

# UNIFIED FACILITIES CRITERIA (UFC)

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## RAILROAD TRACK MAINTENANCE & SAFETY STANDARDS



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**UNIFIED FACILITIES CRITERIA (UFC)**

**RAILROAD TRACK MAINTENANCE  
& SAFETY STANDARDS**

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U.S. ARMY CORPS OF ENGINEERS (Preparing Activity)

NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

Record of Changes (changes are indicated by  
1\ ... /1/)

| <b>Change No.</b> | <b>Date</b> | <b>Location</b> |
|-------------------|-------------|-----------------|
|                   |             |                 |
|                   |             |                 |

## FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with [USD\(AT&L\) Memorandum](#) dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA). Therefore, the acquisition team must ensure compliance with the more stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

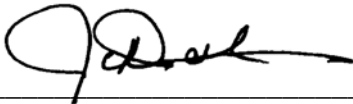
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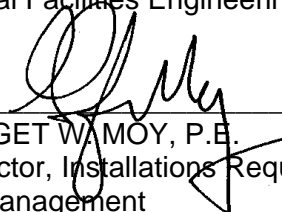
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**UNIFIED FACILITIES CRITERIA (UFC)  
REVISION SUMMARY SHEET**

**Description of Changes:** UFC 4-860-03 unifies the Army/Air Force Handbook of Railroad Track Standards with the Navy's Railroad Trackage Field Assessment Manual into one Department of Defense UFC manual.

**Reasons for Changes:**

- Consolidation of DOD railroad track standards into one single document.
- Consolidation of both railroad track maintenance standards and safety standards into a singular technical manual.

**Impact:** Inspection frequencies remain unchanged and the quality of track required remains nearly the same. These factors reflect a negligible cost impact as a result of the required track maintenance activities. However, the following benefits should be realized:

- Improvement in installation personnel's ability to determine the level of effort required for each track inspection.
- DOD Inspections that will be more consistent with the Federal Railway Administration (FRA) safety standards used for commercial trackage.
- Proper and expanded use of new technology and materials, such as new types of ties that have gained industry acceptance.
- Improvement of railroad track inspections and overall railroad management due to the much greater use of table formats for clarity and understanding.
- Improved inspections since the UFC now differentiates between railroad maintenance requirements and the very minimal FRA safety standards.

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## CHAPTER 1

### INTENT AND APPLICATION

#### 1-1. INTRODUCTION.

a. The Department of Defense's (DOD) railroad system is a critical asset for both peacetime and mobilization missions.

b. The standards in this UFC are presented to protect investments in track maintenance and rehabilitation and to ensure that DOD's railroad track is maintained at the level needed to support mission requirements. The standards in this UFC provide maintenance standards for each possible type of deficiency addressed in the Federal Railroad Administration (FRA) *Track Safety Standards*. DOD policy is to maintain its railroad track at a standard that exceeds FRA Class 2 safety standards and adhere to additional DOD speed restrictions as stated in this UFC. The following standards specifically identify separate thresholds for safety standards and maintenance standards. If a standard is not specifically listed as a safety standard, it shall be used as a maintenance standard. For Navy installations, NAVFAC Instruction (NAVFACINST) 11230.1, *Inspection, Certification, and Audit of Crane and Railroad Trackage*, shall also be used based on category of track and amount of use.

c. Simply meeting the minimum standard required in this UFC is not necessarily the best, most cost-effective, long-term maintenance policy. The frequent occurrence of substandard or restricted conditions indicates the need for a comprehensive track evaluation to determine if major repair or rehabilitation is warranted.

#### 1-2. DEFINITIONS. The following standards are discussed in this UFC:

a. **Safety Standards.** Based on the degree of hazard, these standards provide minimum safe operating limits for specific defects. FRA and DOD safety standards are addressed in [Appendix F](#) for comparison with maintenance standards. When established safety limits are exceeded, speed restrictions or "No Operation" shall be applied and enforced.

b. **Maintenance Standards.** These standards provide limits for specific defects and should be used to determine when maintenance is desirable and should be accomplished. This allows for maintenance or repair before the condition exceeding safety standards develops. Each installation shall develop a maintenance policy for additional defects not addressed in this UFC.

#### 1-3. REFERENCES. [Appendix A](#) contains a list of references used in this UFC.

#### 1-4. INTENT.

a. These standards define the minimum required maintenance condition levels for railroad track. These standards shall be used for inspection and routine maintenance of railroad track by in-house or contract personnel.

b. These standards are not intended for, and shall not be used as specifications for, new construction or major track rehabilitation. The guidance given for Navy projects in UFC 4-860-02N, *Design: Trackage*, and for Army and Air Force projects in UFC 4-860-01FA, *Design: Railroad Design and Rehabilitation*, with Unified Facilities Guide Specification (UFGS) 05650, *Railroad Track and Accessories*, and/or host nation industry/government



standards will continue to apply to new construction and the complete reconstruction of segments of existing facilities.

c. Should the commercial carrier serving the installation require a more restrictive FRA standard or criteria not included in these standards, the installation track shall be maintained to meet the carrier's requirements.

d. The judgment of the designated track inspector and the criteria presented in this UFC must supplement each other in the application of these standards.

**1-5. TRACK CATEGORIES.** All railroad track shall be maintained in accordance with one of the following categories:

| Category | Types of Track and Use  | Minimum FRA Class of Track Safety Standard |
|----------|---|--|
| A        | All active mainline track, or other active track with speed greater than 10 mph                 | 2  |
| B        | Active passing track, sidings, yard tracks, holding track, classification yard or storage track | 2  |
| C        | Inactive track; no current mobilization requirements  | 0  |

**1-6. APPLICATION.**

a. **Requirements versus Recommendations.** In this UFC, the words “shall” and “is required” indicate requirements of the standards that must be met as prescribed by NAVFACINST 11230.1 for the Navy or AR 420-72 for the Army. Recommendations are indicated by the words “may,” “should,” and “it is recommended that...” These recommendations represent good maintenance practice. **DOD policy is to maintain the railroad track at full compliance with these maintenance standards and to restrict operations on any track below the safety standards.**

b. **Condition Levels.** These standards establish four levels of track condition. These condition levels indicate relative seriousness of defects, allow comparison of different types of defects, and provide a means for prioritizing repair work. The three track condition levels are as follows:

(1) **Full Compliance:** Track that meets all the requirements of the standards. Track at this level has, at most, only minor defects and should be fully capable of handling all train operations within the operating rules of the installation. Routine maintenance is required to maintain this condition level, and repair work will generally be only minor.

(2) **Restricted Operation:** Track has defects serious enough to make it unsuitable for operations greater than 10 mph, essentially “normal yard speed.” Based on the inspector’s judgment, track which has defects serious enough to make it unsuitable for operations at 10 mph may be reduced to 5 mph. Essentially, a train may be allowed to “crawl” over the track. This level is intended as a warning zone to indicate that the track is approaching a condition that will require removal from service.

(3) **No Operation:** Track has defects serious enough to require removal from service. At this level, the operation of trains over the track is generally considered hazardous. Operations shall not be allowed except as noted in paragraph 1-6.c.(5).

c. **Operating Restrictions.**

(1) These standards establish minimum required condition levels and also identify track conditions requiring restriction or suspension of train operations. It is intended that a track inspector apply the required restriction or suspension immediately upon discovery of the substandard condition, and that the track be repaired to meet the appropriate condition level as soon as practical. A track restriction shall require the operational speed to be less than posted speed, but not more than 10 mph.

(2) *Notification of Track Restriction.*

(a) Army Track. The certified track inspector shall notify both the train operating personnel first and the director of public works (DPW) immediately upon the discovery of any condition that would warrant any restriction below normal operating practices. The DPW shall notify the installation transportation officer (ITO) verbally and in writing of any condition requiring train operations to be restricted or suspended.

(b) Air Force Track. The track inspector shall notify both the train operating personnel and the base civil engineer (BCE) immediately upon the discovery of any condition that would warrant any restriction below normal operating practices. The BCE shall notify the base traffic management officer (TMO) verbally and in writing of any condition requiring train operations to be restricted or suspended.

(c) Navy Track. The track inspector shall notify both the train operating personnel and the trackage certifying official immediately upon the discovery of any condition that would warrant a restriction beyond normal operating practices or a suspension in operations. Documentation and notification of restricted or non-certification of track shall be performed by the certifying official in accordance with NAVFACINST 11230.1.

(3) *Operations over Restricted Track.* For locations where operating restrictions have been imposed, the speed of the train or other on-track vehicles shall be reduced to the required level before the first wheel reaches the defective area and not increased until the last wheel has passed the defective area.

(4) *Removal of Track Restriction.* A track restriction may be removed after all defects resulting in the restriction have been repaired.

(a) Army Track. The certified track inspector shall notify the DPW upon completion of the repairs. The DPW shall notify the ITO in writing that the restrictions have been lifted.

(b) Air Force Track. The restriction shall not be considered removed until the TMO receives written notification of removal from the BCE.

(c) Navy Track. The trackage certifying official shall recertify the trackage repaired to the level allowed by repairs made. Certification and notification will be in accordance with NAVFACINST 11230.1.

(5) *Track Removed From Service.* Any portion of track where conditions fall below the minimum operable track condition (track condition is at the "No Operation" level) shall be closed to operations until repairs are completed. However, such track may be used under written permit from the track management authority and in the presence of a track inspector. During operations over the closed portion of track, the track inspector shall have visual contact with the train operator at all times and be prepared to signal the train crew to stop. For Navy track, movement of hazardous materials over track removed from service will be in accordance with NAVFACINST 11230.1.

**d.** Judgment of the track inspector shall govern. A track inspector shall have the authority to impose operating restrictions beyond the minimum required in these standards when conditions warrant.

**e.** Defective conditions or combinations of conditions may be found which are not directly addressed in these standards. In such cases, a track inspector shall exercise judgment in applying an appropriate operating restriction.

## CHAPTER 2

### INSPECTION OF TRACK AND RECORD KEEPING

**2-1. TRACK INSPECTORS' QUALIFICATIONS.** Track inspectors are responsible for conducting safety inspections ([paragraph 2-3.c](#)) and detailed track inspections ([paragraph 2-3](#)).

**a. Army.** For Army track, the individual who completes the required track inspections shall be a certified track inspector as specified in AR 420-72.

**b. Air Force.** For Air Force track, the individual who completes the required track inspections shall be qualified to perform such inspections as designated by the BCE.

**c. Navy.** The individual who completes the required track inspections shall meet the requirements of NAVFACINST 11230.1 and be designated by the activity's certifying official.

#### **2-2. RESPONSIBILITY OF THE TRACK INSPECTORS.**

**a.** The designated track inspector is responsible for:

**(1)** Assuring that inspections are performed in accordance with this chapter and for Navy installations the additional requirements of NAVFACINST 11230.1.

**(2)** Examining the track to determine whether the track condition complies with the safety requirements and the maintenance standard requirements addressed in this UFC.

**(3)** Reporting any deficiencies from the full compliance condition level.

#### **2-3. CATEGORIES OF INSPECTIONS.**

**a. Continuous Operator Inspection.** Safety checks shall be conducted daily or before use. In addition, on-the-job observations shall be going on at all times when equipment is working. Railroad operations personnel shall be encouraged to observe and report track problems, deficiencies, obstructions and the "feel" of the track. Items to be aware of are broken rails and other rail defects, faulty switch point closure, indication of wide gage, poor alignment or surface (profile), loose crossing planks, wheel flanges hitting frog points and joint bars, working spikes and loose joints, rail pull-a-parts, evidence of imminent track buckling, blocked drainage, scour at bridges, and the threat of slides. All these things can contribute to train derailments and should be brought to the attention of the responsible person for correction.

**b. Preventive Maintenance Inspection.** Preventive maintenance is a continuous working inspection, examination of component parts, lubrication, adjustment, and minor repair. If not affecting the full compliance level, maintenance defects shall be corrected during the next maintenance cycle.

**(1) Navy Installations Only.** Further discussion of requirements and instructions on performing preventive maintenance are provided in NAVFACINST 11230.1.

**c. Safety Inspection.** Safety inspection is that inspection of track performed in accordance with paragraphs 213.233, 213.235 and 213.239 of the FRA Track Safety Standards (see Appendix E) and this UFC. The purpose of this inspection is to identify defects that require restricted operations or no operations on the track being inspected.

**(1) Schedule.** As a minimum, track shall be inspected at the following interval:

| Track Category | Traffic Frequency  | Minimum Required Inspection Frequency                                 |
|----------------|--|---|
| A              | Mainline Track –<br>Off-station Navy only*                               | Weekly  |
| A & B          | Two or more movements per week   | Monthly   |
| A & B          | Greater than one movement per month but less than two movements per week | Quarterly   |
| A & B          | One movement or less per month   | Semi-annual   |
| C              | No movements or inactive   | Annual detailed inspection only<br>( <a href="#">See Chapter 15</a> ) |

\*For Navy installation only: Off-station track is defined as that track belonging to the Navy that extends outside the main station through residential and/or commercial public areas.

(2) *Inspection Method.* Track inspections shall be made on foot or in an on-track vehicle at a speed which is conducive to effective track inspection, but in no case to exceed 5 mph. Turnouts, rail crossings, and bridges shall be inspected on foot.

(3) *Inspection Records.* The inspector shall complete and sign the Track Inspection Record on the day the inspection is made. Inspection records must specify the track inspected, date of inspection, location and nature of any deviation from the requirements, proposed corrective action, and the remedial action taken. Inspection reports which document deficiencies resulting in a track falling below its designated condition level shall be kept on file until all deficiencies have been corrected. As a minimum, inspection records shall be retained for at least one year after the inspection covered by the report. An example record is provided in [Figure B-1](#). A reproducible master of the Track Inspection Record is provided in NAVFACINST 11230.1 or in [Appendix B](#) as used in the RAILER software.

**d. Detailed Track Inspection.** A detailed inspection shall be made to support sustainment, restoration and maintenance (SRM). Detailed inspections are conducted annually. Detailed inspections will be supported by engineering evaluations when there is any doubt of physical condition. The Track Inspection Record discussed in [paragraph 2-3.c.\(3\)](#) should be used to document detailed inspections. The purpose of the detailed inspection is to identify all track defects including those exceeding maintenance standards provided in this UFC. Results of this inspection will not only be used to establish urgent repairs, but by using the inspection reports and relating them to the activity's basic trackage requirements, its in-house capabilities, priorities, available funding, and other factors, the annual and long-range trackage maintenance and repair programs are developed and programmed.

**e. Electric/Electromechanical Grade Crossing Signals.** The inspection and testing of electric/ electromechanical signals at road–railroad grade crossings shall be performed at the frequency specified in [paragraph 10-6.b](#) and documented in accordance with [paragraph 10-6.c](#).

f. **Internal Rail Defect Inspection.** Internal rail defect inspection shall be performed on class A and B railroad tracks at five-year intervals as specified in [paragraph 7-2.b.](#)

g. **Special Safety Inspections.**

(1) *Infrequently Used Track.* Track that has not been used for a period of six months or more shall be inspected prior to the first movement over the track.

(2) *Mass Rail Movement.* For track that has not been inspected within the last two months, a track inspection is recommended before any mass rail movement (15 cars or more).

(3) *Unusual Occurrences.* Track inspections shall be conducted following unusual occurrences such as derailment, accident, flood, fire, earthquake, severe storm, or other occurrence that could have an adverse effect on the track structure. These inspections shall be conducted before the first movement over the track following the unusual occurrence.

**2-4. INSPECTION OF PARTIALLY VISIBLE TRACK.**

a. At locations where vegetation, dirt, debris, or other undesirable materials cover the ties and/or rail preventing effective track inspection, the undesirable material shall be removed and a thorough track inspection performed. Train operation shall not exceed 10 mph until the undesirable materials are removed and a thorough track safety inspection is performed.

b. At locations where ballast or other material is installed to meet operational requirements, sufficient material shall be removed to spot-check trackage.

c. **Paved Areas.**

(1) In road crossings and other paved areas where complete inspection of the track is not possible, the track inspector must be alert for external signs of track deterioration. External signs indicating track deterioration are:

(a) Changes in gage and/or crosslevel.

(b) Settlement of the rails (changes in track profile).

(c) Excessive vertical or lateral movement of the rails as a train passes.

(d) Deterioration (cracking or breaking up) of the pavement in the vicinity of the track.

(2) Based on indication of defects with consideration taken for age and usage, activities shall establish a program to spot-check trackage encased in pavement.

(3) *Operating Restrictions for Track in Pavement.* When external signs of track deterioration develop, particular attention should be given to the track geometry measurements through the paved area. Track geometry measurements—combined with visual indications of lateral and vertical movement and the requirements for road crossing flangeways—shall be used to assign operating restrictions for the track through the paved area.

**2-5. TRACK MAPS AND TRACK SCHEMATICS.** Track maps are essential in identifying and locating the components of the track network. Installations shall maintain a complete, accurate, and up-to-date set of track maps for use by maintenance and engineering personnel.

a. **Track Charts.** As described in the documents below, track charts may be used to supplement track maps.

- (1) Army/Air Force: TM 5-627/AFM 91-33, *Maintenance of Trackage*.
- (2) Navy: MO-103, *Maintenance of Trackage*, and NAVFACINST 11230.1.

**b. Criteria:**

- (1) *Scale*. Track maps should be drawn to a legible scale. The scale should be shown on each page of the map.
- (2) *Title*. Track maps should contain a standard title block.
- (3) *Legend*. Track maps should contain a legend identifying all symbols used on the track map.

**c. Track Data.** Data presented on track maps should include:

- (1) All track, active and inactive.
- (2) Track name or identification for each track.
- (3) Track category for each track.
- (4) Buildings, loading docks, bridges, trestles, culverts, and other structures on or adjacent to the railroad roadway.
- (5) Highway and road crossings.
- (6) Connections to serving railroads.
- (7) Limits of track ownership and maintenance responsibilities.
- (8) Installation property lines and railroad right-of-way lines.
- (9) Rail weight and section.
- (10) Turnout identification number and weight and section.
- (11) Degree of curvature for all curves.
- (12) Grades and profile information.
- (13) Track stationing or mileposts.

**d. Track Schematics.** Non-scaled, condensed track plans describing layout of tracks and turnouts. They are useful in track inspection reporting and record keeping.

## CHAPTER 3

### ROADWAY

#### 3-1. ROADWAY.

a. **Inspection.** The roadway shall be inspected for the following defects:

- (1) Ballast/subgrade pumping.
- (2) Erosion of embankments and cut slopes.
- (3) Embankment sliding or slippage.
- (4) Potential slope stability problems.
- (5) Settlement at approaches to bridges and road crossings.
- (6) Washouts under and adjacent to the track.

If any of these defects are present, remedial action is required within a time frame necessary to prevent damage to the track structure.

b. **Hazardous Conditions.** Any condition presenting a hazard to the safe movement of trains shall be corrected before the first movement over that location.

#### 3-2. DRAINAGE.

a. **General.**

- (1) A well-drained roadbed is essential to good track maintenance.
- (2) Any attempts to divert water onto the roadway or to obstruct ditches or drainage structures shall be reported immediately to the trackage certifying official.
- (3) Drains, ditches, and other open drainage structures shall be protected to prevent hazard to personnel.

b. **Size and Design.** Ditches and other drainage structures (culverts, drains, and drop inlets) shall be of sufficient size and construction to handle the expected flow of water.

c. **Obstructions.** Ditches and drainage structures shall be maintained to allow the free passage of water. At locations where flow is obstructed or otherwise inadequate, remedial action is required. During construction operations adjacent to the track structure, all ditches and other drainage structures shall be kept unobstructed.

d. **Inspection.**

- (1) Inspection and cleaning of drainage structures and channels shall be performed at least annually, preferably in the fall in anticipation of spring runoffs.
- (2) Inspections of ditches and other drainage structures during and after heavy rains are recommended to assure that these structures are adequate to carry the runoff.
- (3) Drainage ditches and structures shall be inspected for the presence of:
  - (a) Brush.
  - (b) Drift.
  - (c) Excessive ice and snow.
  - (d) Other obstructions that may interfere with the flow of water.

If any of these are present, immediate remedial action is required to prevent damage to the roadway and track structure.

(4) Particular attention shall be given to drainage conditions at turnouts, rail crossings, road crossings, bridge ends, and all locations where conditions may restrict adequate drainage.

(5) For obstructed or partially collapsed drainage structures, a safety standard shall be implemented to restrict speeds.



