1	4						
4	1 3/4	7	6	9						
5	4	16	22	16						
6	6 1/4	25	47	16						
7	5 1/2	22	69	16						
8	2 3/4	11	80	16						
9	3	12	92	16						
10	4 1/2	18	110	16						
11	4 3/4	19	129	16						
12	3 1/2	14	143	16						
13	3	12	155	16						
14	3 3/4	15	170	16						
15	4 1/4	17	187	16						Center of High Street Crossing.
16	4	16	203	16						
17	3 1/2	14	217	16						
18	5	20	237	16						
19	3 1/2	14	251	16						
20	4	16	267	16						
21	4	16	283	16						
22	2	8	291	9						
23	1 1/4	5	296	3						
24	0	0	296	0						
25	- 1/4	-1	295	0						
26	1/2	2	297	0						

Figure B-4. Bartlett Stringline Example: Stage 2.

STRINGLINE NOTES **Date:** 2/25/95 **Location:** Example Curve

Sta.	Ord. Meas.	Curve Units (in.) 1/4 Orig.	Cum.	Rev.	Cum.	Diff.	Sum	Half Throw	Full Throw (Inches)	Remarks
1							0	0		62-foot string
2	- 1/4	-1	-1	0	0	-1	-1	0		
3	0	0	-1	4	4	-4	-5	-1		
4	1 3/4	7	6	9	13	-2	-7	-6		
5	4	16	22	16	29	0	-7	-13		
6	6 1/4	25	47	16				-20		
7	5 1/2	22	69	16						
8	2 3/4	11	80	16						
9	3	12	92	16						
10	4 1/2	18	110	16						
11	4 3/4	19	129	16						
12	3 1/2	14	143	16						
13	3	12	155	16						
14	3 3/4	15	170	16						
15	4 1/4	17	187	16						Center of High Street Crossing.
16	4	16	203	16						
17	3 1/2	14	217	16						
18	5	20	237	16						
19	3 1/2	14	251	16						
20	4	16	267	16						
21	4	16	283	16						
22	2	8	291	9						
23	1 1/4	5	296	3						
24	0	0	296	0						
25	- 1/4	-1	295	0						
26	1/2	2	297	0						

Figure B-5. Bartlett Stringline Example: Stage 3.

STRINGLINE NOTES **Date:** 2/25/95 **Location:** Example Curve

Sta.	Ord. Meas.	Curve Units (in.) 1/4 Orig.	Cum.	Rev.	Cum.	Diff.	Sum	Half Throw	Full Throw (Inches)	Remarks
1							0	0		62-foot string
2	- 1/4	-1	-1	0	0	-1	-1	0		
3	0	0	-1	2	2	-2	-3	-1		
4	1 3/4	7	6	9	11	-2	-5	-4		
5	4	16	22	16	27	0	-5	-9		
6	6 1/4	25	47	16	43	9	4	-14		
7	5 1/2	22	69	16	59	6	10	-10		
8	2 3/4	11	80	16	75	-5	5	0		
9	3	12	92	16	91	-4	1	5		
10	4 1/2	18	110	16	107	2	3	6		
11	4 3/4	19	129	16	123	3	6	9		
12	3 1/2	14	143	16	139	-2	4	15		
13	3	12	155	16				19		
14	3 3/4	15	170	16						
15	4 1/4	17	187	16						Center of High Street Crossing.
16	4	16	203	16						
17	3 1/2	14	217	16						
18	5	20	237	16						
19	3 1/2	14	251	16						
20	4	16	267	16						
21	4	16	283	16						
22	2	8	291	9						
23	1 1/4	5	296	5						
24	0	0	296	0						
25	- 1/4	-1	295	0						
26	1/2	2	297	0						

Figure B-6. Bartlett Stringline Example: Stage 4.

STRINGLINE NOTES **Date:** 2/25/95 **Location:** Example Curve

Sta.	Ord. Meas.	Curve Units (in.) 1/4 Orig.	Cum.	Rev.	Cum.	Diff.	Sum	Half Throw	Full Throw (Inches)	Remarks
1							0	0		62-foot string
2	- 1/4	-1	-1	0	0	-1	-1	0		
3	0	0	-1	2	2	-2	-3	-1		
4	1 3/4	7	6	9	11	-2	-5	-4		
5	4	16	22	16	27	0	-5	-9		
6	6 1/4	25	47	16	43	9	4	-14		
7	5 1/2	22	69	16	59	6	10	-10		
8	2 3/4	11	80	17		-6	4	0		
9	3	12	92	17		-5	-1	4		
10	4 1/2	18	110	17		1	0	3		
11	4 3/4	19	129	16		3	3	3		
12	3 1/2	14	143	16		-2	1	6		
13	3	12	155	16		-4	-3	7		
14	3 3/4	15	170	16		-1	-4	4		
15	4 1/4	17	187	16				0		Center of High Street Crossing.
16	4	16	203	16						
17	3 1/2	14	217	16						
18	5	20	237	16						
19	3 1/2	14	251	15						
20	4	16	267	15						
21	4	16	283	15						
22	2	8	291	9						
23	1 1/4	5	296	5						
24	0	0	296	0						
25	- 1/4	-1	295	0						
26	1/2	2	297	0						