**3-3. VEGETATION.**

a. Vegetation shall be controlled so that it does not:

- (1) Grow within the ballast section or obstruct ballast drainage.
- (2) Interfere with adequate visibility (sight distance) at grade crossings.
- (3) Obstruct visibility of location markers, switch position indicators, signs, or signals.
- (4) Obstruct drainage.
- (5) Interfere with the safe operation of trains.
- (6) Prevent proper track inspection.
- (7) Present a fire hazard to timber structures.
- (8) Interfere with personnel walking within 8 feet of the track centerline.
- (9) Brush the sides of engine or rolling stock.

b. **Vegetation Interference.** At locations where vegetation interferes with the effective inspection of the track or train operations, train operations shall be restricted until the vegetation is removed and a thorough track inspection is performed.

c. **Vegetation Control.** Undesirable vegetation growing within the roadway shall be removed by chemical or manual means. Chemical vegetation control shall be accomplished as prescribed in the following manuals:

- (1) Army: AR 200-5, *Pest Management Program*, and TM 5-630, *Natural Resources Land Management*.
- (2) Air Force: AFI 32-1053, *Pest Management Program*.
- (3) Navy: OPNAVINST 6250.4, *Pest Management Program*.

d. **Desirable Vegetation.** Vegetation such as crown vetch may be planted and grown on the slopes of cuts and fills and in other locations within the roadway to prevent erosion. The growth of desirable vegetation should be controlled to meet the requirements of [paragraph 3-3.a](#).

## CHAPTER 4

### BALLAST

**4-1. GENERAL.** Ballast is a select material placed on the subgrade to:

- a. Provide adequate drainage of the track.
- b. Restrain the track laterally, longitudinally, and vertically under the dynamic loads imposed by trains and the thermal stresses induced in the rails by changing temperature.
- c. Distribute the load of the track and trains to prevent overstressing the subgrade.

**4-2. SELECTION CRITERIA.**

- a. Considerations for selecting materials to be used as ballast include:
  - (1) Size and gradation.
  - (2) Shape (angularity).
  - (3) Weight.
  - (4) Strength.
  - (5) Durability.
  - (6) Cleanliness (no dirt or fines).
  - (7) Economics.
- b. New ballast materials used in the maintenance of track shall meet the requirements specified in the *AREMA Manual For Railway Engineering*, Chapter 1, Part 2.

**4-3. MAINTENANCE.**

- a. The ballast section should be clean, free-draining, and free of vegetation, soil (mud), and other foreign materials.
- b. During major maintenance or track rehabilitation, dirty or fouled crushed stone or slag ballast meeting the requirements of [paragraph 4-2.b](#) may be cleaned/screened or reconditioned and reused.
- c. Ballast materials shall provide a full crib and uniform shoulders, but shall not be allowed to cover or be at a level above the top of the ties. At turnouts, ballast shall not interfere with moveable parts of switches and sufficient clearance shall be maintained around switch rods and connecting rods. See [paragraph 8-3.g](#), "Pocketing Switches."

## CHAPTER 5

### TIES

**5-1. GENERAL.** The functions of a tie are to:

- a. Maintain gage.
- b. Maintain surface (profile).
- c. Maintain alignment.
- d. Distribute the load from the rail to the ballast and subgrade.

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

**5-2. WOOD TIES.**

**a. Tie Selection, Treatment and Inspection.**

(1) *Tie Selection.* New ties selected for the maintenance of track shall be adequately seasoned and treated and meet the requirements specified in the AREMA *Manual For Railway Engineering*, Chapter 30, Part 1, for 6-inch grade and the preferred 7-inch grade ties. The preferred species for ties are the following hardwoods: red oak, white oak, beech, ash, and hickory ties. Gum ties can also be used if local experience reflects satisfactory service. Where softwoods are used, the southern pine and Douglas fir species are preferred. Southern pine is not recommended for main line track or areas with high humidity. Beech and ash ties can also be used if local experience reflects satisfactory experience.

(2) *Treatment.* Ties shall be pressure-treated in accordance with the most current version of the American Wood Preserver's Association (AWPA) Standard C6. See UFGS 05650 for tie treatment recommendations.

(3) *Inspection.* It is recommended that all timber ties be inspected by an independent, qualified, professional inspector. Inspections should take place at producing plants where the ties can be inspected in the white (before treatment) and after treatment. Accepted ties are to be branded (stamped) by the inspector responsible for the acceptance.

(4) *Switch Ties & Turnout Ties.* It is recommended that switch ties be mixed oak hardwood.

**b. Installation.** Ties shall be installed perpendicular to the rails and properly tamped and spiked. Ties shall be installed with the top of the tie (or the tie plate) in full contact with the base of the rail and the bottom of the tie near the rail seat in full contact with the ballast.

**c. Identification of Defective Wood Ties.** A wood tie is defective if it is:

- (1) Broken through.
- (2) Split or otherwise impaired to the extent that it will not hold spikes or other rail fasteners.
- (3) So deteriorated that the tie plate can move laterally more than 0.5 inch relative to the crosstie.
- (4) Cut by the tie plate more than 2 inches.
- (5) Cut by wheel flanges, dragging equipment, fire, etc., to a depth of more than 2 inches within 12 inches of the base of the rail, frog, or load-bearing area.
- (6) Rotted, hollow, or generally deteriorated to a point where a substantial amount of the material is decayed or missing.

(7) Ties that are “end-broken.” End-broken ties often can be broken beneath the base plate and the defect is not noticeable except for a small rise in the end of the tie, from a plane of the center portion.

These defects are shown in [Figure 5-1](#).

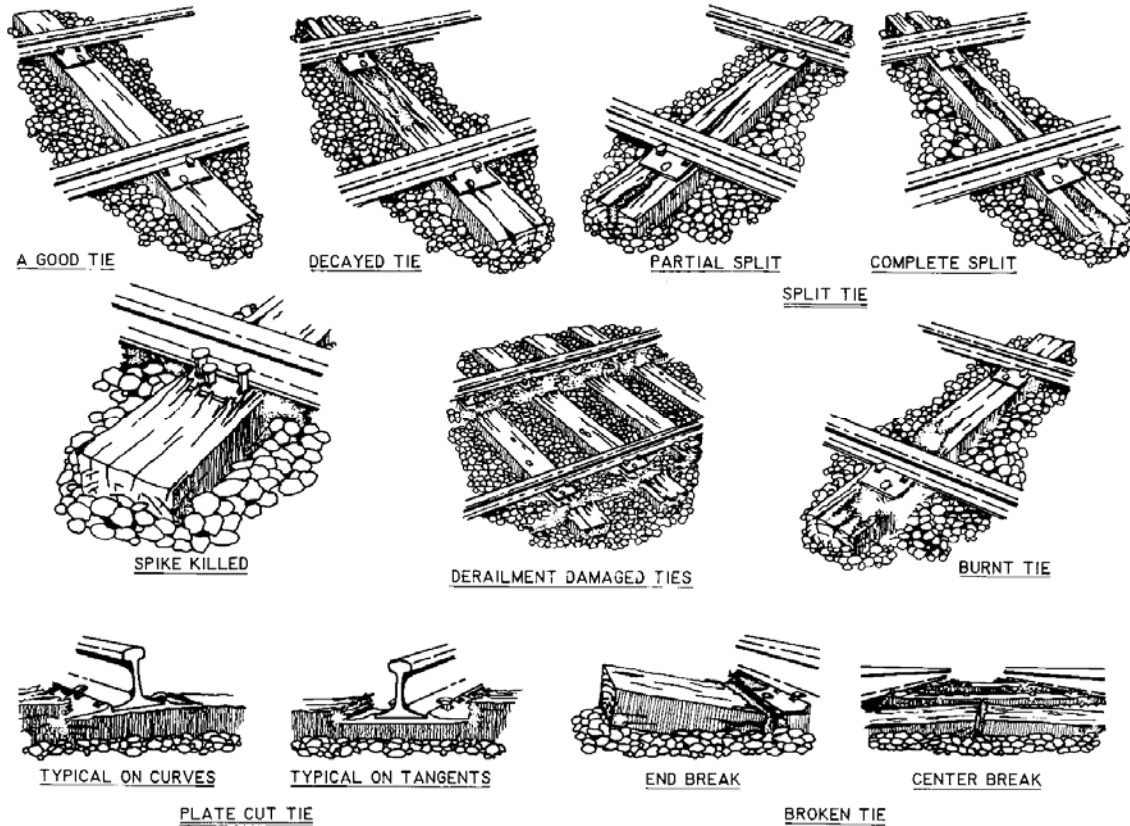


Figure 5-1. Examples of Good and Defective Ties

### 5-3. CONCRETE TIES.

a. **Tie Selection.** New concrete ties selected for the maintenance of track shall meet the requirements specified in *AREMA Manual for Railway Engineering*, Chapter 30, Part 4. Mixing wood and concrete ties in the same track section is not recommended. Concrete ties are very susceptible to impact, leading to premature failure when used in jointed track and require a more substantial ballast section.

b. **Switch Ties.** At this time, few concrete switch ties are being manufactured due to weight and difficulty in handling; hardwood switch ties are recommended.

c. **Installation.** Ties shall be installed perpendicular to the rails and properly tamped and fastened. Ties shall be installed with the top of the tie in full contact with the base of the rail and the bottom of the tie near the rail seat in full contact with the ballast.

d. **Identification of Defective Concrete Ties.** A concrete tie is defective if:

- (1) Tie is broken across under one or both rail seats.
- (2) Tie is broken across in the center and showing signs of further deterioration, loss of tension in pre-stressing wires, exposure of wires, crumbling, etc.
- (3) Tie is broken longitudinally, resulting in loss of ability to hold one or both cast-shoulders in place.

(4) Both cast-shoulders in one rail are loose. (One loose shoulder per rail is not sufficient cause for removal unless it is causing some distress to adjacent ties.)

(5) Tie is damaged by derailment or dragging equipment which, in the opinion of the track inspector, should be replaced. It should be noted that quite serious damage can be done to the tie ends without seriously affecting the performance of the tie.

#### 5-4. PLASTIC TIES

a. **Tie Selection.** Various plastic ties have been tested and proven to provide adequate support and low maintenance. Plastic ties shall have textured sides to provide stability. See UFGS 05650 for material requirements. Plastic ties can be cost-effective in areas of high decay. The weight of plastic is similar to wood and mixing wood and plastic ties in the same track section is permissible.

b. **Installation.** Ties shall be installed perpendicular to the rails and properly tamped and fastened. Ties shall be installed with the top of the tie in full contact with the base of the rail and the bottom of the tie near the rail seat in full contact with the ballast. Plastic ties can be installed with either cut or screw spikes, with screw spikes recommended.

c. **Identification of Defective Plastic Ties.** Plastic ties shall be treated as wood ties for determining defective ties. See [paragraph 5-2.c.](#)

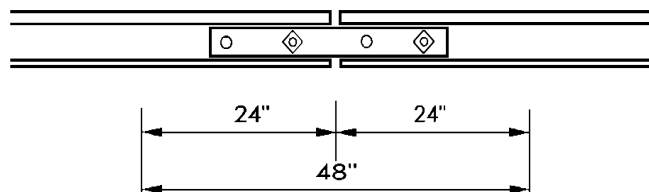
#### 5-5. STEEL TIES AND COMPOSITE TIES.

a. Advances in steel tie technology have proven successful and practical and should be considered as a possible alternative in replacing wood ties.

b. One type of composite tie is a hardwood tie treated with borates to prevent decay and rot from fungus, insects, and termites, then encapsulated in a tough plastic covering. Another composite tie is one which includes high-density polyethylene, rubber, and fiberglass with certain proprietary inert filler materials. Yet another composite tie is produced with fiberglass blown foam and molded into various tie sizes and lengths.

#### 5-6. GENERAL.

a. **Improper Tie Support (Down or Hanging Ties).** Ties that do not support both rails are considered defective. If these ties are not materially defective, they shall be ballasted, tamped up, and respiked/refastened to fully support the rails.



AT EACH JOINT, AT LEAST ONE TIE WITHIN  
THIS AREA MUST BE NON-DEFECTIVE.

**Figure 5-2. Required Tie Support at Joints (Safety Standard)**

b. **Missing Fasteners.** Ties that are installed, but not spiked with a sufficient number of spikes in accordance with [paragraph 6-3.c.](#), are considered defective. If these ties are not materially defective, necessary spikes shall be added.

**c. Tie Requirements.**

(1) Track shall have a minimum number of non-defective ties per 39-foot rail length in combination with a maximum number of consecutive defective ties as specified below:

|                    | Minimum Number of Non-Defective Ties per 39 Feet |                                    |
|--------------------|--|------------------------------------|
|                    | Tangent & Curves Less Than 2°                    | Curves Equal to or Greater Than 2° |
| <b>Maintenance</b> |  |                                    |
| Category A         | 12   | 13                                 |
| Category B         | 10   | 11                                 |
| <b>Safety</b>      |  |                                    |
| Restricted         | 8  | 10                                 |
| No Operation       | 7  | 9                                  |

|                    | Number of Consecutive Defective Ties |                                    |
|--------------------|--------------------------------------|------------------------------------|
|                    | Tangent and Curves Less Than 2°      | Curves Equal to or Greater Than 2° |
| <b>Maintenance</b> |                                      |                                    |
|                    | 3                                    | 2                                  |
| <b>Safety</b>      |                                      |                                    |
| Restricted         | 4                                    | 3                                  |
| No Operation       | 5                                    | 4                                  |

(2) *Joint Ties.* All joints shall be supported by the number of non-defective ties specified below. The centerline of these joint ties shall be within 24 inches of the rail ends as shown in [Figure 5-2](#). Safety standard: Any track without a non-defective tie within 24 inches of the rail ends shall be “No Operations.”

|                    | Minimum Number of Non-Defective Ties per Joint |
|--------------------|--|
| <b>Maintenance</b> |  |
| Category A         | 2  |
| Category B         | 1  |
| <b>Safety</b>      |  |
| No Operation       | 0  |

**d. Tie Spacing.** The center-to-center distance between adjacent ties usually ranges from 19 to 22 inches. The recommended tie spacing for new track is given below:

| Track Category | Tie Spacing (Inches) | Number of Ties per 39-ft Rail |
|----------------|----------------------|-------------------------------|
| A              | 19.5                 | 24                            |
| B              | 21                   | 22                            |

**Army Criteria:** For all track with an average tie spacing greater than 22 inches (less than 22 ties per 39-foot rail), the desired spacing should be established during the next maintenance or rehabilitation cycle.

**Navy & Air Force Criteria:** The maintenance standards shall require a maximum average center-to-center tie spacing of 24 inches within the distance of a rail length. For track having average tie spacing greater than 24 inches, the desired spacing should be established during the next major maintenance or rehabilitation cycle.

**e. Missing Ties.** The maintenance standard requires all missing ties to be replaced. The safety standards consider a missing tie a defective tie and any location where the center-to-center tie spacing measured along either rail exceeds 48 inches to be “Restricted Operations,” unless at a joint, which will be “No Operations.”

**f. Skewed Ties.** A skewed tie is a tie that is not perpendicular to the rails by more than the tie width. Slightly skewed or individual skewed ties are not serious. A section of track with skewed ties indicates a problem area (possible tight gage) that should be investigated (see Chapter 12, [“Track Geometry”](#)). Maintenance standards require that where localized areas have three or more ties skewed greater than 8 inches, the cause of the skewing shall be corrected and the ties straightened.

## CHAPTER 6

### OTHER TRACK MATERIALS (OTM), TIE PLATES, ANCHORS, RAIL FASTENINGS, ETC.

#### 6-1. GENERAL MAINTENANCE STANDARD

a. All OTM shall be the proper size and type (sections) as specified in Chapters 4 and 5 of the AREMA *Manual For Railway Engineering* and the following:

- (1) *Army*: UFC 4-860-01FA and TM 5-627.
- (2) *Air Force*: UFC 4-860-01FA and AFM 91-33.
- (3) *Navy*: UFC 4-860-02N, Appendix A, Section 5, and MO-103.

b. OTM shall not be flame cut or otherwise altered.

c. OTM that are of improper type, broken, or otherwise defective shall be replaced with the proper size (weight) and type (sections) material.

#### 6-2. TIE PLATES.

a. **Use.** Tie plates distribute the applied loads from the rail to the tie as well as assist in keeping the rail in position. Their use is especially important on curves where they provide additional lateral restraint.

b. **Type.** Tie plates may be of either the single shoulder type ([Figure 6-1](#)) or the double shoulder type ([Figure 6-2](#)). Plates may be canted or flat. Canted plates are preferred, particularly in curves; however, canted and flat plates cannot be mixed together.

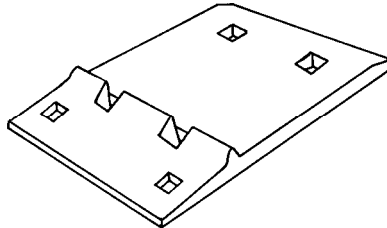


Figure 6-1. Single Shoulder Tie Plate

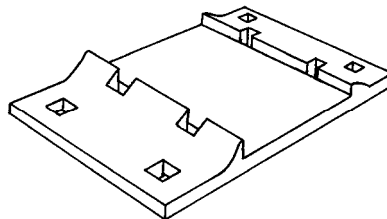


Figure 6-2. Double Shoulder Tie Plate

c. **Installation.** For track without tie plates, plates shall be installed on replacement ties during tie renewals or installed during rail replacement.

d. **Shifted Plates.** Where the shoulder of a tie plate has become lodged beneath the base of the rail, the spikes shall be pulled, the spike holes plugged, the tie plate properly reset, and the rail respiked.

#### 6-3. SPIKES.



a. The rail shall have a sufficient number of fasteners (spikes) to effectively maintain gage and provide sufficient rail restraint. Spikes provide primarily lateral support for the rail.

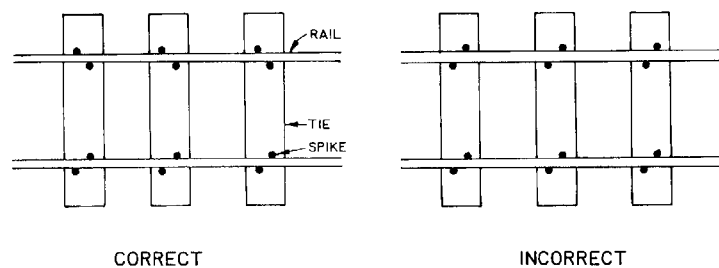
b. Spikes shall be:

- (1) Of proper size for the tie plates used.
- (2) Driven vertically and square with the rail.
- (3) Either of the cut or screw type.
- (4) Driven with approximately 0.125 inch of space remaining between the head of the spike and the base of the rail.

of the spike and the base of the rail.

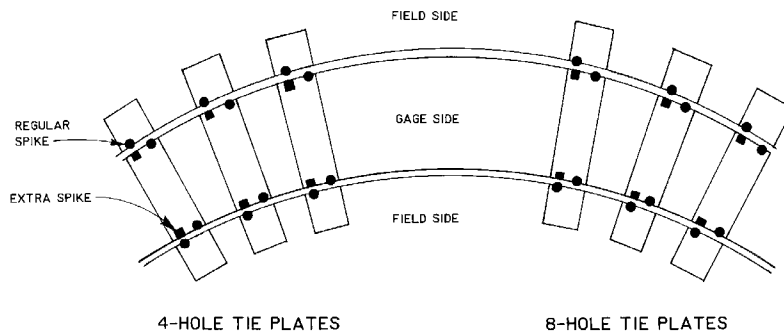
c. **Spiking Pattern.**

(1) On tangent track and curves of 4 degrees or less, spikes shall be installed as shown in [Figure 6-3](#).



**Figure 6-3. Spiking Pattern for Tangents and Curves of 4 Degrees or Less**

(2) On curves greater than 4 degrees but less than 36 degrees and on the curved side of turnouts, the use of an additional spike per tie plate as shown in [Figure 6-4](#) is recommended. However, it is acceptable to have the third spike on the field side of the rail. A maximum 12-degree curve is recommended for typical railroad applications.

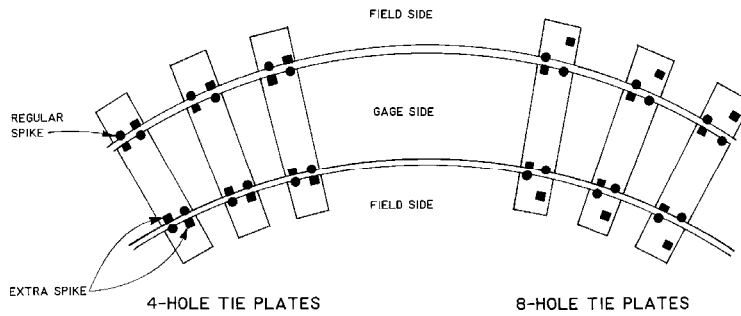


Note: Extra spike can be on the field side

and is preferred by the Army.

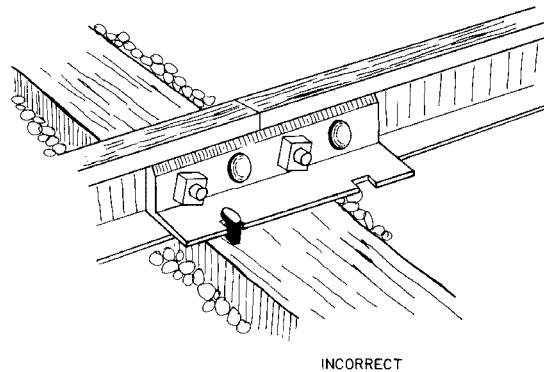
**Figure 6-4. Spiking Pattern for Curves Greater than 4 Degrees but Less than 36 Degrees**

(3) On curves of 36 degrees and greater the use of two additional spikes per tie plate as shown in [Figure 6-5](#) is recommended.

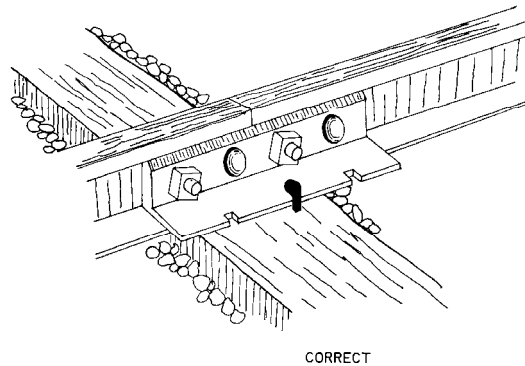


**Figure 6-5. Spiking Pattern for Curves 36 Degrees and Greater**

(4) Spikes shall not be installed through the slots in skirted-type slotted joint bars (angle bars) as shown in [Figure 6-6](#). Correct spiking is shown in [Figure 6-7](#).



**Figure 6-6. Incorrect Spiking of Angle Bars**



**Figure 6-7. Correct Spiking of Angle Bars**

(5) Correction of incorrect spiking patterns. An incorrect spiking pattern by itself is not a cause for removing and redriving spikes. However, an incorrect spiking pattern shall be corrected when other maintenance requires the spikes to be removed. Old spike holes shall be plugged to prevent accelerated tie deterioration.

**d. Missing and Loose Spikes.** Maintenance standards require missing spikes to be replaced. Old spike holes shall be plugged with a treated tie plug before replacing the

spikes. Loose spikes shall be removed, the holes plugged, and the spikes redriven. Gage shall be checked at these locations. Safety standards permit the track to be restricted at the track inspector's discretion.

**e. Spikes Beneath Rail Base.** Maintenance standards require where the head of a spike has become lodged beneath the base of a rail, the spike shall be removed immediately, the hole in the tie plugged, and the spike properly redriven. A spike lodged beneath the rail base is an undesirable condition that can lead to a broken rail base.

**f. Other Hold-Down Devices.** Maintenance standards require any defective hold-down device to be replaced. Safety standards permit the track to be restricted at the track inspector's discretion.

#### 6-4. JOINTS.

**a. Joint Bars.** Rails shall be joined with proper factory-designed and -constructed joint bars. Joint bars shall not be altered with a flame in any manner, including the bolt holes. Maintenance standards require joint bars not meeting these requirements to be replaced. Safety standards require the track to be restricted until repairs are completed.

**b. Compromise Joints.** Rails of different weight and/or section shall be joined with proper factory-designed and -forged compromise bars, taper rails, or offset thermite welds. Safety standards require track to be restricted until all non-factory items are replaced.

**c. Cracked or Broken Joint Bars.** Maintenance standards require cracked or broken joint bars to be replaced. Safety standards require:

(1) Track to be "No Operation" when one or both joint bars are cracked or broken between the center bolt holes.

(2) Operations shall not be permitted over any location where both joint bars are broken, or where worn or loose joint bars allow vertical movement of either rail with respect to the other.

**d. Bolts.** Maintenance standards require each joint to be bolted with at least two bolts in each rail tightened to approximately 400 foot-pounds of torque which develops between 25,000 and 30,000 pounds of tension in the bolts.

(1) All bolts shall be of proper size and tightly in place. Proper bolt installation is shown in [Figure 6-8](#).

(2) Bolts shall be installed with AREMA spring washers. Nuts shall be installed against the spring washer as shown in [Figure 6-8](#). At least one full bolt thread shall extend past the outside of the nut.

(3) Bolts shall be installed so the nuts will run alternately on the inside and outside of the rail as shown in [Figure 6-9](#).

(4) Whenever bolts and joint bars are removed, the rail in the joint area and the contact surfaces of the joint bar shall be cleaned (wire brushed) and lubrication applied to the joint bar and the bolt threads. New joint bars and bolts shall be lubricated before installation.

(5) Safety standards require a restriction if all bolts are loose or if there is only one bolt through a rail. No operations are permitted over locations where all bolts in one rail are missing or ineffective.

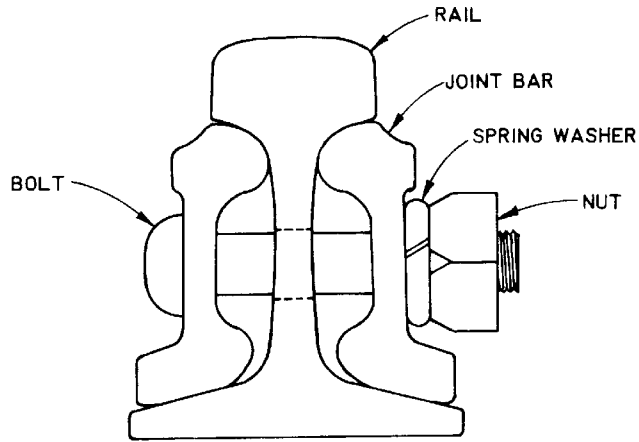


Figure 6-8. Proper Bolt Installation

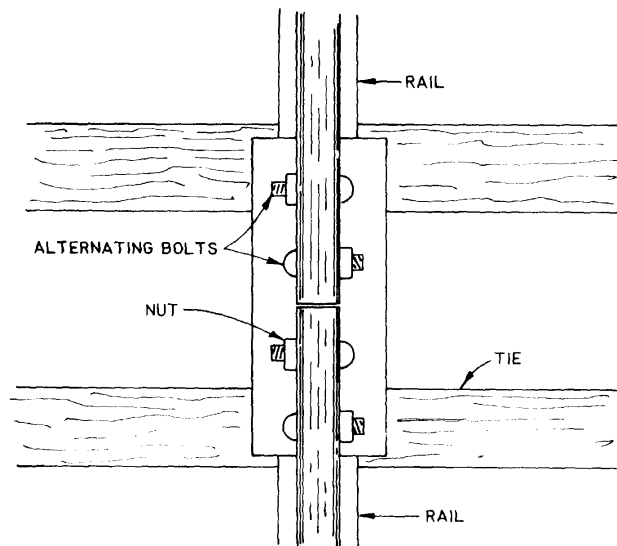


Figure 6-9. Alternating Bolt Pattern

**e. Loose and Missing Bolts.**

(1) Maintenance standards require loose bolts to be tightened (approximately 400 foot-pounds) during the next maintenance activity. Bolts that cannot be tightened shall be replaced.

(2) Maintenance standards require that missing bolts be replaced.

**f. Rail End Mismatch.** Rail end mismatch on the tread portion or the gage side shall not exceed the following:

| Rail End Mismatch (Inch) |          |           |
|--------------------------|----------|-----------|
|                          | Tread    | Gage Side |
| <b>Maintenance</b>       | GT 0.125 | GT 0.125  |
| <b>Safety</b>            |          |           |
| Restriction              | N/A      | GT 0.1875 |
| No Operation             | GT 0.25  | GT 0.25   |

**g. Joint Gap.** Standard rail gaps in properly drilled new rails and punched joint bars produce a rail gap of 0.125 to 0.25 inch. As the bolts, bars and rails wear, a gap of 0.5 to 0.625 inch may develop in some rail joints with track usage. Greater gaps indicate a potential problem. Rail joint gap shall not exceed the following:

| Joint Gap (Inch)   |         |
|--------------------|---------|
| <b>Maintenance</b> | GT 0.75 |
| <b>Safety</b>      |         |
| Restriction        | GT 1.25 |
| No Operation       | GT 2    |

**h. Joints in Restricted Areas.** It is recommended that the joint be thermite-welded whenever a joint is installed within 20 feet of a road crossing, the outer perimeter of any structure, or any location that restricts access to the joint.

**i. Shims.** All shims shall be removed from joints. See UFGS 05650 for proper joint gap determination when replacing rails. Failure to compensate for the temperature could result in buckled track or pull-apart.

#### 6-5. RAIL ANCHORS (MAINTENANCE STANDARD).

**a.** Rail anchors are designed to fit tight on the base of the rail. It is, therefore, extremely important to know the weight and section of the rail when ordering the anchors. Rail anchors help prevent the longitudinal movement of rails commonly known as "running" or "creeping." Rail anchors should be used at locations where the track is subject to serious longitudinal movement from thermal stresses (rail expansion) or traffic conditions.

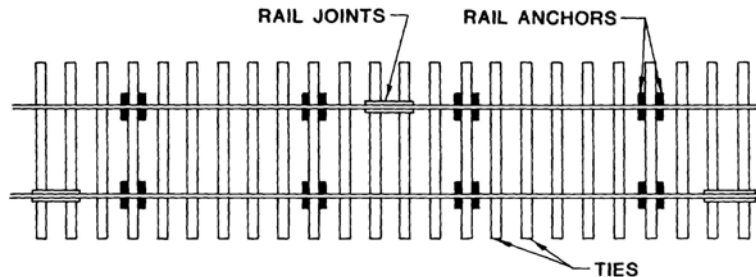
**b. Rules for Anchor Application.** General rules on the use of rail anchors are:

- (1) Anchors shall be applied to the gage side of the rail base against the same tie face on opposite rails.
- (2) Anchors shall grip the base of the rail firmly and have full bearing against the face of the tie.
- (3) When the bearing of the rail anchor against the tie has been disturbed by removal of the tie, the anchor shall be removed and reapplied to the new tie.
- (4) Anchors shall not be moved by driving them along the rail.
- (5) Skewed ties shall be straightened before applying rail anchors.

c. Rail anchors not meeting requirements of [6-5.a](#) and [6-5.b](#) should be removed and reapplied.

**d. Anchor Locations.**

(1) Where used, a minimum of eight anchors (four in each direction [boxed]) per 39-foot rail (or 16 anchors per 80-foot rail) is recommended as shown in [Figure 6-10](#). Steep grades increase the importance of anchors and may justify more than the minimum number shown in Figure 6-10. If additional anchors are required, it is recommended to box-anchor approximately every third tie.



**Figure 6-10. Recommended Minimum Anchoring Pattern for 39-foot Rails.**

(2) *At Open Deck Bridges.* Where anchors are used on track approaching open deck bridges, every third tie should be box-anchored (four anchors per tie) for at least two rail lengths off each end of the bridge. No anchors shall be applied on the bridge itself.

(3) *At Rail Crossings.* Where anchors are used on track approaching rail crossings, every third tie should be box anchored (four anchors per tie) for at least two rail lengths in all directions from the crossing.

(4) *Turnouts.* Anchoring in turnouts is optional and can be used to correct geometry problems. Where used, every other tie (that can be anchored) should be anchored.

**6-6. GAGE RODS.**

a. **Use.** Gage rods are not required but are sometimes needed to help maintain proper track gage. However, they 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 on the curved closure rail.

b. **Spacing.** Where gage rods are used in sharp curves, two to four rods should be installed next to the joint on the outside rail and at evenly spaced intervals along the rail length.

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; ensure gage is not affected by over-tightening of gage rods.

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

**(3)** Gage rods shall not be tightened if spikes are holding the rail from moving. It may be necessary to pull the spikes, plug the tie, tighten the rods to gage, then respike.

## CHAPTER 7

### RAIL

#### 7-1. DEFECTIVE RAIL AND REMEDIAL ACTIONS.

a. Standards for rail defects are presented in [Table 7-1](#). Remedial actions for rail defects are presented in [Table 7-2](#). Where rail defects have been identified but remedial action has not been completed, the operating restrictions presented in [Table 7-1](#) shall apply. [Appendix C](#) provides a glossary of common rail terms and brief descriptions of the common rail defects that may be observed in track.

b. **Multiple Defects.** Any individual rail having two or more of the transverse fissure or fracture type defects listed in [Table 7-1](#), whether they are the same or different, shall be removed and replaced in lieu of other remedial actions.

c. **Worn Rails.** On rail suspected of being worn more than the allowances provided for in [Table 7-1](#), wear measurements shall be taken at the center and at each end of the rail not more than 1 foot from the end of the joint bar. Rail wear measurements shall consist of a vertical head wear measurement and a horizontal side wear measurement as shown in [Figure 7-1](#). [Appendix D](#) presents a table of details and properties for various rail sections and may be used to assist in identifying rail weight and sections for estimating the amount of rail wear.



**Table 7-1. Rail Defect Standards**

| <i>Defect Type</i>                   | <i>Maintenance Standard</i>                       |          | <i>Safety Standard</i>              |                         |
|--------------------------------------|---|----------|-------------------------------------|-------------------------|
|                                      | <i>Maximum Defect Category for Track Category</i> |          | <i>Restricted (10mph) Operation</i> | <i>Close to Traffic</i> |
|                                      | <i>A</i>  | <i>B</i> |                                     |                         |
| Bolt hole crack                      | RI  | 0.75"    | GT 1.5"                             | BO                      |
| Bolt Hole – torch cut <sup>(3)</sup> | RI  | RI       | RI                                  | *                       |
| Broken base                          | RI  | RI       | *                                   | GT 6"                   |
| Corrosion (rail base)                | 0.25"   | 0.25"    | *                                   | *                       |
| Complete break                       | RI  | RI       | RI                                  | RI                      |
| Crushed (flattened) head             | RI  | RI       | GT 0.375"                           | BO                      |
| End Batter                           | 0.25"   | 0.25"    | GT 0.375"                           | GT 0.5"                 |
| Defective weld <sup>(1)</sup>        | 20%   | 20%      | GT 20%                              | GT 40%                  |
| Fissure-compound <sup>(1)</sup>      | RI  | RI       | GT 20%                              | GT 40%                  |
| Fissure-Transverse <sup>(1)</sup>    | RI  | RI       | GT 20%                              | GT 40%                  |
| Fissure-detail <sup>(1)</sup>        | RI  | RI       | GT 20%                              | GT 40%                  |
| Fracture-engine burn <sup>(1)</sup>  | RI  | RI       | GT 20%                              | GT 40%                  |
| Head/web separation                  | RI  | 2"       | GT 4"                               | BO <sup>(2)</sup>       |
| Piped rail                           | RI  | 2"       | GT 4"                               | BO <sup>(2)</sup>       |
| Horizontal split head                | RI  | 2"       | GT 4"                               | BO <sup>(2)</sup>       |
| Vertical split head                  | RI  | 2"       | GT 4"                               | BO <sup>(2)</sup>       |
| Split web                            | RI  | 2"       | GT 4"                               | BO <sup>(2)</sup>       |
| Flow on gage face                    | 0.1875"   | 1/4"     | GT 0.3125"                          | *                       |
| Running surface damage               | 0.25"   | 1/4"     | GT 0.375"                           | GT 0.5"                 |
| Short rail                           | 13'   | 13'      | *                                   | *                       |
| Torch cut rail                       | RI  | RI       | *                                   | *                       |
| Wear - up to 90 lb rail              |   |          |                                     |                         |
| Horizontal side wear                 | 0.375"  | 0.375"   | GT 0.5"                             | *                       |

**Table 7-1. Rail Defect Standards**

|                              |        |        |           |   |
|------------------------------|--------|--------|-----------|---|
| Vertical head wear           | 0.375" | 0.375" | GT 0.375" | * |
| Wear - 100 lb to 119 lb rail |        |        |           |   |
| Horizontal side wear         | 0.5"   | 0.5"   | GT 0.625" | * |
| Vertical head                | 0.375" | 0.375" | GT 0.375" | * |
| Wear - rail above 119 lb     |        |        |           |   |
| Horizontal side wear         | 0.625" | 0.625" | GT 0.75"  | * |
| Vertical head wear           | 0.5"   | 0.5"   | GT 0.5"   | * |

**Notes:**

1. Defect testing normally reports these defects as small (S), medium (M), or large (L). General relationship to size is:

Small: 10–20% of head area.

Medium: 21–40% of head area.

Large: 41+% of head area.

Need to request inspector performing ultrasonic rail inspection to provide estimated percent of rail head affected by defect.

2. Rails having longitudinal defects accumulating to 3 feet or more in any 10 feet of rail shall be closed to traffic.

3. Include bolt holes anywhere in the rail.

4. Abbreviations:

RI = Repair Immediately

BO = Break Out in railhead

GT = Greater Than

LT = Less Than

N/A = Not Applicable

\* The activity shall evaluate the severity of each such defect and shall classify the degree of hazard based on engineering judgment and experience.

**Table 7-2. Remedial Action for Rail Defect**

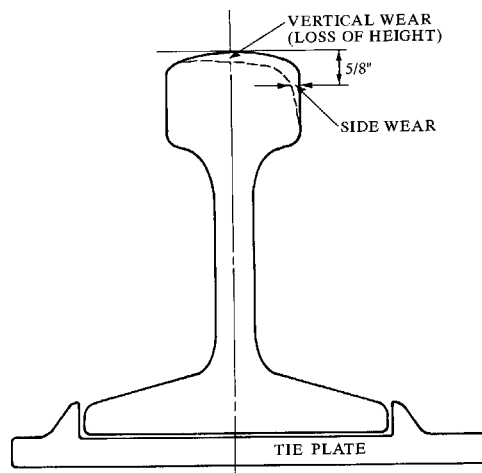
| Defect Type                         | Remedial Actions              |                               |                                 |
|-------------------------------------|-------------------------------|-------------------------------|---------------------------------|
|                                     | Replace Entire Defective Rail | Crop Defect <sup>(2, 3)</sup> | Apply Joint Bars (Fully Bolted) |
| Bolt hole crack                     | Allowed                       | Allowed                       | ---                             |
| Broken base                         | Allowed                       | Allowed                       | Not Allowed                     |
| Corrosion (rail base)               | REQUIRED                      | Not Allowed                   | Not Allowed                     |
| Complete break - clean and square   | Preferred                     | ---                           | Allowed <sup>(3)</sup>          |
| Complete break - rough or angled    | Preferred                     | Allowed                       | Not Allowed <sup>(4)</sup>      |
| Crushed head                        | Preferred                     | Allowed                       | Not Allowed <sup>(4)</sup>      |
| Defective weld                      | ---                           | Allowed                       | Preferred                       |
| End Batter                          | Allowed                       | Allowed                       | ---                             |
| Fissure-compound <sup>(5)</sup>     | Preferred                     | Allowed                       | Allowed <sup>(3)</sup>          |
| Fissure-transverse <sup>(5)</sup>   | Preferred                     | Allowed                       | Allowed <sup>(3)</sup>          |
| Fracture-engine burn <sup>(5)</sup> | Preferred                     | Allowed                       | Allowed                         |
| Head/web separation                 | REQUIRED                      | Not Allowed                   | Not Allowed                     |
| Piped rail                          | REQUIRED                      | Not Allowed                   | Not Allowed                     |
| Running surface damage              | Allowed                       | Allowed                       | Not Allowed                     |
| Short rail                          | REQUIRED                      | ---                           | ---                             |
| Horizontal split head               | REQUIRED                      | Not Allowed                   | Not Allowed                     |
| Vertical split head                 | REQUIRED                      | Not Allowed                   | Not Allowed                     |
| Split web                           | REQUIRED                      | Not Allowed                   | Not Allowed                     |
| Torch cut rail ends                 | Allowed                       | Allowed                       | Not Allowed<br>Not Allowed      |
| Torch cut bolt hole                 | Allowed                       | Allowed                       |                                 |
| Wear                                | REQUIRED <sup>(6)</sup>       | ---                           | ---                             |
| Flow on gage face                   | Preferred                     | Allowed                       | ---                             |

**Notes:**

1. If two or more of these defects are found in any individual rail, that rail shall be replaced.
2. Rails may be cropped by cutting the rail with a rail saw or other appropriate cutting tool at least 6

**Table 7-2. Remedial Action for Rail Defect**

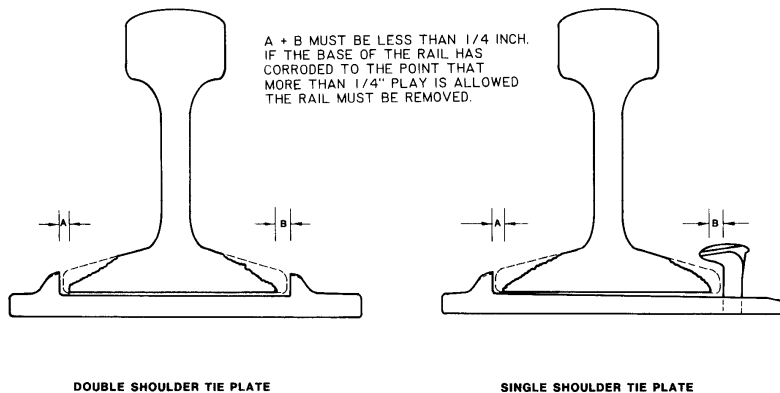
|  |
|--|
| <p>inches either side of the defect.</p> <ol style="list-style-type: none"> <li>3. Not allowed if results in a rail length of less than 13 feet (see "<a href="#">Short Rail</a>" below).</li> <li>4. May be allowed as an emergency measure until defect is removed, provided train operations are speed-restricted.</li> <li>5. If broken through or cracked out, rules for rough or angled complete break apply.</li> <li>6. Rail with wear on only one side may be transposed if the horizontal wear does not exceed 0.375 inch.</li> <li>7. Short lengths of flow may be ground off.</li> </ol> |
|--|



**Figure 7-1. Rail Wear Measurement**

**d. Base Corrosion.** Rail shall be removed from track if the base is corroded such that more than 0.25 inch play is allowed in the rail as shown in [Figure 7-2](#).