Figure B-7. Bartlett Stringline Example: Stage 5.

from stations 19 through 21 (which were changed from 16 to 15), thus keeping the total ordinate count unchanged. By making these changes, the half throw at station 13 was reduced from 19 to 7, and a zero throw was produced at High Street crossing (station 15).

m. *Zero the Half Throw at the Last Station.* In Figure B-8, the arithmetic for the ordinates in Figure B-7 is completed to show the results. However the solution is not yet complete because the throws have become too large again, and the half throw at the last station is not zero. (Also, if the last entry for sum is not zero, a mistake has probably been made somewhere in the preceding arithmetic). In the example, adjustments were made to stations 16 though 24 to produce the completed solution in Figure B-9.

n. *Conclusion.* When the curve solution is complete, fill in the full throw column by multiplying the entries in the half throw column by 2 and converting to inches, keeping any negative signs. The entry in the full throw column is the amount that the track must be moved at each station to reline the curve. Positive values mean the track must be moved outward, and negative values mean the track must be moved inward toward the center of the curve.

o. The Bartlett stringline form can be set up on any standard computer spreadsheet software, with the calculating rules included. If this is done, any time a new ordinate is chosen all the resulting calculations and throws will be instantly done by the software, which makes using this method much easier and quicker. The Bartlett example forms (Figures B-2 through B-9) were all done with computer spreadsheet software.

B-4. The Bracket (Portser) Stringline Method.

Alignment measurements for the bracket method of curvature correction are taken using the same procedure as defined for the Bartlett Method. Initial calculations for the bracket method of curvature correction are also similar to the calculations used in the Bartlett Method. Mid-ordinate readings are made in either inches and converted to units or taken directly in units (typically 1/8-inch units). A blank form for using the Bracket method is shown in Figure B-10.

a. The next step is to determine the average curvature within the full curve. From the mid-ordinate readings, one can estimate the beginning and ending stations of the full body of the curve. Stations before and after these points represent the spirals into and out of the curve, or even part of the adjoining tangent track.

b. Once the beginning and ending stations of the actual curve are defined, sum the mid-ordinate readings of these stations and all those in between. Then divide by the number of stations which were included in the ordinate sum. This provides the average mid-ordinate within the full curve. This average mid-ordinate value, in units, can be converted to inches. Using the relationship of 1 inch equals 1 degree of curvature for a 62-foot chord or 1 inch equals 4 degrees of curvature for a 31-foot chord, the average mid-ordinate value in inches can be converted to an average degree of curvature for this particular curve.

c. After determining the average mid-ordinate value in units, the next step is to determine the throws (the inward or outward movements of the track at each station) which will be needed to restore proper curve alignment, and then, to see what the final ordinates should be once these throws are executed.

d. By observing the mid-ordinate readings taken at each station, one can determine where throws will need to be made to correct the curvature. In the full curve, the objective is to have all mid-ordinates of equal value, or close in value (to within a couple of units of the average mid-ordinate). Achieving this objective will result in a smooth curve. At each end of the curve, the spiral should provide a smooth, uniform transition from mid-ordinate reading of 0 units in the tangent track to the average mid-ordinate value in the full curve.

e. The Bracket Method is a trial and error process of curvature correction. Two rules need to be followed when making the calculations to determine the throws needed for curvature correction:

(1) If only one station is thrown, that station will get the full effect of the throw and the adjacent stations will get an apparent half-throw (appears to move, but does not actually move) in the opposite direction of the original throw.