**e. End Batter.** Rail end batter is measured 0.5 inch from the rail end with an 18-inch straightedge laid only on the rail being measured as shown in [Figure 7-3](#). [Table 7-2](#) presents remedial actions for end batter.



**Figure 7-2. Rail Base Corrosion Measurement**

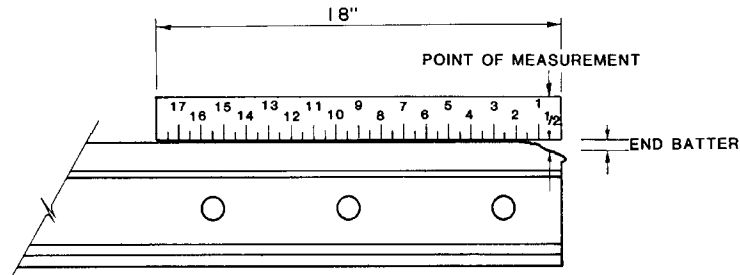


Figure 7-3. End Batter Measurement

f. **Running Surface Damage.** Rail running surface damage (e.g., deep engine burns, dents, equipment gouges) is measured at the midpoint of an 18-inch straightedge laid on the railhead over the defect.

## 7-2. RAIL MAINTENANCE.

a. **Rail.** New rail used in the maintenance of track shall meet the requirements specified in the *AREMA Manual For Railway Engineering*, Chapter 4.

b. **Internal Defect Inspection.** A “continuous search” internal rail defect inspection shall be performed on all active track. This internal rail defect inspection should be conducted using ultrasonic inspection techniques at a maximum of five-year intervals.

c. **Torch Cut.** Rail shall not be flame cut in any manner. This includes cropping the rail end, burning bolt holes, and trimming mismatched ends. Rail shall be cut using a mechanical or abrasive rail saw or other appropriate cutting tool.

d. **Short Rail.** Rail less than 13 feet in length shall not be installed in track.

7-3. **LIGHTWEIGHT RAIL.** Lightweight rail is defined as rail weighing less than 90 pounds/yard. Research has shown that lightweight rail may not be suitable for use in track subjected to heavy wheel loads.

a. Rail weights of 70 pounds/yard or less should be replaced if that rail will experience carloads of more than 50 tons (25,000-pound axle loads.)

b. Rail weighing 75 to 85 pounds/yard may be adequate depending upon tie and ballast support conditions. A structural evaluation and stress analysis is necessary to determine the adequacy of these rail weights. Rail not adequate to support the desired wheel loads should be replaced.

c. The replacement of any lightweight rail in Categories A and B track should be considered when planning major repair and/or rehabilitation projects.

## CHAPTER 8

### TURNOUTS

**8-1. GENERAL.** Turnouts are designed to divert trains from one track to another. Good turnout maintenance is essential for the safe and efficient operation of trains. Major components of a turnout are the switch, frog, and guardrails. [Figure 8-1](#) shows a typical split switch turnout with the various parts identified. Tongue and mate switches used in paved areas are also commonly found in Navy trackage.

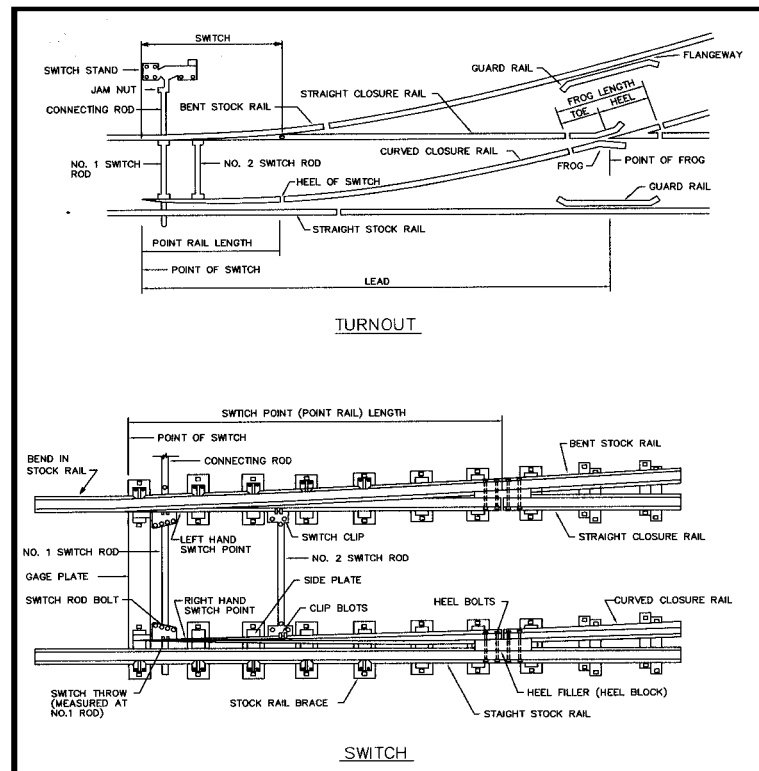
#### 8-2. GENERAL REQUIREMENTS.

**a. Materials.** All materials used within the limits of a turnout shall:

- (1) Be factory-designed and -constructed.
- (2) Be the proper weight and section.
- (3) Be properly installed.
- (4) Not be flame-cut or otherwise altered.

**b. Rail.** All rail used within the limits of a turnout shall be of the same weight and section. Compromise joints are not permitted within the limits of a turnout and shall be removed in the next maintenance cycle.

**c. Ties.** The standards in [Chapter 5](#) of this UFC shall apply to ties within the limits of a turnout. Interlaced cross ties are not permitted and shall be removed in the next maintenance cycle.



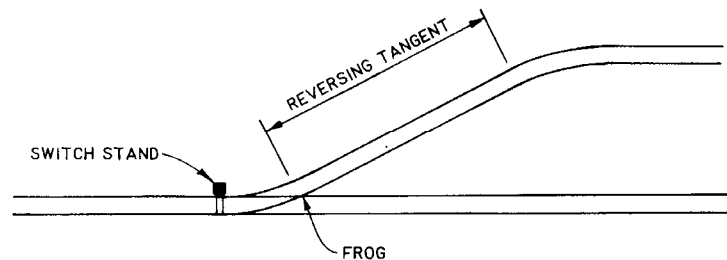
**Figure 8-1. Parts of a Turnout**

d. **Track Geometry.** The track inspector shall rate turnout track geometry as “Full Compliance,” “Maintenance Required,” “Restricted” or “No Operation” to conform to the standards in [Chapter 12](#) and this chapter.

e. **Reversing Tangent.** It is recommended that the tangent between the frog and any reverse curve past the frog be no less than 50 feet in length as shown in [Figure 8-2](#).

f. **Switch Stand Placement.**

(1) The switch stand shall be installed so that when the switch is lined for the normal (main) route, the connecting rod keeps the points closed with a pulling (rather than a pushing) force. In most cases this will mean installing the stand on the diverging side of the turnout as shown in [Figure 8-2](#).



**Figure 8-2. Reversing Tangent Length and Switch Stand Placement**

(2) When a ground-throw stand is used, the handle shall point toward the frog when the switch is lined for the normal (main) route.

g. **Cleaning, Lubrication, and Adjustment.** As scheduled, but at least annually, switches and switch stands shall be cleaned, lubricated, and adjusted. For Navy installations see NAVFACINST 11230.1 for additional guidance.

h. **Plates.** The proper type and size of tie plates shall be used. Double shoulder plates are preferred.

### 8-3. SWITCHES AND SWITCH STANDS.

a. Switches shall be inspected for the following defects:

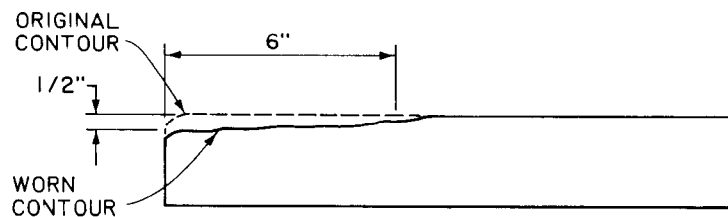
- (1) Switch difficult to operate.
- (2) Gap between the switch point and the stock rail. Check with points in both positions. (See [paragraph 8-3.b.](#))
- (3) Worn or chipped switch points. (See [paragraph 8-3.c.](#))
- (4) Point of switch higher than stock rail. (See [paragraph 8-3.c.](#))
- (5) Point rail beyond taper lower than stock rail. (See [paragraph 8-3.c.](#))
- (6) Damaged or missing switch stand lever latches or switch point lock. (See [paragraph 8-3.d.](#))
- (7) Loose, damaged, or improperly installed switch stand. (See [paragraph 8-3.f.](#) and [8-3.g.](#))
- (8) Loose, damaged, or missing jam nut at the end of the connecting rod. (See [paragraph 8-3.h.](#))
- (9) Bent, damaged, loose, binding, or improperly installed connecting rod, switch rods, or switch clips. (See [paragraph 8-3.h.](#))
- (10) Loose, damaged, or missing switch clip, switch rod, or connecting rod bolts. (See [paragraph 8-3.h.](#))

- (11) Loose, damaged, or missing heel bolts; cracked or improper heel joint bars or heel filler. (See [paragraph 8-3.i.](#))
- (12) Loose, damaged, or missing rail braces. (See [paragraph 8-3.i.](#))
- (13) Loose, damaged, or missing slide plates; dirt and debris buildup on slide plates.
- (14) Missing cotter keys on switch rod and switch clip bolts. (See [paragraph 8-3.i.](#))
- (15) Debris in flangeways. (See [paragraph 8-3.i.](#))
- (16) Debris obstructing switch rods and connecting rod. (See [paragraph 8-3.h.](#))
- (17) Loose, damaged or missing point rail stops.

**b. Switch Point Gap.** Maintenance standards require an adjustment if the switch can be thrown and locked in either direction with a 0.25-inch spacer between the switch point and the stock rail or if the gap is greater than zero. Safety standards require restricted track at over 0.25-inch up to 0.375-inch gap and no operations if gap is over 0.375 inch.

**c. Switch Points.**

- (1) If the switch point is chipped, broken, or worn more than 0.5 inch down and 6 inches back from the point, maintenance standards require the switch point to be restored or replaced. (See [Figure 8-3.](#))

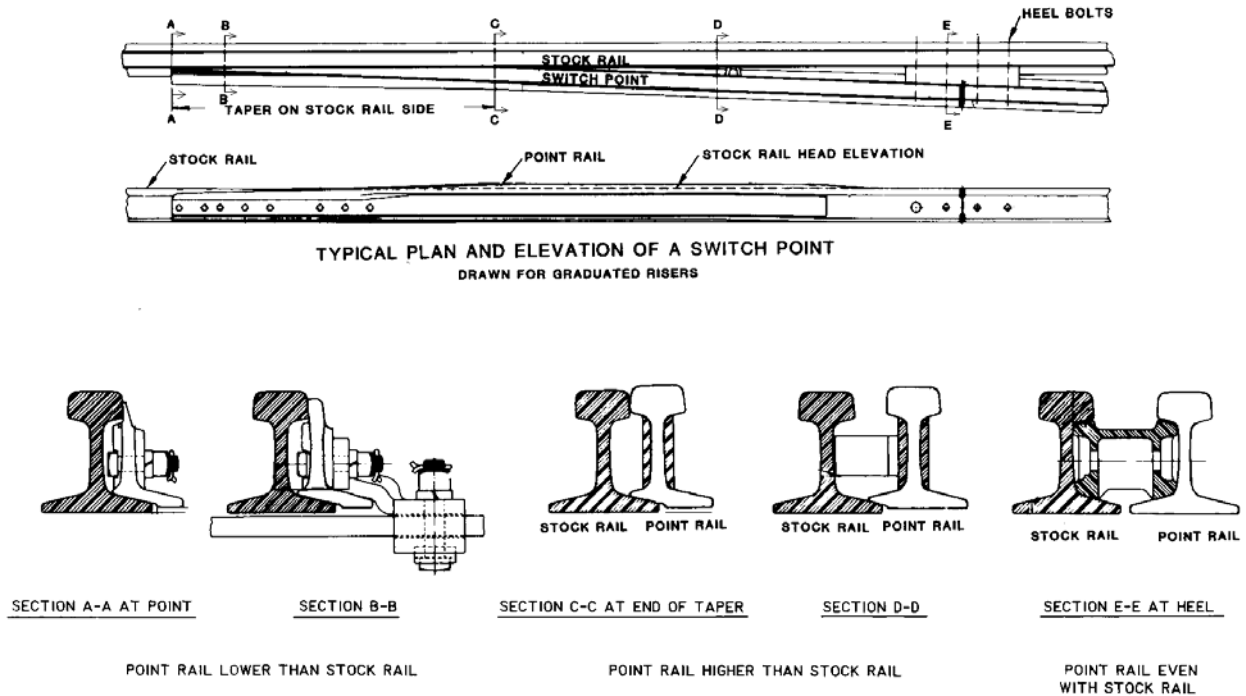


**Figure 8-3. Switch Point Contour**

- (2) If switch point is worn or damaged beyond these limits or the top surface of the switch point is higher than the stock rail, safety standards require operation through the turnout to be restricted.

- (3) If the point rail beyond the taper is lower than the top of the stock rail, no operations shall be permitted. Metal flow shall be removed by grinding to ensure proper closure. [Figure 8-4](#) shows the proper elevation of the switch point and point rail with respect to the stock rail.





**Figure 8-4. Switch Point Plan and Elevation.**

**d. Switch Stand Lever Latches and Point Locks.** Safety standards require turnouts with latches that are missing, damaged, insecure, or otherwise inoperative, to be “No Operation.”

**e. Switch Stand.** Maintenance standards require the switch stands to be fully secured to the head block ties to prevent any unintentional movement of the switch points. Where operations through the switch result in visible lateral movement of the switch stand or opening of the switch points (point gap), safety standards require “No Operation.”

**f. Connecting Rod, Switch Rods, and Switch Clips.**

(1) Maintenance standards require that these parts shall be installed and maintained to allow unobstructed motion when the switch is thrown. Rods and clips shall not contact adjacent ties. Damaged parts shall be replaced and improperly installed parts shall be adjusted. Washers or similar spacers shall not be permitted between the switch clip and the switch point. The jam nut at the adjustable end of the connecting rod shall be kept tight against the clevis.

(2) Safety standard is “No Operation” if the connecting rod, switch rod, or switch clip is insecurely fastened or is damaged. Where washers or similar spacers do not have full contact surface areas between the clip and switch point, operations through the turnout shall be restricted. Spacers, if needed, shall be constructed of steel plate with the dimension of the back of the switch clip and thickness, as required.

**g. Pocketing Switches.** Ballast shall not be allowed at a level that will interfere with the smooth operation of the switch.

(1) The ballast level in cribs beneath the connecting rod, switch point rails, and switch rods should be at least 2 inches below any steel. In regions where the snow and ice accumulate or frost heave is a problem, at least 4 inches of clearance should be provided. This should be checked and performed in the fall.

(2) For switches where this clearance is not provided, the cribs shall be pocketed to provide adequate clearance.

**h. Connecting Rod Bolts, Switch Rod Bolts, and Clip Bolts.** Maintenance standards require that connecting rod and switch rod bolts shall be installed with the nut on top and cotter keys in place. Clip bolts shall have cotter keys. If bolts are not tight, safety standards require restricted operation.

**i. Switch Heel (Bolts, Fillers, and Joint Bars).**

(1) *Maintenance Standards.* The heel of the switch shall be secure and the supporting switch ties solidly tamped. Where there are no existing heel blocks (filler), hook plates shall be used to secure the heel of the switch. The inside joint bar (nearest the track center) should be a bent bar per AREMA design. Remember, this assembly is a hinge allowing the switch rail to pivot in the joint assembly.

(2) Safety standards require restricted operation if any heel bolts are loose or missing, or the heel is otherwise not fully secure.

**j. Rail Braces.**

(1) *Maintenance Standards.* Rail braces are essential to provide proper lateral support to the stock rails. Rail braces shall be fully secured to the tie and tight against the outside of the stock rail on both sides of the turnout. Rail braces should be installed in accordance with the appropriate plans for a given length point rail found in the AREMA *Portfolio of Track Plans*. It is recommended that non-adjustable rail braces be installed on each switch tie from the point of switch to within two ties of the switch heel. Adjustable rail braces should be installed per the AREMA *Portfolio of Track Plans*.

(2) Safety standards require restricted operation through the turnout if there are less than four rail braces properly secured to the tie and tight against the outside of each stock rail while switch is thrown.

**k. Point Rail Stops.** Safety standards require track with bent or missing point stops to be "Restricted Operations."

**l. Debris in Flangeways.** Flangeways shall be kept clear of debris. Any obstructions, including ice and packed snow, shall be removed.

**8-4. FROGS.**

**a. Frog Point.**

(1) Maintenance standards require frogs to be restored if the point is chipped, broken, or worn more than 0.5 inch below the original top surface and 6 inches back from the original point location. ([See Figure 8-5](#))

(2) Safety standards require the track to be restricted for frog points with wear greater than 0.625 inch.

**b. Frog Tread Surface.**

(1) Maintenance standards require a frog to be restored when the tread surface is worn more than 0.3125 inch below its original contour. Frogs that cannot be rebuilt and restored to a "like new" condition shall be replaced.

(2) Safety standards require the track to be restricted if the frog tread surface is worn greater than 0.375 inch below its original contour. ([See Figure 8-5](#))

(3) If welding repairs are made on the frog, the tread portion of the frog will be restored before restoring the point.

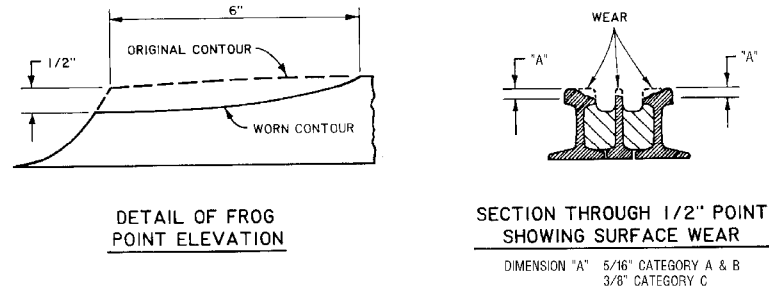


Figure 8-5. Frog Point and Tread Contours

**c. Guarding Face of Self-Guarded Frogs.**

(1) *Maintenance Standards.* The raised guarding face on a self-guarded frog shall not be worn more than 0.3125 inch. (See Figure 8-6)

(2) Safety standards require the track to be “No Operation” if the raised guarding face on a self-guarded frog is more than 0.375 inch.

**d. Repairing Self-Guarded Frogs.** If repairs are made to a self-guarded frog without removing it from service, the raised guarding face and tread portion must be restored before rebuilding the point.

**e. Frog Bolts.** All frog bolts shall be in place and tight.

**f. Frog Flangeway Width.** Standard frog flangeway width is 1.875 inches. Standards for frog flangeway width are presented in Table 8-1. (See Figure 8-7)

**g. Flangeway Depth.** Standard frog flangeway depth is 1.875 inches. Standards for frog flangeway depth are presented in Table 8-1. (See Figure 8-7)

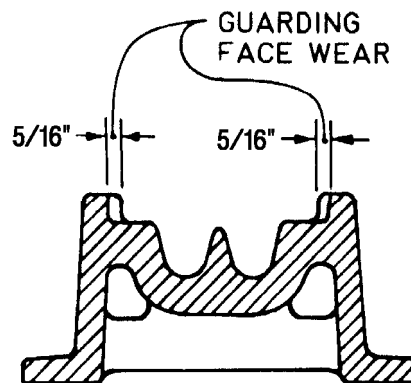


Figure 8-6. Allowable Wear on Guarding Face of Self-Guarded Frog

**8-5. GUARD RAILS.**

**a.** Guard rails shall be in place, properly positioned, and fully secured with guard rail plates placed with the shoulder against the guard rail. All guardrail bolts shall be in place and tight.

**b.** Guard rails shall be installed so the straight guarding face (the portion of the guard rail parallel with the running rail) extends in advance of the frog point a distance at least equal to the values given in Table 8-2.

**c. Guard Check Gage.** Standard guard check gage is 54.625 inches. Standards for guard check gage are presented in [Table 8-1](#). ([See Figure 8-7](#)) After the measurements are taken and appear satisfactory, if visual observations indicate that the frog point is being hit by the wheel flanges, a careful inspection must be made to determine the cause of the problem. Something may be loose. Remember, these are static measurements that are being taken.

**d. Guard Face Gage.** Standard guard face gage is 52.75 inches. Standards for guard face gage are presented in [Table 8-1](#). ([See Figure 8-7](#))

**e. Guardrail Flangeway Width.**

(1) Standard guardrail flangeway width is 1.875 inches. Standards for guardrail flangeway width are presented in [Table 8-1](#). ([See Figure 8-7](#))

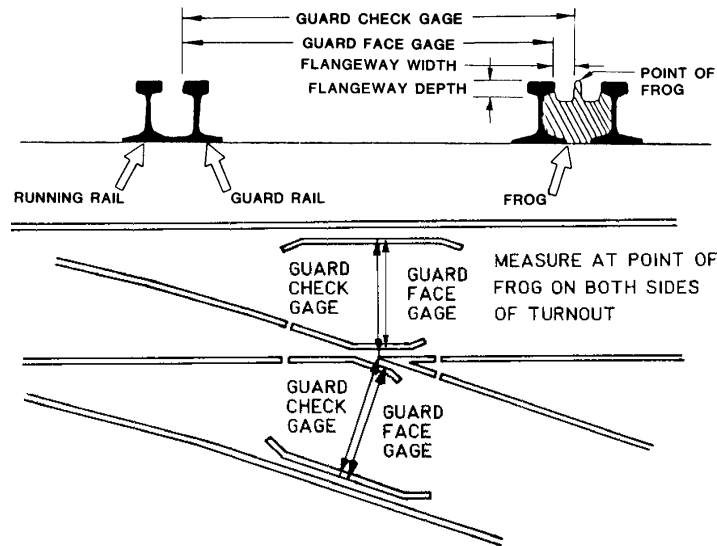
(2) Excessive wear on a guardrail is often indicated by a wide guardrail flangeway measurement or by tight guard check gage. Typically, guardrail flangeway widths of 2.125 inches or greater indicate that maintenance or replacement of the guardrail may be needed.

**8-6. GAGE MEASUREMENT.** See [Chapter 12](#) for gage measurements.

**Table 8-1. Measurements and Operating Restrictions for Frogs and Guard Rails**

| <i>Parameter</i>             | <b>Measurement</b>             |                               |   |                               |
|------------------------------|--------------------------------|-------------------------------|---|-------------------------------|
|                              | <b>Maintenance Standards</b>   |                               | <b>Safety Standard Operating Restrictions</b> |                               |
|                              | <i>(New or Fully Restored)</i> | <i>Minimum</i>                | <i>Restriction</i>                            | <i>No Operations</i>          |
| <b>Frog Flangeways</b>       |                                |                               |   |                               |
| Width                        | 1-7/8 in.<br>(1.875 in.)       | 1-5/8 in.<br>(1.625 in.)      | LT 1-5/8 in.<br>(1.625 in.)                   | LT 1-1/2 in.<br>(1.50 in.)    |
| Depth                        | GE 1-7/8 in.<br>(1.875 in.)    | LT 1-5/8 in.<br>(1.625 in.)   | LT 1-1/2 in.<br>(1.50 in.)                    | LT 1-3/8 in.<br>(1.375 in.)   |
| Guard Check Gage             | 54-5/8 in.<br>(54.625 in.)     | LT 54-3/8 in.<br>(54.375 in.) | LT 54-1/4 in.<br>(54.25 in.)                  | LT 54-1/8 in.<br>(54.125 in.) |
| Guard Face Gage              | 52-3/4 in.<br>(52.75 in.)      | GT 53 in.<br>(53.00 in.)      | GT 53-1/8 in.<br>(53.125 in.)                 | GT 53-1/4 in.<br>(53.25 in.)  |
| <b>Guard Rail Flangeway:</b> |                                |                               |   |                               |
| Width                        | 1-7/8 in.<br>(1.875 in.)       | 1-5/8 in.<br>(1.625 in.)      | LT 1-5/8 in.<br>(1.625 in.)                   | LT 1-1/2 in.<br>(1.50 in.)    |

Note: GE = greater than or equal to, LT = less than, GT = greater than



**Figure 8-7. Measurement of Flangeway Width, Flangeway Depth, Guard Check Gage, and Guard Face Gage**

**Table 8-2. Minimum Length of Straight Guarding Face in Advance of Frog Point**

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

## CHAPTER 9

### RAIL CROSSINGS

**9-1. GENERAL.** Rail crossings are designed to carry one track across another at grade. Drainage is vital in protecting the subgrade from increased impacts.

**9-2. MAINTENANCE REQUIREMENTS.**

**a. Size.** Rail crossings shall be the proper weight and section for the rails being joined.

**b. Flangeway Width and Depth.** Standards for rail crossing flangeways are identical to the frog flangeway standards given in [Table 8-1](#) and shall be used.

**c. Debris in Flangeways.** Flangeways shall be kept clear of debris. Any obstructions, including ice and packed snow, shall be removed.

**d. Bolts.** All crossing bolts shall be in place and tight. Loose bolts shall be tightened and bolts that cannot be tightened shall be replaced. Missing bolts shall be replaced.

**e. Special Components.** All broken or damaged components shall be replaced or repaired.

**9-3. ANCHORS.** Where rail anchors are used on track approaching rail crossings, every third tie should be box-anchored (four anchors per tie) for at least two rail lengths in all directions from the crossing.

## CHAPTER 10

### ROAD CROSSINGS

#### 10-1. DRAINAGE.

- a. Adequate drainage is essential for satisfactory long-term performance of the track and roadway crossing.
- b. Water shall not be allowed to pond on or near the track at a road crossing.
- c. Catch-basins, gutters, ditches, sub-drains, and culverts should be properly installed and kept free of debris.

#### 10-2. FLANGEWAYS.

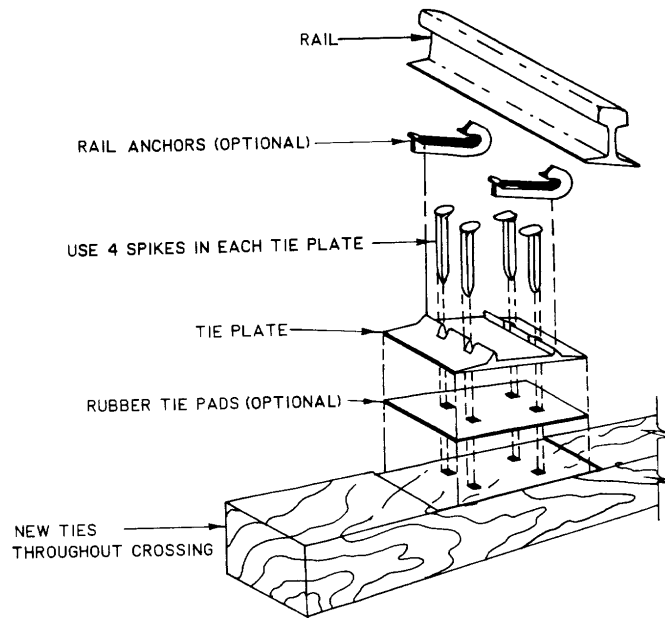
- a. **Flangeway Width.** Maintenance standards require the flangeway width in a road crossing to be no less than 2.5 inches nor greater than 3 inches. Safety standards require "Restricted Operation" for formed flangeway widths less than 1.75 inches.
- b. **Flangeway Depth.** Maintenance standards require the flangeway depth in a road crossing to be no less than 2 inches. Safety standards require "Restricted Operation" for flangeway depth less than 1.5 inches.
- c. **Debris.** Flangeways shall be kept clear of debris. Any obstructions, including ice and packed snow, shall be removed immediately.

#### 10-3. TRACK.

- a. **Ties, Tie Plates, and Spikes.** When crossings are rebuilt, all ties within the crossing limits and for at least 20 feet beyond each end of the crossing shall be replaced, fully tie plated, and spiked with eight rail-holding spikes on each tie ([see Figure 10-1](#)). For crossings, the use of hardwood ties is recommended.
- b. **Joints.** Bolted rail joints are not desirable in road crossings. When crossings are rebuilt, it is highly recommended that all joints within the crossing and up to 20 feet outside the crossing be welded.
- c. **Rail Anchors.** Where the track on either side of the crossing is anchored, it is recommended that the anchoring pattern be continued through the crossing, provided that the crossing panels can accommodate anchors.

#### 10-4. CROSSING SURFACES AND MATERIALS.

- a. It is essential that the crossing surface be maintained to provide a smooth crossing for vehicles and to prevent vehicle tires from striking the rails. The crossing surface shall be maintained at an elevation level with the top of the rails. Additionally, there shall be a smooth transition between the crossing surface and the adjoining pavement.
- b. During routine track inspections the inspector should take note of the general condition of the crossing materials and report any damage or condition requiring repair or replacement. Any condition observed in a road crossing which would cause a hazard to motor vehicles using the crossing should be corrected immediately.



**Figure 10-1. Track Construction for Road Crossing**

**10-5. GRADE CROSSING PROTECTION—SIGNS AND SIGNALS.** During routine track inspections, the inspector should observe the condition of all whistle posts, highway warning signs and crossbucks, and signals. Signs and signals should be easily legible and clearly visible to the highway user. Signs and signals shall conform to the requirements of the Federal Highway Administration (FHA) *Manual on Uniform Traffic Control Devices* (MUTCD), Part 8, “Traffic Controls for Highway–Rail Grade Crossings.” Additional guidance may be obtained from the FHA *Railroad–Highway Grade Crossing Handbook*.

**10-6. ELECTRIC/ELECTROMECHANICAL GRADE CROSSING SIGNALS.** Inspection and maintenance of electric and/or electromechanical signals should conform to manufacturer's recommendations, state/local requirements, and the FRA Part 234 “Grade Crossing Signal System Safety.” Paragraph [10-6.a](#) and [b](#) summarizes the minimum requirements of the FRA standards. The inspections and tests described are performed to determine if the warning system and its component parts are maintained in a condition to perform their intended function. Any electromagnetic device, relay or other electromagnetic device that fails to meet the requirements of the tests shall be removed from service until corrected. All reference to “system” in the remainder of this section shall refer to the grade crossing signal system. The inspector shall meet the qualifications of FRA Part 212.231. Signals shall be inspected once each month.

**a. Maintenance Standards.**

(1) *Location of Plans.* Plans required for proper maintenance and testing shall be kept at each system location (equipment cabinet). Plans shall be legible and correct.

(2) All control circuits shall operate on a fail-safe principle.

(3) Operating characteristics of electromagnetic, electronic, or electrical apparatus shall be maintained in accordance with the limits within which the system is designed to operate.

(4) When any essential component fails to perform its intended function, the cause shall be determined and the faulty component adjusted, repaired, or replaced



immediately. Until repair is completed, comply with appropriate action to flag vehicular traffic in accordance with activity/installation regulations or, for the Navy, paragraph 3.3.f of NAVFAC P-301, *Navy Railway Operating Handbook*.

(5) During testing or performing work on signals or track structure, which affects the integrity of the warning system, alternative methods must be provided to maintain safety for the highway user. Immediately after repairs, adjustments, or replacements have been completed, an appropriate test of the affected equipment must be made to verify that the system is operating as intended.

(6) Highway-rail grade crossing warning system apparatus shall be secured against unauthorized entry (i.e., locked equipment cabinet).

(7) Each circuit that affects the proper functioning of a grade crossing warning system shall be kept free of any ground or combination of grounds that will permit a current flow of 75 percent or more of the release value of any relay or electromagnetic device in the circuit.

(8) A standby source of power shall be provided with sufficient capacity to operate a warning system for a reasonable length of time during a period of primary power interruption. The designated capacity shall be specified on the plans ([Paragraph 10-6.a.\(1\)](#)). Batteries shall be checked as follows:

(a) Keep battery terminals, vent caps and cell casings clean. Keep terminals lightly coated with no-oxide grease.

(b) Keep electrolyte at the correct level in each cell.

(c) Check the charging rate and adjust as necessary.

(d) Measure and record the voltage of each cell.

(9) Flashing light units shall:

(a) Be properly positioned and aligned and shall be visible to a highway user approaching the crossing.

(b) Be maintained to prevent dust and moisture from entering the interior of the unit. Roundels and reflectors shall be clean and in good condition.

(c) Flash alternately. The number of flashes per minute for each light unit shall be 35 minimum and 65 maximum.

(10) Each gate arm light shall be maintained in such condition as to be properly visible to approaching highway users. Gates shall be cleaned and lubricated as necessary. Lights and light wire shall be secured to the gate arm.

(11) The voltage at each lamp shall be maintained at no less than 85 percent of the prescribed rating for the lamp.

(12) Each gate arm, when in the downward position, shall extend across each lane of approaching highway traffic and shall be clearly viewable by approaching highway users. Each gate arm shall start its downward motion not less than three seconds after flashing lights begin to operate and shall be in a horizontal position at least five seconds before the train arrives at the crossing.

(13) System must activate at least 20 seconds prior to rail traffic occupying a grade crossing.

(14) Train detection apparatus shall be maintained to detect a train or railcar in any part of a train detection circuit. If the presence of sand, rust, dirt, grease, or other foreign matter is known to prevent effective shunting, flagging of the crossing shall be accomplished.

(15) Each train detection circuit shall detect the application of a shunt of 0.06-ohm resistance when the shunt is connected across the rails of any part of the circuit.

(16) Each set of fouling wires in a train detection circuit shall consist of two discrete conductors, each maintained in such condition to ensure proper operation of detection apparatus when the circuit is shunted.

(17) Each non-insulated rail joint located within the limits of a train detection circuit shall be bonded by means other than joint bars and the bonds shall be maintained in such condition to ensure electrical conductivity.

(18) Each insulated rail joint shall be maintained to prevent current flowing between rails separated by the insulation in an amount sufficient to cause failure of the detection circuit.

(19) A switch, when equipped with a switch circuit controller connected to the point and interconnected with warning system circuitry, shall be maintained so that the warning system can only be cut out when the switch point is within 0.5 inch of full reverse position.

(20) Each wire shall be tagged or otherwise marked so that it can be identified at each terminal. Tags and other marks shall be made of insulating material and so arranged that tags and wires do not interfere with moving parts of the apparatus.

(21) Insulated wire shall be protected from mechanical injury. The insulation shall not be punctured for test purposes. A splice in underground wire shall have insulation resistance at least equal to that of the wire spliced.

(22) Wire on a pole line shall be securely attached to an insulator that is properly fastened to a cross arm or bracket supported by a pole or other support. Wire shall not interfere with other wires on the pole line. An open-wire transmission line operating at 750 volts or more shall be placed not less than 4 feet above the nearest cross arm carrying active warning system circuits.

(23) Each sign mounted on a signal system post shall be in good condition and be visible to the highway user.

**b. Inspections and Tests.** Inspection and tests of electric/electromechanical signals shall be performed to determine if the warning system and its component parts are maintained in a condition to perform their intended function. Any electronic device, relay, or other electromagnetic device that fails to meet the requirements of tests required by this UFC shall be removed from service and shall not be restored to service until its operating characteristics are in accordance with the limits within which such device or relay is designed to operate. Additional tests, adjustments, cleaning and lubrication in accordance with the equipment manufacturer shall be accomplished. Proper precautions must be taken to protect highway traffic and safe operation of trains before any changes or tests are initiated on a highway-grade crossing warning system.

(1) *Monthly Inspection and/or Tests.*

(a) Ground Tests: A test of grounds on each energy bus furnishing power to circuits that affect the safety of the warning system operation. (See [paragraph 10-6.a.\(7\)](#))

(b) Standby Power: Standby power shall be tested. (See [paragraph 10-6.a.\(8\)](#))

(c) Flashing Light Units: Each flashing light unit shall be inspected for proper visibility, dirt and damage to roundels and reflectors. Lenses shall be cleaned and bulbs replaced, as necessary. (See [paragraph 10-6.a.\(9\)\(b\)](#))

(d) Gate Arms and Gate Mechanism: Each gate arm and mechanism shall be inspected and observed for proper operation. (See [paragraph 10-6.a.\(10\)](#) and [\(12\)](#))

(e) Warning System Operation: Each crossing warning system, including warning bells or other stationary audible warning devices, shall be tested to determine that it functions as intended. (See [paragraph 10-6.a.\(15\)](#))

(f) Highway traffic signal pre-emption interconnection shall be tested.

(2) *Quarterly Inspections and/or Tests.*

(a) Cut-out circuits shall be tested at least every three months to determine that the circuit functions as intended. A cutout circuit is any circuit or device that overrides the operation of the automatic warning system. This includes both switch cutout switches and devices that enable personnel to manually override the system operation.

(b) Insulated rail joints, bond wires, and track connections shall be inspected. (See [paragraph 10-6.a.\(17\)](#) and [\(18\)](#))

(3) *Annual Inspection and/or Tests.*

(a) Flashing Light Units and Lamp Voltage:

1. Each flashing light unit shall be inspected for proper alignment and frequency of flashes in accordance with installation specifications. (See [paragraph 10-6.a.\(9\)\(a\)](#) and [\(c\)](#))

2. Lamp voltage shall be tested. (See [paragraph 10-6.a.\(11\)](#))

(b) Gate mechanism hold-clear devices shall be tested for proper operation.

(c) Each crossing warning system shall be tested for the prescribed warning time. (See [paragraph 10.6.a.\(13\)](#))

(d) Timing Relays and Timing Devices: Each timing relay and timing device shall be tested. The timing shall be maintained at not less than 90 percent nor more than 110 percent of the 41 predetermined time intervals. The predetermined time intervals shall be shown on the plans or marked on the timing relay or timing device.

(4) The following shall be tested at the frequency indicated:

(a) Relays affecting the proper functioning of a crossing warning system:

1. Alternating current centrifugal relays shall be tested every 12 months.

2. Alternating current vane-type relays, direct current polar-type relays and relays with soft iron magnetic structure shall be tested every two years.

3. Other type relays shall be tested at least every four years.

(b) Insulation resistance tests, wires in trunking and cables:

1. Insulation resistance tests shall be made on wires or cables every 10 years.

2. Insulation resistance tests shall be made between all conductors and ground, between conductors in each multiple conductor cable and between conductors in trunking. Insulation resistance tests shall be performed when wires, cables and insulation are dry.

3. When insulation resistance of wire or cable is found to be less than 500,000 ohms, prompt action shall be taken to repair or replace the defective wire or cable. Until replacement is completed, insulation resistance testing shall be made annually. A circuit with a conductor having an insulation resistance of less than 200,000 ohms shall not be used.

**c. Results of Inspections and Tests.** Results of inspections and tests made in accordance with [paragraph 10-6.b](#) shall be recorded. A sample form is provided in Appendix B, [Figure B-3](#). The inspector shall sign each record. Each record shall be retained for two years or until the next reported inspection, whichever is longer. Each record shall indicate activity name, crossing inventory name, place and date, equipment tested, results of tests, repairs, replacements, adjustment made, and condition in which the apparatus was left.

## CHAPTER 11

### BRIDGES

#### 11-1. GENERAL.

a. For inspection purposes, track standards are applied to the bridge ties and all the components resting on them. Bridge standards are applied to those components supporting the bridge ties and below.

b. All track bridges shall be equipped with inner guardrails. Guardrails may be an appropriate safety measure for tracks located under bridge overpasses.

c. Rail anchors shall not be installed on track over open deck bridges. Any anchors found on track over an open deck bridge shall be removed immediately.

#### 11-2. BRIDGE INSPECTION AND LOAD RATINGS.

a. Railroad bridges shall be inspected using the procedures and checkpoints described in NAVFAC MO-322, *Inspection of Shore Facilities*, for the Navy; TM 5-600/AFJPAM 32-1088, *Bridge Inspection, Maintenance and Repair*, for the Air Force and Army; and AR 420-72 for the Army. For the Air Force, the BCE is responsible for determining the inspection requirements. The minimum frequency for inspecting railroad bridges is every two years.

b. Structure analysis based on current loading or larger anticipated loadings shall be maintained on file in accordance with NAVFACINST 11230.1 for Navy activities and AR 420-72 for Army garrisons.

**11-3. DANGEROUS CONDITIONS.** Inspectors shall note any condition of a bridge that might adversely affect train operations. Such conditions shall be reported immediately to the proper authorities. Train operations over the structure shall not be permitted until a damage or in-depth inspection is completed and has documented that the bridge is sufficient for normal operations.