(2) If two or more stations are thrown at the same time (forming a bracket), the stations at the end of the bracket will see a throw equal to one-half of the original throw while the interior stations of the bracket see no effect of the throw. The adjacent stations will see an apparent half-throw in the opposite direction of the original throw.

f. Using the process of throws and apparent half-throws, new ordinates can be calculated for the stations affected by the throw. Several trials may be

STRINGLINE NOTES		**Date:** 2/25/95			**Location:** Example Curve					
Sta.	Ord. Meas.	Curve Units (in.) 1/4 Orig.	Cum.	Rev.	Cum.	Diff.	Sum	Half Throw	Full Throw (Inches)	Remarks
1							0	0		62-foot string
2	- 1/4	-1	-1	0	0	-1	-1	0		
3	0	0	-1	2	2	-2	-3	-1		
4	1 3/4	7	6	9	11	-2	-5	-4		
5	4	16	22	16	27	0	-5	-9		
6	6 1/4	25	47	16	43	9	4	-14		
7	5 1/2	22	69	16	59	6	10	-10		
8	2 3/4	11	80	17	76	-6	4	0		
9	3	12	92	17	93	-5	-1	4		
10	4 1/2	18	110	17	110	1	0	3		
11	4 3/4	19	129	16	126	3	3	3		
12	3 1/2	14	143	16	142	-2	1	6		
13	3	12	155	16		-4	-3	7		
14	3 3/4	15	170	16		-1	-4	4		
15	4 1/4	17	187	16		1	-3	0		Center of High Street Crossing.
16	4	16	203	16		0	-3	-3		
17	3 1/2	14	217	16		-2	-5	-6		
18	5	20	237	16		4	-1	-11		
19	3 1/2	14	251	15		-1	-2	-12		
20	4	16	267	15		1	-1	-14		
21	4	16	283	15		1	0	-15		
22	2	8	291	9		-1	-1	-15		
23	1 1/4	5	296	5		0	-1	-16		
24	0	0	296	0		0	-1	-17		
25	- 1/4	-1	295	0		-1	-2	-18		
26	1/2	2	297	0		2	0	-20		

Figure B-8. Bartlett Stringline Example: Stage 6.

STRINGLINE NOTES **Date:** 2/25/95 **Location:** Example Curve

Sta.	Ord. Meas.	Curve Units (in.) 1/4				Diff.	Sum	Half Throw	Full Throw (Inches)	Remarks
		Orig.	Cum.	Rev.	Cum.					
1							0	0	0	62-foot string
2	- 1/4	-1	-1	0	0	-1	-1	0	0	
3	0	0	-1	2	2	-2	-3	-1	- 1/2	
4	1 3/4	7	6	9	11	-2	-5	-4	-2	
5	4	16	22	16	27	0	-5	-9	-4 1/2	
6	6 1/4	25	47	16	43	9	4	-14	-7	
7	5 1/2	22	69	16	59	6	10	-10	-5	
8	2 3/4	11	80	17	76	-6	4	0	0	
9	3	12	92	17	93	-5	-1	4	2	
10	4 1/2	18	110	17	110	1	0	3	1 1/2	
11	4 3/4	19	129	16	126	3	3	3	1 1/2	
12	3 1/2	14	143	16	142	-2	1	6	3	
13	3	12	155	16	158	-4	-3	7	3 1/2	
14	3 3/4	15	170	16	174	-1	-4	4	2	
15	4 1/4	17	187	16	190	1	-3	0	0	Center of High Street Crossing.
16	4	16	203	15	205	1	-2	-3	-1 1/2	
17	3 1/2	14	217	15	220	-1	-3	-5	-2 1/2	
18	5	20	237	15	235	5	2	-8	-4	
19	3 1/2	14	251	15	250	-1	1	-6	-3	
20	4	16	267	15	265	1	2	-5	-2 1/2	
21	4	16	283	14	279	2	4	-3	-1 1/2	
22	2	8	291	10	289	-2	2	1	1/2	
23	1 1/4	5	296	7	296	-2	0	3	1 1/2	
24	0	0	296	1	297	-1	-1	3	1 1/2	
25	- 1/4	-1	295	0	297	-1	-2	2	1	
26	1/2	2	297	0	297	2	0	0	0	

Figure B-9. Stringline Example: Final Solution.

Curve Name or No.: ____________________
Track: ____________________
Inspector: ____________________

Date: ____________________
Stations: 15'-6"/31'-0"
Ordinates: ⅛" units

Station	Measured Ordinate	Throw	Revisions	New Ordinate	Throw	Revisions	New Ordinate	Throw	Revisions	Final Ordinate	Final Throw

31'-0" stations (62'-0" string), 1" midordinate reading = 1° of curvature
15'-6" stations (31'-0" string), 1" midordinate reading = 4° of curvature

Calculations:

Figure B-10. Bracket Stringline Method.

required to smooth the curve. Once a final set of ordinates is determined, the final throw must be determined for each station. This is done by summing the throws for each station across the calculation sheet. The example calculation sheet (Figure B-11) illustrates these principles.