## CHAPTER 12 TRACK GEOMETRY

### 12-1. GENERAL.

a. One rail shall be designated as the line rail. This rail establishes the alignment of the track. Either rail may be used as the line rail on tangent track so long as the same rail is used for the entire length of the tangent. The outside rail in a curve is always the line rail.

b. In curves, the inside rail is designated as the grade rail. The grade rail is the reference from which superelevation is applied to the outside rail of the curve.

c. During routine track inspections, track geometry measurements shall be taken as a minimum at the following locations:

- (1) Wherever there are visual indications of track geometry deviations.
- (2) Wherever track geometry deviations were previously detected, unless the deviation has been corrected.
- (3) Other locations as specified in this chapter.

### 12-2. GAGE.

a. **Definition.** Gage is the distance between the two rail heads, measured at right angles to the rails in a plane 0.625 inch below the top surface of the rail head as shown in [Figure 12-1](#). Gage measurements shall include any evidence of lateral movement under load, such as any space between the field side rail base and tie plate shoulder.

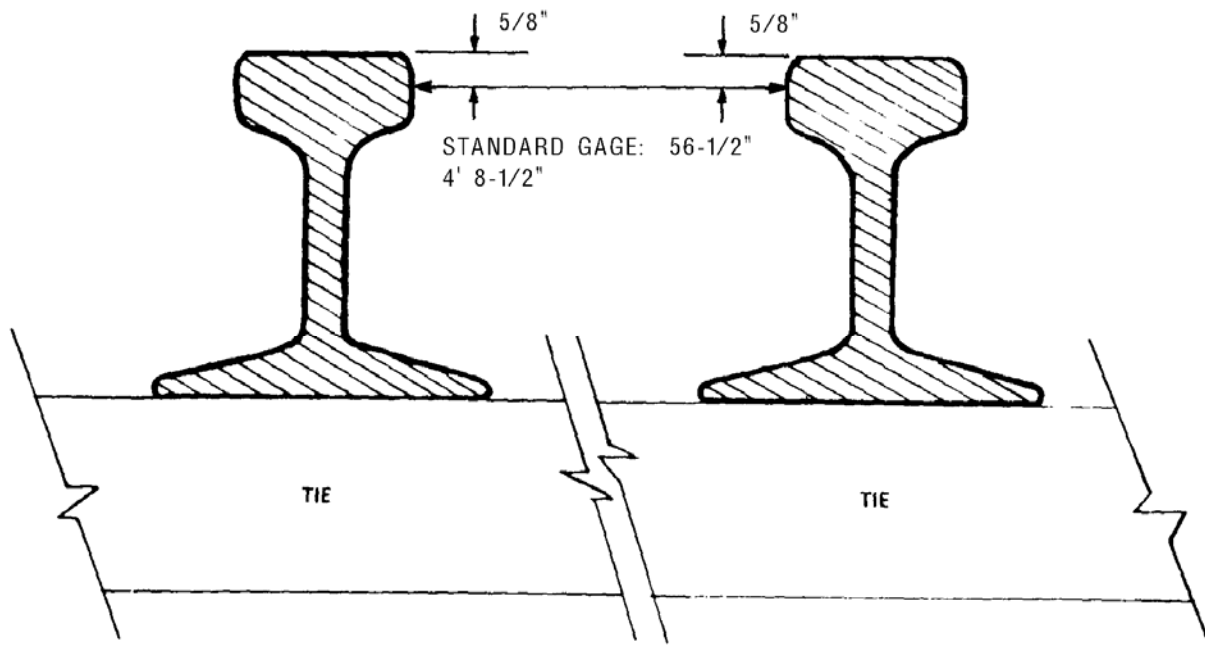
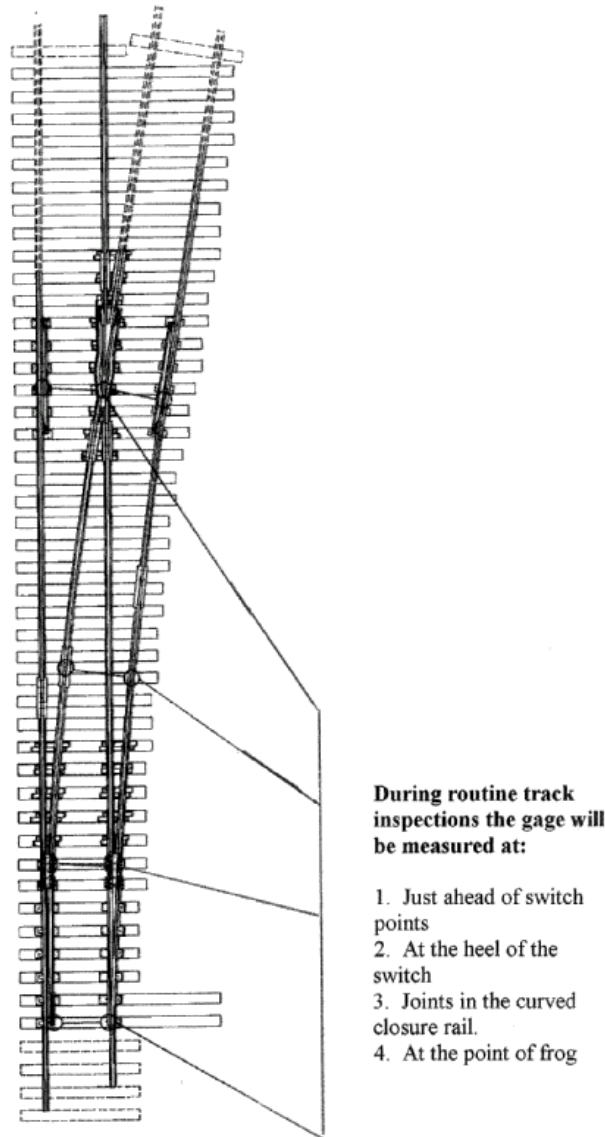


Figure 12-1. Gage Measurement

b. **Measurement Locations.** During routine track inspections, gage shall be measured at the following locations:

- (1) In turnouts, just ahead of switch points (ahead of the bend in the stockrail) and at the joints in curved closure rails. ([See Figure 12-2](#))

- (2) Two measurements at the heel of the switch for the straight rail and the turnout side.
- (3) At the point of frog on both sides of turnouts and rail crossings. ([See Figure 12-2](#))
- (4) Wherever there is a dark streak running along the field side of the top surface of the railhead.
- (5) Wherever wear marks on a tie indicate lateral tie plate movement.
- (6) Where a significant gap exists between the rail base and outside shoulder of the tie plate.
- (7) At locations where ties are badly skewed.
- (8) In road crossings.
- (9) Near the beginning and ending of curves.
- (10) In curves greater than 6 degrees, gage shall be measured in at least three well-spaced locations within the curve. Outside rail joints should also be observed for gage widening.



**Figure 12-2. Required Gage Measurement Locations Within Turnouts**

c. **Standard Gage.** Standard gage is 56.5 inches. Track will be gaged to this standard except in curves with high degrees of curvature ([see Table 12-1](#)) or other unusual conditions where the engineer in charge does not recommend standard gage.

**Table 12-1a. Recommended Gage for Curved Track  
(Navy & Air Force)**

| Degree of Curvature              | Recommended Gage (Inches) |
|----------------------------------|---------------------------|
| Up to 12 degrees                 | 56.5                      |
| Over 12 degrees up to 14 degrees | 56.625                    |
| Over 14 degrees up to 16 degrees | 56.75                     |



|                                  |        |
|----------------------------------|--------|
| Over 16 degrees up to 18 degrees | 56.875 |
| Over 18 degrees,                 | 57     |

**Table 12-1b. Recommended Gage for Curved Track (Army)**

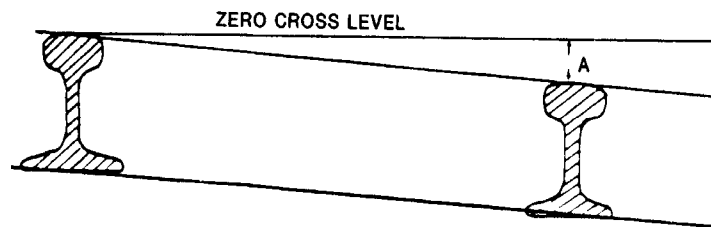
| Degree of Curvature              | Recommended Gage (Inches) |
|----------------------------------|---------------------------|
| Up to 22 degrees                 | 56.5                      |
| Over 22 degrees up to 26 degrees | 56.625                    |
| Over 26 degrees up to 30 degrees | 56.75                     |
| Over 30                          | 56.875                    |

d. Standards for gage are as follows:

| Safety Standards Allowable Gage<br>(Inch) |            |                      |            | Maintenance<br>Allowable Gage<br>(Inch) |            |
|---|------------|----------------------|------------|---|------------|
| <i>Restriction</i>                        |            | <i>No Operations</i> |            | <i>Min</i>                              | <i>Max</i> |
| <i>Min</i>                                | <i>Max</i> | <i>Min</i>           | <i>Max</i> |   |            |
| 56  | GT 57.5    | LT 56                | GT 57.75   | 56.125                                  | 57.5       |

**12-3. CROSSLEVEL.**

a. **Definition.** Crosslevel is the difference in elevation between the top surfaces of the two rails measured at right angles to the track, as shown in [Figure 12-3](#). Crosslevel measurements shall include any evidence of vertical movement under load.



**Figure 12-3. Crosslevel Measurement**

b. **Designated Crosslevel.** On tangent track, the designated crosslevel is zero. On curved track, the designated crosslevel is equal to the designated superelevation.

c. Standards for the allowable deviation from designated elevation for crosslevel are as follows:

| Track Category | Safety Standard (Inches) |                     | Maintenance Standard (Inches) |
|----------------|--------------------------|---------------------|-------------------------------|
|                | <i>Restriction</i>       | <i>No Operation</i> |                               |
| A              | GT 2                     | GT 3                | GT 1.25                       |
| B              | GT 2                     | GT 3                | GT 1.5                        |

**12-4. SUPERELEVATION.**

a. **Definition.** Superelevation is the intended increase in elevation of the outer rail above the inner rail in a curve.

b. **Reverse Superelevation.** Safety standards require a restriction if the outside rail of a curve is lower than the inside rail by more than 0.5 inch. Maintenance standards require the outside rail of a curve to be at the same elevation or above the inside rail.

c. **Maximum Superelevation.** The outside rail of a curve may not be more than 4 inches higher than the inside rail.

d. **Uniform Superelevation.** If a curve is superelevated, the superelevation shall be uniform throughout the curve.

e. **Superelevation Runoff.** Superelevation runoff shall be at a uniform rate and shall extend at least the full length of the spiral. If no spiral is present, the superelevation runoff shall be accomplished on the tangent track. Safety standards require a restriction if the superelevation runoff exceeds –1.75 inches in any 31 feet of rail. Maintenance standards recommend a target of 1 inch of runoff in 31 feet.

f. **Recommended Superelevation.** The recommended superelevation for a given maximum operating speed for curved track can be determined from [Table 12-2](#). Table 12-2 reflects the recommended 0.5 inch of unbalance. Safety standards require a restriction if the curve superelevation exceeds 3 inches of unbalance. Three (3) inches of unbalance would be equal to 2.5 inches less than the recommended values of superelevation in Table 12-2. Maintenance shall be performed during the next maintenance cycle when the superelevation exceeds 1.5 inches of unbalance. One and one-half (1.5) inches of unbalance would be equal to 1 inch less than the recommended values of superelevation in Table 12-2. If reverse superelevation exists see paragraph 12-4.b.

Table 12-2. Recommended Superelevation for Curved Track

| Degree of Curvature | Maximum Operating Speed (mph) |      |      |      |      |      |      |      |
|---------------------|-------------------------------|------|------|------|------|------|------|------|
|                     | 10                            | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
| 0.50                | 0.50                          | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| 1.00                | 0.50                          | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.75 | 1.00 |
| 1.50                | 0.50                          | 0.50 | 0.50 | 0.50 | 0.50 | 0.75 | 1.25 | 1.75 |
| 2.00                | 0.50                          | 0.50 | 0.50 | 0.50 | 0.75 | 1.25 | 1.75 | 2.25 |
| 2.50                | 0.50                          | 0.50 | 0.50 | 0.50 | 1.00 | 1.75 | 2.25 | 3.00 |
| 3.00                | 0.50                          | 0.50 | 0.50 | 0.75 | 1.50 | 2.00 | 2.75 | 3.75 |
| 3.50                | 0.50                          | 0.50 | 0.50 | 1.00 | 1.75 | 2.50 | 3.50 |      |
| 4.00                | 0.50                          | 0.50 | 0.50 | 1.25 | 2.00 | 3.00 | 4.00 |      |

| Degree of Curvature | Maximum Operating Speed (mph) |      |      |      |      |      |    |    |
|---------------------|-------------------------------|------|------|------|------|------|----|----|
|                     | 10                            | 15   | 20   | 25   | 30   | 35   | 40 | 45 |
| 4.50                | 0.50                          | 0.50 | 0.75 | 1.50 | 2.25 | 3.25 |    |    |
| 5.00                | 0.50                          | 0.50 | 1.00 | 1.75 | 2.75 | 3.75 |    |    |
| 5.50                | 0.50                          | 0.50 | 1.00 | 2.00 | 3.00 |      |    |    |
| 6.00                | 0.50                          | 0.50 | 1.25 | 2.25 | 3.25 |      |    |    |
| 6.50                | 0.50                          | 0.50 | 1.25 | 2.25 | 3.50 |      |    |    |
| 7.00                | 0.50                          | 0.75 | 1.50 | 2.50 | 4.00 |      |    |    |
| 7.50                | 0.50                          | 0.75 | 1.50 | 2.75 |      |      |    |    |
| 8.00                | 0.50                          | 1.00 | 1.75 | 3.00 |      |      |    |    |
| 8.50                | 0.50                          | 1.00 | 2.00 | 3.25 |      |      |    |    |
| 9.00                | 0.50                          | 1.00 | 2.00 | 3.50 |      |      |    |    |
| 9.50                | 0.50                          | 1.00 | 2.25 | 3.75 |      |      |    |    |
| 10.00               | 0.50                          | 1.00 | 2.25 | 4.00 |      |      |    |    |
| 10.50               | 0.50                          | 1.25 | 2.50 | 4.00 |      |      |    |    |
| 11.00               | 0.50                          | 1.25 | 2.50 |      |      |      |    |    |
| 11.50               | 0.50                          | 1.25 | 2.75 |      |      |      |    |    |
| 12.00               | 0.50                          | 1.50 | 2.75 |      |      |      |    |    |
| 13.00               | 0.50                          | 1.50 | 3.25 |      |      |      |    |    |
| 14.00               | 0.50                          | 1.75 | 3.50 |      |      |      |    |    |
| 15.00               | 0.75                          | 1.75 | 3.75 |      |      |      |    |    |
| 16.00               | 0.75                          | 2.00 | 4.00 |      |      |      |    |    |
| 17.00               | 0.75                          | 2.25 |      |      |      |      |    |    |
| 18.00               | 1.00                          | 2.25 |      |      |      |      |    |    |
| 19.00               | 1.00                          | 2.50 |      |      |      |      |    |    |
| 20.00               | 1.00                          | 2.75 |      |      |      |      |    |    |

TRAINS SHALL NOT BE OPERATED ON CURVES AT SPEEDS WHICH REQUIRE MORE THAN 4 IN. SUPERELEVATION

Notes for [Table 12-2](#):

- At least 0.5 inch of superelevation is recommended on all curves as indicated to prevent reverse superelevation. On curves that historically do not retain the minimum 0.5 inch of superelevation, the next maintenance cycle should surface the curve with 1 inch of superelevation.
- Safety standards should use the 3-inch unbalanced formula in accordance with the FRA *Track Safety Standards*.
- Superelevation calculated using 0.5-inch unbalanced formula, i.e.:

$$E = (0.0007DV^2) - 0.5$$

**where:** E = Superelevation, inches, D = Degree of Curvature V = Speed, mph. All values have been rounded to 0.25-inch increments.

**Examples:**

To determine superelevation:

- Enter table at maximum operating speed.
- Go down to maximum degree of curvature.
- Read Superelevation.

Known:

- Maximum operating speed: 25 mph.
- Degree of curvature: 8°

Required superelevation is 3.00 inches.

- Cross-level ([paragraph 12-3](#)) shall determine the need for maintenance (related to superelevation) on curves.

**12-5. WARP.**

**a. Definition.** Warp is the difference in crosslevel between any two points less than or equal to 62 feet apart. Warp is determined as follows:

(1) Use the line rail as the reference rail.

(2) Measure the crosslevel at any two points less than 62 feet apart, normally at joints in the rail. If the reference rail is lower than the opposite rail, the sign of the measurement is negative (-). If the reference rail is higher than the opposite rail, the sign of the measurement is positive (+).

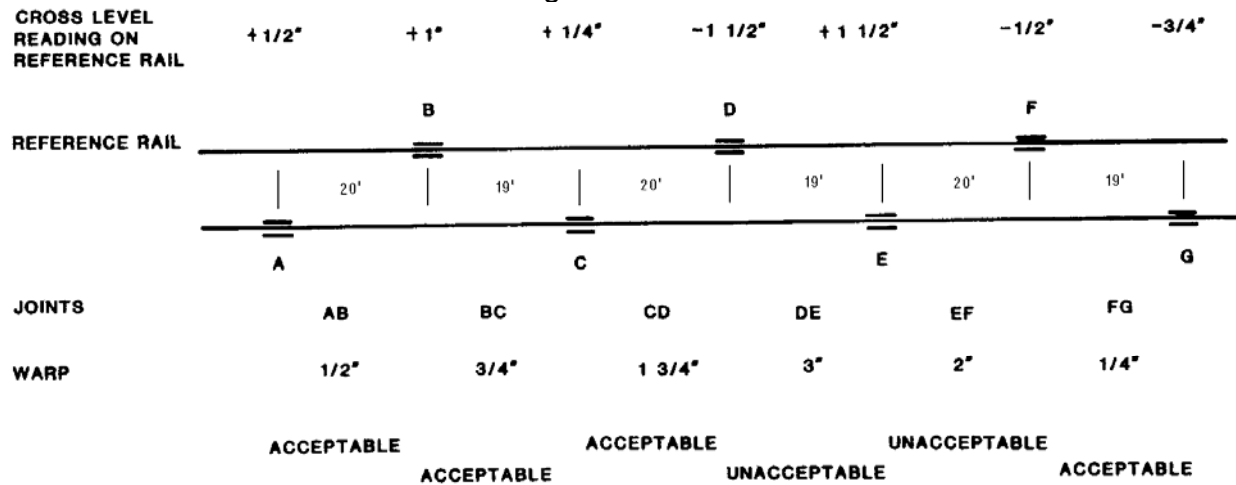
(3) *Determining Warp.* If both signs are the same, drop the signs and subtract the smaller measurement from the larger measurement. If the signs are different, drop the signs and add the measurements. [Figure 12-4](#) presents an example of the warp calculation.

**b. Designated Warp.** The designated warp on both tangent and curved track is zero.

**c. Maintenance and Safety Standards.** Standards for the maximum allowable deviation due to warp are as follows:

| Safety Standards (Inches) |              | Maintenance Standards (Inches) |
|---------------------------|--------------|--------------------------------|
| Restriction               | No Operation |                                |
| GT 2.25                   | GT 3.0       | GT 1.75                        |

**d.** All measurements taken at joints within the 62-foot distance must be calculated for warp. Assuming 39-foot rails, in addition to calculating warp at AB & AC, warp shall also be checked at AD as shown on Figure 12-4.



**NOTE: DISTANCE BETWEEN MEASUREMENTS IS 62 FEET OR LESS.  
 POSITIVE MEASUREMENT INDICATES REFERENCE RAIL IS HIGHER THAN OPPOSITE RAIL.  
 NEGATIVE MEASUREMENT INDICATES REFERENCE RAIL IS LOWER THAN OPPOSITE RAIL.**

**Figure 12-4. Determination of Warp**

**12-6. ALIGNMENT.**

**a. Definition.** Alignment is the relative position of the rails in a horizontal plane.

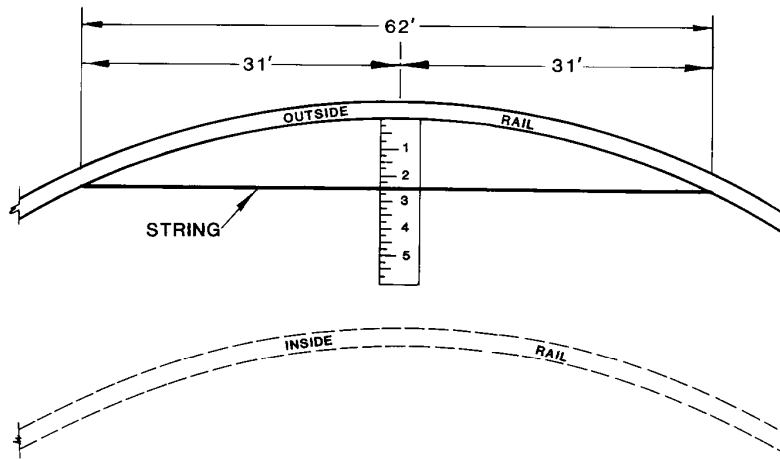
**b. Measurement.** Alignment is measured at the midpoint of a 62-foot string line stretched along the gage side of the line rail at a distance of 0.625 inch below the top of the railhead. The alignment measurement is the distance in inches from the midpoint of the string line to the gage side of the line rail. It is measured at right angles to the string line.

**c. Designated Alignment.** For tangent track the designated alignment is zero. For curved track the designated alignment is the degree of curvature. In spirals the change in curvature will be at a uniform rate.

**d. Curvature Measurement.** On curves, 1-inch distance from the 62-foot string line to the line rail equals approximately 1 degree of curvature, as shown in [Figure 12-5](#). If the degree of curvature is not known, it can be determined as follows:

(1) Beginning at a point near the center of the curve, mark at least two stations spaced 31 feet apart in both directions along the line rail.

(2) Measure the alignment at each station, including the beginning point, and average the measurements. This average measurement is the approximate degree of curvature.



**MEASUREMENTS OF ALIGNMENT USING A 62 FOOT STRINGLINE:**

1. STRETCH STRING WITH ENDS AGAINST GAGE SIDE OF LINE RAIL  $5/8$ " BELOW THE SURFACE OF THE RAIL.
2. MEASURE AT THE MID- POINT (31') FROM STRING TO GAGE SIDE OF RAIL  $5/8$ " DOWN
3. ONE INCH EQUALS APPROXIMATELY ONE DEGREE OF CURVATURE.

EXAMPLE ILLUSTRATES A MEASUREMENT OF ABOUT  $2-1/2$ ", OR APPROXIMATELY 2 DEGREES 30 MINUTES OF CURVATURE FOR THE ONE ISOLATED SPOT WHERE THE MEASUREMENT WAS TAKEN.

**Figure 12-5. Measurement of Curve Alignment**

e. **Safety and Maintenance Standards.** Standards for the maximum allowable deviations from designated alignment are as follows:

| Track Category | Safety Standard (Inch) |                     | Maintenance Standard (Inch) |
|----------------|------------------------|---------------------|-----------------------------|
|                | <i>Restriction</i>     | <i>No Operation</i> |                             |
| A & B          | GT 3                   | GT 5                | GT 2                        |

**12-7. PROFILE.**

a. **Definition.** Profile is the relative elevation of the two rails along the track. Profile deviation is the deviation from uniform profile on either rail at the midpoint of a 62-foot chord.

b. **Safety and Maintenance Standards.** When the maintenance standards are exceeded, maintenance shall be performed in the next cycle. Standards for the allowable deviations from uniform profile are as follows:

| Track Category | Safety Standards (Inch) |                     | Maintenance Standards (Inch) |
|----------------|-------------------------|---------------------|------------------------------|
|                | <i>Restriction</i>      | <i>No Operation</i> |                              |
| A & B          | GT 2.75                 | GT 3                | GT 2.25                      |

## CHAPTER 13

### CLEARANCES

**13-1. MEASUREMENT.** Vertical clearance shall be measured vertically from the top surface of the rail. Side clearance shall be measured horizontally from the centerline of the track.

**13-2. CLEARANCE REQUIREMENTS, TANGENT TRACK.** Clearances for tangent track shall not be less than those listed in [Table 13-1](#) and shown in [Figure 13-1](#).

**13-3. CLEARANCE REQUIREMENTS, CURVED TRACK.**

a. For each degree of curvature, side clearances shall be increased 1.5 inches over that required in [Table 13-1](#) and [Figure 13-1](#).

b. When an obstruction is located adjacent to tangent track but the track is curved within 80 feet of the obstruction, the side clearances shall be increased by the following amounts:

| Distance from Obstruction to Curved Track (Feet) | Increase per Degree of Curvature (Inches) |
|--|---|
| 0–20   | 1.5                                       |
| 21–40  | 1.125                                     |
| 41–60  | 0.75                                      |
| 61–80  | 0.375                                     |

**13-4. TRACK CENTERS.** The minimum spacing between the centerlines of adjacent tracks shall be maintained as given below and state department of transportation (DOT) clearance requirements shall also be checked as a minimum:

| Type of Tracks                               | Minimum Center-to-Center Distance |
|--|-----------------------------------|
| Yard, loading, and storage tracks            | 13 feet (recommend 14 feet)       |
| Yard track parallel to main or running track | 15 feet                           |
| Passing track                                | 15 feet                           |

**13-5. CHANGES TO CLEARANCES.** Whenever changes in alignment or elevation are made, clearances shall be checked for compliance with the criteria given in this chapter. This is especially important in the vicinity of buildings, bridges, overhead structures, platforms, and tunnels. All four vertical clearance points (see Figure 13-1) under bridges/structures shall be measured. The least dimension shall govern for clearance.

**Table 13-1. Clearance Requirements for Tangent Tracks**

| Obstruction  | Required Clearance |
|--|--------------------|
| <b>Vertical Clearances</b>                                     |                    |
| Overhead wires: open supply, arc wires, service drops          |                    |
| 0 to 750 volts   | 27 feet            |
| 750 to 15,000  | 28 feet            |
| Exceeding 15,000 volts   | 30 feet            |
| Other overhead wires   | 27 feet            |
| Building entrances (including engine-houses)                   | 18 feet            |
| Overhead   | 22 feet            |
| Other overhead obstructions                                    | 22 feet            |
| <b>Side Clearances</b>   |                    |
| Buildings  | 8 feet 6 inches    |
| Buildings without platforms (delivery required)                | 8 feet             |
| <b>Platforms</b>   |                    |
| Freight platforms up to 4 feet maximum height                  | 6 feet 2 inches    |
| Refrigerator car platforms up to 3 feet 3 inch                 | 6 feet 2 inches    |
| Refrigerator car platforms 3 feet 3 inch to 4 feet high        | 8 feet             |
| Low platforms (less than 8 inches high)                        | 5 feet             |
| Engine-house entrances   | 6 feet-6 inches    |
| Building entrances (other than engine-houses)                  | 8 feet             |
| Canopies over platforms (canopy height 16 feet or less)        | 8 feet             |
| Fences, retaining walls, utility poles, and other obstructions | 8 feet 6 inches    |
| Bridges  | 8 feet             |
| Signs  | 8 feet             |
| All loose, palliated, and stacked materials                    | 8 feet             |
| Parked vehicles  | 8 feet             |

**Note:** In curves, side clearances shall be increased 1.5 inches for each degree of curvature.



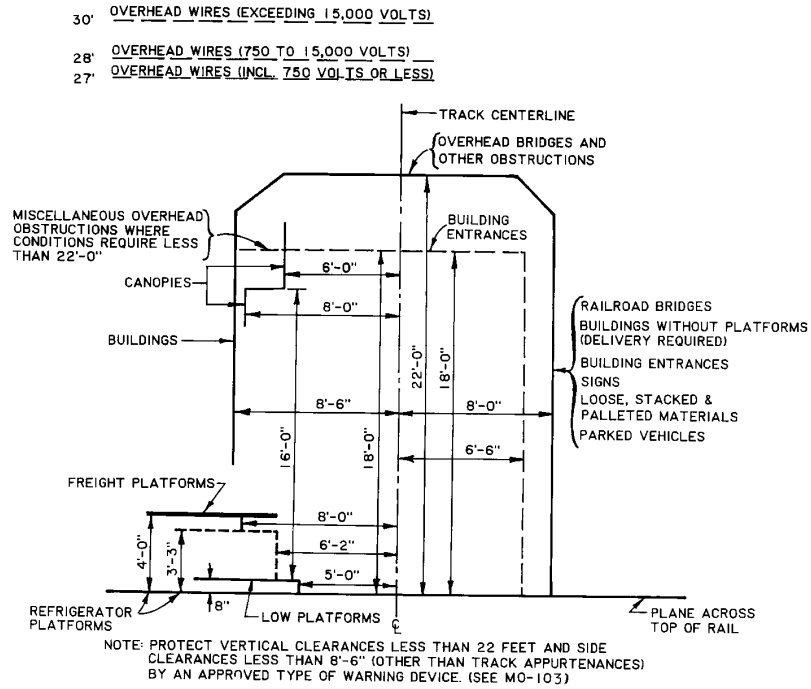


Figure 13-1. Minimum Clearances for Tangent Track

## CHAPTER 14

### MISCELLANEOUS TRACK APPLIANCES

**14-1. TRACK SCALES.** The inspection, maintenance, and calibration of railroad track scales are covered in the Association of American Railroads *Scale Handbook*, published annually as a part of the AREMA *Manual for Railway Engineering*. Track scales should be inspected and calibrated periodically in accordance with the recommendations given in the *Scale Handbook*.

**14-2. BONDED AND GROUNDED TRACK.**

a. Certain tracks used for the loading/unloading of fuels and ordnance are required to be bonded and grounded. Grounding requirements are given in UFC 4-860-01FA for Army and Air Force installations, and NAVSEA OP 5, *Ammunition and Explosives Ashore Safety Regulations for Handling, Storing, Production, Renovation and Shipping*, for the Navy. During maintenance of bonded and grounded track, care shall be taken to maintain the integrity of the rail bonds, ground rods, and connections.

b. During routine track inspections, the general condition of the bonds, ground wires, and connections shall be observed. Loose or missing bonds or connections shall be repaired immediately. The occurrence of excessive corrosion in the terminal areas of the bond wires and ground wires indicates a need for cleaning, repair, or replacement. Bonds and grounds shall be replaced if there is a large difference in electrical potential between the rails.

**14-3. DERAILS.**

a. Derails shall be maintained in good operating condition.

b. Derails shall be maintained free of lost motion that would allow it to be operated without removing the lock.

c. Derails shall be kept clean and painted in order to be readily visible to operating personnel.

d. Derails, normally supplied in 1-inch increments allowing no more than 0.5 inch of shimming, shall be properly installed for the rail to which it is applied.

**14-4. OTHER TRACK APPLIANCES.** Other track appliances, like bumper stops and cushion heads, wheel stops, etc., shall be in good working order for their intended use. Wheel stops are not designed for, nor shall they be used as, bumper stops. They are only designed to keep cars from rolling off the end of a track or past a point.

## CHAPTER 15

### MAINTENANCE ACTIVITIES FOR CATEGORY C TRACK

**15-1. GENERAL.** The minimum level of maintenance for inactive (Category C) track will be consistent with the anticipated future mission of the activity and the particular track involved. This chapter summarizes the general requirements.

**15-2. MAINTENANCE REQUIREMENTS.**

- a. Maintenance of rail, ties, and ballast shall be discontinued.
- b. Drainage shall be maintained in accordance with [paragraph 3-2](#).
- c. Damaging vegetation in the ballast, roadbed, and ditches shall be controlled in accordance with [paragraph 3-3](#).
- d. Bridges and other track structures shall be maintained in structurally sound condition with respect to their expected loading.
- e. Clearances addressed in [Chapter 13](#) shall be maintained to ensure that permanent facilities are not constructed within the railroad right-of-way.
- f. If there is a mobilization requirement, switches shall be kept properly adjusted and fully operational.

**15-3. INACTIVATION AND DISPOSAL.** In accordance with NAVFAC P-73, *Real Estate Procedures Manual*, for Navy activities; AR 420-72 and AR 405-90, *Disposal of Real Estate*, for Army; and AFI 32-9004, *Disposal of Real Estate*, for Air Force installations, action will be taken to dispose of track having no foreseeable need.

## APPENDIX A

### REFERENCES

#### A-1. GOVERNMENT PUBLICATIONS.

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

|                                       |  |
|---------------------------------------|--|
| AR 405-90/AFI 32-9004                 | Disposal of Real Estate  |
| AR 420-72                             | Transportation Infrastructure and Dams   |
| AR 200-5/AFI 32-1053/OPNAVINST 6250.4 | Pest Management Program  |
| NAVFACINST 11230.1                    | Inspection, Certification and Audit of Crane and Railroad Trackage   |
| NAVFAC MO-322, Vol I & II             | Inspection of Shore Facilities   |
| NAVFAC P-73                           | Real Estate Procedures Manual  |
| NAVFAC P-301                          | Navy Railways Operating Handbook   |
| NAVSEA OP 5                           | Ammunition and Explosives Ashore Safety Regulations for Handling, Storing, Production, Renovation and Shipping |
| TM 5-600/AFJPAM 32-1088               | Bridge Inspection, Maintenance, and Repair   |
| TM 5-627/AFM 91-33/MO-103             | Maintenance of Trackage  |
| TM 5-629/MO-314                       | Natural Resources – Weed Control and Plant Growth Regulation   |
| TM 5-630                              | Natural Resources Land Management  |
| UFC 4-860-01FA                        | Design: Railroad Design and Rehabilitation   |
| UFC 4-860-02N                         | Design Trackage  |
| UFC 4-860-01FA                        | Design: Railroad Design and Rehabilitation   |
| UFGS 05650                            | Railroad Track and Accessories   |

**Department of Transportation**

|                                 |  |
|---------------------------------|--|
| Federal Highway Administration  | Manual on Uniform Traffic Control Devices – Part 8 Traffic Control for Highway-Rail Grade Crossings<br>Railroad-Highway Grade Crossing Handbook  |
| Federal Railroad Administration | Track Safety Standards Code of Federal Regulations, Title 49, Chapter II, Part 213<br>Grade Crossing Signal System Safety, Code of Federal Regulations, Title 49, Chapter II, Part 234 |

**NON-GOVERNMENT PUBLICATIONS**

**American Railway Engineering & Maintenance-of-Way Association,**  
8201 Corporate Drive,  
Suite 1125  
Landover, MD 20785

Manual for Railway Engineering & Portfolio of Trackwork Plans

**American Wood Preservers' Association,**  
P.O. Box 5690  
Granbury, TX 76049

C6

Crossties and Switch Ties - Preservative Treatment by Pressure Process

P2

Standard for Creosote and Creosote Solutions

P3

Standard for Creosote Petroleum Oil Solution

## APPENDIX B

### TRACK INSPECTION RECORD AND TURNOUT INSPECTION CHECKLIST

**B-1.** To aid in the inspection of track, the Track Inspection Record, Turnout Inspection Checklist, and Highway Grade Crossing Warning System Inspection/Test Report provided in Figures [B-1](#), [B-2](#), and [B-3](#) are available for use. These forms can also be found in NAVFACINST 11230.1. Figures [B-4](#) through [B-10](#) show the inspection worksheets for use with the RAILER Engineered Management System (EMS). These forms are intended for recording inspection findings in the RAILER software database after returning to the office. Alternatively, an electronic track inspection program, RAILER Remote Entry Database (RED), can be used to collect and record data on a tablet PC for electronic upload to the RAILER software. The RAILER database keeps an electronic record of the inspection defects and automatically reports the current standard condition level for each. Policies can also be created to match each defect up to its corrective work action. Note that, in general, each RAILER inspection form requires information about the inspector name, inspection date, track and segment. In addition, inspection information includes the type of defect, location, length, density, quantity, and other component-specific information. Some forms are formatted as checklists to provide the inspector a list of everything that needs to be verified during an inspection—the Turnout Inspection Worksheet ([Figure B-7](#)) is one example of this. Information on RAILER EMS is available at the following website:

<http://www.tac.uiuc.edu/software/railer/railer.html>

[Appendix E](#) provides a summary of the maintenance standards and safety standards.

#### **B-2. TRACK INSPECTION RECORD.**

**a. *Intent and Application.*** The Track Inspection Record is intended for use as a record of scheduled maintenance, safety, and special track inspections. This form will be used for each operational and special track inspection to record the type and location of deviations from the standards, degree of hazard, proposed corrective action and time frame for completion, and the actions taken to correct the deviation. For scheduled maintenance inspections, the inspector shall record the location and description of deficiencies. Completed records shall be provided to the appropriate office for action.

**b.** The form includes identifying information such as installation name, reporting organization, inspector's name (both printed and signed), and the inspection date. The remainder of the form is available for listing deviations observed during the track inspection. In this section one line is normally used to record each deviation, although two or more lines may be required if additional comments are needed. [Figure B-1](#) presents an example of a Track Inspection Record. A description of each of the columns on this form is given below:

*Degree of Hazard:* The hazard of each defect shall be provided in accordance with NAVFACINST 11230.1 for Navy installations. Army and Air Force Installations shall use local guidance policy. Abbreviations for degree of hazard are provided on the bottom of the Track Inspection Record.

Catastrophic - CAT  
Critical - CRIT  
Marginal - M

*Location Milepost or Station Number:* Location of the deviation as referenced to the installations system of track stationing. May be recorded as stations or as Milepost + Feet.

Examples: Stations: 0+00, 6+39, 102+06  
Mileposts: 0+0000, 0+639, 1+4926

*Deficiency Description:* Brief description of the deficiency of deviation observed in the track.

Examples: -Wide gage 57.875 inches  
-Small amount of vegetation  
growing on track

*Proposed Corrective Action and Time Frame:* What needs to be done to correct the deviation and when. This should include the application of operating restrictions where required.

Examples: -Limit speed to 10 mph, regage, and respike as soon as possible  
-Spray for vegetation control  
within 1 month

*Follow-up Actions:* Action taken and date completed: what was done to correct the problem and the date repairs were completed.

Examples: 10 mph restriction applied  
10/2/00; Repaired 10/15/00;  
Herbicide application 6/2/01

### **B-3. TURNOUT INSPECTION CHECKLIST.**

**a. Intent and Application.** The Turnout Inspection Checklist is intended for use in the inspection of turnouts.

**b. Use.** The Turnout Inspection Checklist includes identifying information such as activity name, inspector's name, track identification (track name or number for identifying track), turnout identification (turnout number), and inspection date.

**c.** Additional sections are provided for the major components of the turnout such as ties, switch and stand, frog, and guard rails and for additional required data such as measurements and general items.

**d.** To assist in the use of this form and to promote consistent reporting, standard responses are supplied for many of the items. The applicable response should be circled for each item. If the printed response does not cover the situation or if an additional comment is required, a number can be placed in the blank after "Note \_\_\_" and the comments written in the "Notes" space provided at the bottom of the form. Blank spaces have been provided where items require a numerical response or a measurement. For multiple items such as rail braces, blanks have been provided before the responses so that a number may be indicated. For example, if two rail braces were loose, one is broken, and one is missing, the response would be:

OK 2Loose 1Damaged 1Missing Note\_\_\_\_\_

**e.** Some turnouts may be equipped with self-guarded frogs that do not require the presence of guard rails. In cases where there is a self-guarded frog and no guard rails, the entire section of the form titled "Guard Rails" should be crossed out and the words "Self-Guarded" written in the upper-right corner of the section. This will indicate that there are no guard rails in the turnout. If the frog is self-guarded and there are guard rails, the guard rails shall be inspected and the appropriate sections of the form completed.

f. The requirements for turnouts are found in [Chapter 8](#). [Figure B-2](#) presents an example of a completed Turnout Inspection Checklist.

**B-4. HIGHWAY GRADE CROSSING WARNING SYSTEM INSPECTION/TEST REPORT** ([See Figure B-3](#))

**a. Intent and Application.** The Highway Grade Crossing Warning System Inspection/Test Report is intended for use in the inspection of electric/ electromechanical grade crossing signals as discussed in [paragraph 10-6](#).

**b. Use.** The Highway Grade Crossing Warning System Inspection/Test Report includes identifying information such as activity name, inspector's name, crossing location (track name and highway designation), DOT/AAR Crossing Inventory Number (if applicable), and inspection date.

**c.** A checklist is provided, divided into Parts A, B, and C. Part A is the monthly requirements, Part B is the quarterly requirements and Part C is the annual requirements. When performing a monthly inspection, Part A is completed. When performing a quarterly inspection, Parts A and B are completed. When performing an annual inspection, Parts A, B and C are completed. Additional space is provided to indicate repairs, replacements, adjustments made and condition in which the apparatus was left. Areas are available for recording standby power battery voltages.