g. This example illustrates a curve which has been stringlined using 21 stations and with mid-ordinate readings taken in 1/8-inch units using a 31-foot chord. The limits of the full curve extend approximately from station 8 through station 16. The average mid-ordinate reading is approximately 47 units, which converts to a degree of curvature of approximately 23.5 degrees. As the original ordinate values indicate (column 2), there is misalignment within each spiral and in the full curve.

h. The first trial throws occur with one station in a spiral and two brackets of two stations within the full curve. Station 5 in the spiral receives a throw of -12 units. To make the revisions to this point, station 5 moves the full 12 units while stations 4 and 6 experience an apparent move of one-half the throw, or 6 units. Stations 11 and 12 and stations 15 and 16 are thrown by 4 units and 16 units, respectively. Since these form a bracket, the stations themselves see a revision equal to one-half of the throw, and the adjacent stations see revisions equal to a half-throw in the opposite direction.

i. After revisions are calculated, new mid-ordinates can also be calculated. For this example, second and third trials are needed to produce a curve with uniform spirals and uniform full curvature. The third trial illustrates a very large bracket containing seven stations to correct curvature deviations in both the curve and one spiral. Notice that the interior stations within the brackets saw no revisions to their mid-ordinate readings.

j. The final throw for a station is determined by summing the throw from each trial for that station. Station 5 has a final throw of -12 units. This was calculated by summing the throws of -12 units, 0 units, and 0 units. Station 18 has a final throw of 0 units. This was calculated by summing the throw of 0 units, +4 units, and -4 units. Once the final alignment corrections are made in the field, station 18 will not actually have to be moved.

k. If used properly, the Bracket (Portser) Method is a relatively easy way of determining throws for the correction of alignment deviations in curves.

l. *Adjusting the Track.* At each station, stakes should be driven a specified distance from the rail to serve as a reference for measuring how far the track is actually being moved. Two procedures are common:

(1) Drive all stakes exactly 5 feet (or other distance) from the gage face of the outside rail of the existing curve. Then add or subtract (as the stringline notes show) the distance the track needs to be moved at each station to determine what the final stake-to-rail distance should be after the track is moved.

(2) First add or subtract (as the stringline notes show) the distance the track needs to be moved at each station from a specified distance (for example, 5 feet), and drive stakes that distance from the gage face of the outside rail of the existing curve. Then, at each station, move the track until the specified distance is reached. This procedure has the advantage of not requiring distances to be figured when the track is being moved. When done, the distance from the rail to the stake should be the same at each station.

m. In the Bartlett stringline example, the actual throws needed to reline the curve are shown in Figure B-9. Notice that the track at stations 4 through 7 has to be moved inward several inches, stations 9 through 14 all move outward, and stations 16 through 21 all move inward. In practice, moving several consecutive stations in a curve all in one direction may prove difficult. In such cases, relining may be best accomplished by moving the track in two stages. First, work around the curve making all smaller movements up to 2 inches or so, as the first 2 inches to 4 inches of movement at the stations require larger throws. Then work back around the curve finishing off the movement at the stations requiring the larger throws.

Curve Name or No.: Murphy Bend
Track: McCoy Lead
Inspector: Railroadius Inspectorus

Date: 12/18/95
Stations: 15'-6"/31'-0"
Ordinates: ⅛" units

Station	Measured Ordinate	Throw	Revisions	New Ordinate	Throw	Revisions	New Ordinate	Throw	Revisions	Final Ordinate	Final Throw
0	0			0			0			0	
1	0			0			0			0	
2	0			0			0			0	
3	0			0			0			0	
4	-4		6	2			2			2	
5	18	-12	-12	6		4	10			10	-12
6	18		6	24	-8	-4	20			20	-8
7	34			34		-4	30			30	-8
8	36			36		4	40			40	
9	48			48			48			48	
10	50		-2	48			48			48	
11	46	4	2	48			48			48	4
12	44		2	46			46		2	48	4
13	52		-2	50			52	-4	-2	48	-4
14	40		8	48			48		0	48	-4
15	56	-16	-8	48			48		0	48	-20
16	48		-8	40			40		0	40	-20
17	24		8	32		-2	30		0	30	-4
18	16			16	4	4	20		0	20	0
19	14			14		-2	12		-2	10	-4
20	0			0			0		2	2	
21	0			0			0			0	

31'-0" stations (62'-0" string), 1" midordinate reading = 1° of curvature
15'-6" stations (31'-0" string), 1" midordinate reading = 4° of curvature
Calculations:

Figure B-11. Bracket Stringline Method Example.