Figure B-1. Example Track Inspection Record

| TRACK INSPECTION RECORD  |                              |  | TYPE OF INSPECTION:<br><input type="checkbox"/> SCHEDULED MAINTENANCE <input type="checkbox"/> SAFETY INSPECTION<br><input checked="" type="checkbox"/> CONTROL INSPECTION <input type="checkbox"/> OPERATIONAL INSPECTION |                         |                |             |        |
|--|------------------------------|--|--|-------------------------|----------------|-------------|--------|
| ACTIVITY   |                              | Anywhere Naval Weapons Station               |  | TRACK NAME OR ID        | North Main     | REPORT DATE | 9/9/97 |
| INSPECTOR  |                              | PRINT OR TYPE & SIGN John R. Doe John R. Doe |  | INSPECTION ORGANIZATION |                |             | FMED   |
| DEGREE OF HAZARD   | LOCATION MILEPOST OR STATION | DEFICIENCY DESCRIPTION                       | PROPOSED CORRECTIVE ACTION AND TIMEFRAME   | FOLLOW-UP ACTIONS       |                |             |        |
|  |                              |  |  | ACTION TAKEN            | DATE COMPLETED |             |        |
| CAT  | 1+75                         | 4 Consecutive Defective Ties                 | Close to Traffic   | Track closed            | 9/9/97         |             |        |
|  |                              |  | Replace ties; ASAP   | Ties Replaced           | 9/12/97        |             |        |
| M  | 2+35                         | Vegetation (Brush) growing near track        | Cut Brush Along Row within 2 months  |                         |                |             |        |
| CRIT   | 4+00                         | Broken Joint Bar (Between Center Bolt Holes  | Class 1 Restriction (10mph)  | Restriction Applied     | 9/9/97         |             |        |
|  |                              |  | Replace Bar; within 1 week   | Repaired                | 9/14/97        |             |        |
| CRIT   | 5+80                         | Wide Gage - 57 7/8"                          | Class 1 Restriction (10mph)  | Restriction Applied     | 9/9/97         |             |        |
|  |                              |  | Regage + Respike (ASAP)  | Repaired                | 9/12/97        |             |        |
| EXAMPLE  |                              |  |  |                         |                |             |        |
| LEGEND: Degree of Hazard    CAT - Catastrophic    CRIT - Critical    M- Marginal |                              |  |  |                         |                |             |        |
| Page 1 of 1  |                              |  |  |                         |                |             |        |



|  |   |   |
|--|---|---|
| <b>Activity</b> _____<br><b>Location</b> _____ <b>Crossing No. (if any)</b> _____  |   |   |
| Monthly (Part A)<br>Check (✓) Box for Compliance   | Quarterly (Part B)<br>Check (✓) Box for Compliance<br>(Perform A + B)   | Annual (Part C)<br>Check (✓) Box for Compliance<br>(Perform A + B + C)  |
| <input type="checkbox"/> Observe Relays<br><input type="checkbox"/> Check Voltages / Fuses<br><input type="checkbox"/> Standby Power Test<br><input type="checkbox"/> System Operation<br><input type="checkbox"/> Clean Crossing Roundels<br><input type="checkbox"/> Observe Flasher Operation<br><input type="checkbox"/> Check for Locks<br><input type="checkbox"/> Inspect / Service Batteries<br><input type="checkbox"/> Check AC & DC Grounds<br><input type="checkbox"/> Inspect Pedestrian Bells<br><input type="checkbox"/> Inspect Signs and<br><i>Crossbucks</i> | <input type="checkbox"/> Check Flasher Alignment<br>and Focus<br><input type="checkbox"/> Inspect All Track Wires<br><input type="checkbox"/> Inspect Rail Bonds<br><input type="checkbox"/> Check Insulated Joints<br><input type="checkbox"/> Inspect Approach Batteries<br><input type="checkbox"/> Check Push Button Cutouts<br><input type="checkbox"/> Check Main AC Supply<br><input type="checkbox"/> Circuit Plans in Relay Case<br><input type="checkbox"/> Inspect Poles and<br><i>Foundations</i> | <input type="checkbox"/> Inspect Flasher Relay<br><input type="checkbox"/> Check Lamp Voltages<br><input type="checkbox"/> Check Timing Circuits<br><input type="checkbox"/> Check Warning Time<br><input type="checkbox"/> Verify Equipment<br><input type="checkbox"/> Verify Frequencies<br><input type="checkbox"/> Check Circuit Plans |
| <u>Battery Bank Name</u>   | Cell Type   | <b>Voltage ---- With Charge</b>   |
| Main _____<br><i><b>Electronic</b></i> _____<br>Island Circuit _____<br>Approach 1 _____<br>Approach 2 _____<br>Approach 3 _____<br>Approach 4 _____   | _____<br>_____<br>_____<br>_____<br>_____   | ON    OFF<br>_____<br>_____<br>_____<br>_____<br>_____  |
| <b>Repair, Replacements, Adjustments</b> (if none, so state)<br>_____<br>_____   |   |   |
| <b>Notes:</b> _____<br>_____   |   |   |
| <b>Signature:</b> _____ <b>Date:</b> _____<br>(Signal Maintainer)  |   |   |

**Figure B-3 Highway Grade Crossing Warning System Inspection/ Test Report**



## Tie Detailed Inspection Worksheet

Track: \_\_\_\_\_ Segment: \_\_\_\_\_ Inspector: \_\_\_\_\_ Date: \_\_\_\_\_  
 Begin Location: \_\_\_\_\_ End Location: \_\_\_\_\_

| Defect Description                                  | Occurrence Tally | Total |
|---|------------------|-------|
| Single Defective Tie                                |                  |       |
| Single Defective Joint Tie                          |                  |       |
| All Joint Ties Defective (1 Tie)                    |                  |       |
| Isolated* Defective Tie Cluster (2 Ties)            |                  |       |
| Isolated Defective Tie Cluster (3 Ties)             |                  |       |
| Isolated Defective Tie Cluster (4 Ties)             |                  |       |
| Isolated Defective Tie Cluster (5 Ties)             |                  |       |
| Adjacent* Defective Tie Cluster (2 Ties)            |                  |       |
| Adjacent Defective Tie Cluster (3 Ties)             |                  |       |
| Adjacent Defective Tie Cluster (4 Ties)             |                  |       |
| Adjacent Defective Tie Cluster (5 Ties)             |                  |       |
| Isolated Cluster with 1 Joint Tie** (2 Ties)        |                  |       |
| Isolated Cluster with 1 Joint Tie (3 Ties)          |                  |       |
| Isolated Cluster with 1 Joint Tie (4 Ties)          |                  |       |
| Isolated Cluster with 1 Joint Tie (5 Ties)          |                  |       |
| Defective Joint Tie Cluster** (2 Ties, 1 Joint Tie) |                  |       |
| Defective Joint Tie Cluster (2 Ties, 2 Joint Ties)  |                  |       |
| Defective Joint Tie Cluster (3 Ties, 1 Joint Tie)   |                  |       |
| Defective Joint Tie Cluster (3 Ties, 2 Joint Ties)  |                  |       |
| Defective Joint Tie Cluster (3 Ties, 3 Joint Ties)  |                  |       |
| Defective Joint Tie Cluster (4 Ties, 1 Joint Tie)   |                  |       |
| Defective Joint Tie Cluster (4 Ties, 2 Joint Ties)  |                  |       |
| Defective Joint Tie Cluster (4 Ties, 3 Joint Ties)  |                  |       |
| Defective Joint Tie Cluster (4 Ties, 4 Joint Ties)  |                  |       |
| Defective Joint Tie Cluster (5 Ties, 1 Joint Tie)   |                  |       |
| Defective Joint Tie Cluster (5 Ties, 2 Joint Ties)  |                  |       |
| Defective Joint Tie Cluster (5 Ties, 3 Joint Ties)  |                  |       |
| Defective Joint Tie Cluster (5 Ties, 4 Joint Ties)  |                  |       |
| Defective Joint Tie Cluster (5 Ties, 5 Joint Ties)  |                  |       |
| Single Missing Tie                                  |                  |       |
| 2 Consecutive Missing Tie Cluster                   |                  |       |
| 3 Consecutive Missing Tie Cluster                   |                  |       |
| All Joint Ties Missing (1 Tie)                      |                  |       |
| All Joint Ties Missing (2 Ties)                     |                  |       |
| Improperly Positioned Ties (Skewed, etc.)           |                  |       |
| Center to Center Distance Along Either Rail > 48"   |                  |       |
| Center to Center Distance Along Rail At Joint > 48" |                  |       |

**Figure B-5 Tie Detailed Inspection Worksheet**

\*Isolated: >= two good ties separate; otherwise Adjacent. \*\*Jt Tie Cluster: All jt ties are defective. If a work order is to be issued for a specific item, state location and defect on reverse. Categorize tie clusters on designated curves separately.



## Turnout Inspection Worksheet (Components)

Track: \_\_\_\_\_ Turnout: \_\_\_\_\_ Inspector: \_\_\_\_\_ Date: \_\_\_\_\_

| Component                    | DF | Imp. Size | Imp. Type | Loose | Imp. Pos. | Damaged | Worn | Missing | Other*        | WO |
|------------------------------|----|-----------|-----------|-------|-----------|---------|------|---------|---------------|----|
| Switch Stand                 |    |           |           |       |           |         |      |         |               |    |
| Target/Lamp                  |    |           |           |       |           |         |      |         | Paint Faded   |    |
| Ground Throw Lever           |    |           |           |       |           |         |      |         |               |    |
| Point Locks/Lever Latches    |    |           |           |       |           |         |      |         |               |    |
| Jam Nut                      |    |           |           |       |           |         |      |         |               |    |
| Connecting Rod               |    |           |           |       |           |         |      |         |               |    |
| Switch Rods                  |    |           |           |       |           |         |      |         |               |    |
| Switch Clips                 |    |           |           |       |           |         |      |         | Imp. Spacer   |    |
| Connecting Rod Bolts         |    |           |           |       |           |         |      |         |               |    |
| Switch Rod Bolts             |    |           |           |       |           |         |      |         |               |    |
| Clip Bolts                   |    |           |           |       |           |         |      |         |               |    |
| Cotter Keys                  |    |           |           |       |           |         |      |         |               |    |
| Insulation Filler            |    |           |           |       |           |         |      |         |               |    |
| Switch Points (Left)         |    |           |           |       |           |         |      |         | Metal Flow    |    |
| Switch Points (Right)        |    |           |           |       |           |         |      |         | Metal Flow    |    |
| Switch Point Protector       |    |           |           |       |           |         |      |         |               |    |
| Point Rail (Left)            |    |           |           |       |           |         |      |         |               |    |
| Point Rail (Right)           |    |           |           |       |           |         |      |         |               |    |
| Point Stop (Left)            |    |           |           |       |           |         |      |         |               |    |
| Point Stop (Right)           |    |           |           |       |           |         |      |         |               |    |
| Reinforcing Bar (Left)       |    |           |           |       |           |         |      |         |               |    |
| Reinforcing Bar (Right)      |    |           |           |       |           |         |      |         |               |    |
| Reinforcing Bolts/Rivets     |    |           |           |       |           |         |      |         |               |    |
| Stock Rail                   |    |           |           |       |           |         |      |         | Metal Flow    |    |
| Straight Rail                |    |           |           |       |           |         |      |         | Metal Flow    |    |
| Gauge Plate                  |    |           |           |       |           |         |      |         |               |    |
| Rail Braces - Rigid (Left)   |    |           |           |       |           |         |      |         | <4 Functional |    |
| Rail Braces - Adjustable (L) |    |           |           |       |           |         |      |         | <4 Functional |    |
| Rail Braces - Rigid (Right)  |    |           |           |       |           |         |      |         | <4 Functional |    |
| Rail Braces - Adjustable (R) |    |           |           |       |           |         |      |         | <4 Functional |    |
| Slide Plates                 |    |           |           |       |           |         |      |         |               |    |
| Turnout Plates               |    |           |           |       |           |         |      |         |               |    |
| Twin Tie Plates              |    |           |           |       |           |         |      |         |               |    |
| Heel Filler (Left)           |    |           |           |       |           |         |      |         |               |    |
| Heel Filler (Right)          |    |           |           |       |           |         |      |         |               |    |
| Heel Joint Bolts (Left)      |    |           |           |       |           |         |      |         |               |    |
| Heel Joint Bolts (Right)     |    |           |           |       |           |         |      |         |               |    |
| Heel Joint Bars (Left)       |    |           |           |       |           |         |      |         |               |    |
| Heel Joint Bars (Right)      |    |           |           |       |           |         |      |         |               |    |
| Frog (General)               |    |           |           |       |           |         |      |         |               |    |
| Frog Point                   |    |           |           |       |           |         |      |         | Metal Flow    |    |
| Frog Top Surface             |    |           |           |       |           |         |      |         | Metal Flow    |    |
| SG Frog Guard Faces (Left)   |    |           |           |       |           |         |      |         |               |    |
| SG Frog Guard Faces (Right)  |    |           |           |       |           |         |      |         |               |    |
| SP Frog Hinged Wing Rail     |    |           |           |       |           |         |      |         |               |    |
| SP Frog Springs, etc.        |    |           |           |       |           |         |      |         |               |    |
| Frog Bolts                   |    |           |           |       |           |         |      |         |               |    |
| Frog Plates                  |    |           |           |       |           |         |      |         |               |    |
| Guard Rails (Left)           |    |           |           |       |           |         |      |         |               |    |
| Guard Rails (Right)          |    |           |           |       |           |         |      |         |               |    |
| Guard Rail Fillers (Left)    |    |           |           |       |           |         |      |         |               |    |
| Guard Rail Fillers (Right)   |    |           |           |       |           |         |      |         |               |    |
| Guard Rail Bolts (Left)      |    |           |           |       |           |         |      |         |               |    |
| Guard Rail Bolts (Right)     |    |           |           |       |           |         |      |         |               |    |
| Guard Rail Clamps (Left)     |    |           |           |       |           |         |      |         |               |    |
| Guard Rail Clamps (Right)    |    |           |           |       |           |         |      |         |               |    |
| Guard Rail Plates (Left)     |    |           |           |       |           |         |      |         |               |    |
| Guard Rail Plates (Right)    |    |           |           |       |           |         |      |         |               |    |

Figure B-7. Turnout Inspection Worksheet (Components)

Record number of defective components in each category. If "Defect Free" check "DF". If N/A, cross out or ignore. If a work order is to be issued to correct a defect, check "WO". Use reverse side for comments. \*See specific defect in cell.

## Grade Crossing Detailed Inspection Worksheet

(Includes Rail Crossings)

Track: \_\_\_\_\_ Turnout: \_\_\_\_\_ Inspector: \_\_\_\_\_ Date: \_\_\_\_\_  
 Location: \_\_\_\_\_

| <b>General</b>                              |    |                 |                                    |          |          | <b>WO</b> |           |
|---|----|-----------------|------------------------------------|----------|----------|-----------|-----------|
| Switch Difficult to Operate                 | Y  | N               |                                    |          |          |           |           |
| Rail Weight or Section Change               | Y  | N               |                                    |          |          |           |           |
| Debris in Crib Area                         | Y  | N               |                                    |          |          |           |           |
| Line and Surface                            | DF | Good            | Fair                               | Marginal | Poor     |           |           |
| Less Than 4 Functional Rail Braces (Left)   | Y  | N               |                                    |          |          |           |           |
| Less Than 4 Functional Rail Braces (Right)  | Y  | N               |                                    |          |          |           |           |
| <b>Ties</b>                                 |    | <b>Tie Size</b> |                                    |          |          | <b>WO</b> |           |
| Defective                                   |    |                 |                                    |          |          |           |           |
| Defective Joint                             |    |                 |                                    |          |          |           |           |
| Skewed                                      |    |                 |                                    |          |          |           |           |
| <b>Defective Tie Clusters</b>               |    |                 | <b>2</b>                           | <b>3</b> | <b>4</b> | <b>5</b>  | <b>WO</b> |
| Isolated                                    |    |                 |                                    |          |          |           |           |
| Adjacent                                    |    |                 |                                    |          |          |           |           |
| Isolated w/1 Joint Tie                      |    |                 |                                    |          |          |           |           |
| Joint Tie Cluster                           |    |                 |                                    |          |          |           |           |
| <b>Measurements (Left)</b>                  |    | <b>WO</b>       | <b>Measurements (Right)</b>        |          |          | <b>WO</b> |           |
| Switch Point Gap (Left)                     |    |                 | Switch Point Gap (Right)           |          |          |           |           |
| Gauge at Switch Point                       |    |                 | Comments:                          |          |          |           |           |
| Gauge at Switch Heel                        |    |                 |                                    |          |          |           |           |
| Gauge at Joint in Curved Closure Rail (1st) |    |                 |                                    |          |          |           |           |
| Gauge at Joint in Curved Closure Rail (2nd) |    |                 |                                    |          |          |           |           |
| Gauge at Frog Toe (Left)                    |    |                 | Gauge at Frog Toe (Right)          |          |          |           |           |
| Gauge at Frog Point (Left)                  |    |                 | Gauge at Frog Point (Right)        |          |          |           |           |
| Gauge at Frog Heel (Left)                   |    |                 | Gauge at Frog Heel (Right)         |          |          |           |           |
| Frog Flangeway Width (Left)                 |    |                 | Frog Flangeway Width (Right)       |          |          |           |           |
| Frog Flangeway Depth (Left)                 |    |                 | Frog Flangeway Depth (Right)       |          |          |           |           |
| Guard Rail Flangeway Width (Left)           |    |                 | Guard Rail Flangeway Width (Right) |          |          |           |           |
| Guard Check Gauge (Left)                    |    |                 | Guard Check Gauge (Right)          |          |          |           |           |
| Guard Face Gauge (Left)                     |    |                 | Guard Face Gauge (Right)           |          |          |           |           |

Figure B-8. Turnout Inspection Worksheet (General, Ties and Measurements)

If a crossing is "Defect Free," so state. If a work order is to be issued to correct a defect, check "WO" box. Use reverse side for comments. \*See RAILER Defect List. \*\*Record flangeway width/depth and affected length, if improper.





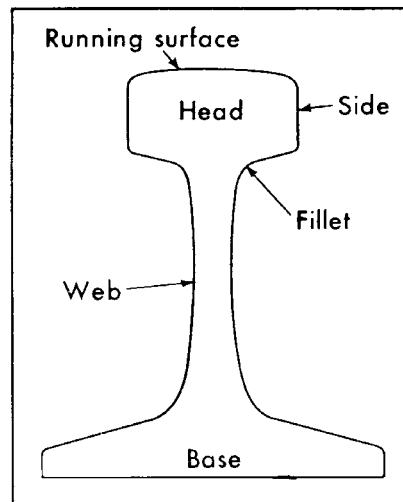


## APPENDIX C

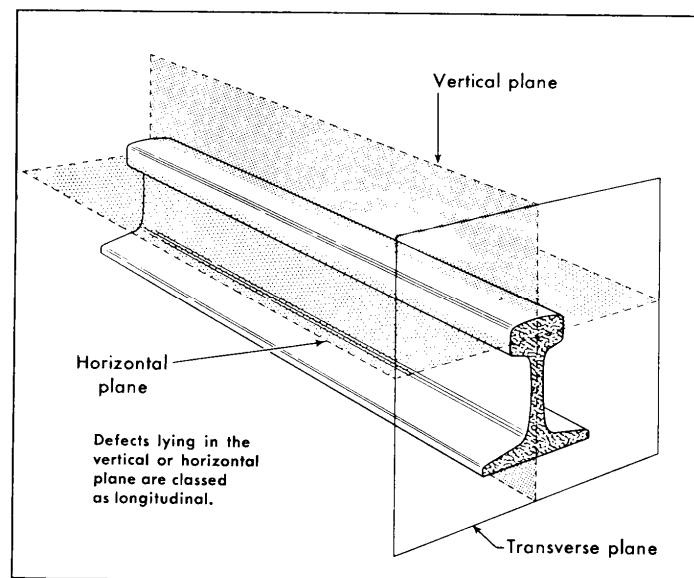
### FIELD IDENTIFICATION OF RAIL DEFECTS

**C-1. RAIL DEFECTS MAY BE OBSERVED IN TRACK.** [Table 7-1](#) presents a listing of rail defects and appropriate maintenance and safety standards. This appendix presents definitions relating to rail and brief descriptions of the common rail defects observed in track. [Figure C-1](#) presents common rail nomenclature, and [Figure C-2](#) shows the relative positions of planes through the rail.

All figures presented in [Appendix C](#) are copyrighted by Sperry Rail Services and used by permission.



*Figure C-1. Rail Nomenclature*



*Figure C-2. Relative Positions of Planes Through a Rail*

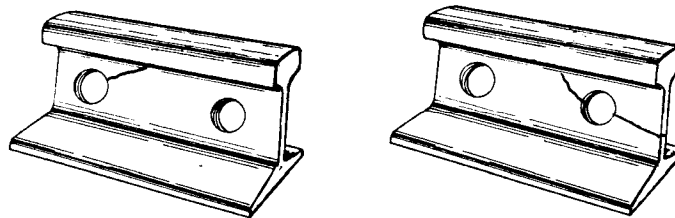
**C-2. DEFINITION OF TERMS.** The following are common terms related to rail and rail defects. For Navy installations, NAVFAC MO-103 presents additional terms and information.

- a. **Bleeding.** Reddish-brown streak on a rail indicating internal rusting.
- b. **Field Side.** The side of the rail away from the wheel flange.
- c. **Gage Side.** The side of the rail closest to the wheel flange.
- d. **Head Checks.** Transverse surface cracks on the gage corner of rails resulting from cold-working the surface metal; sometimes referred to as gage checks.
- e. **Percent Size.** The percentage of rail head cross-sectional area weakened by a rail defect. Used only with transverse defects.
- f. **Relaid Rail.** Rail that is worn but still usable, taken from track and reused in another location. Sometimes referred to as relayer rail.
- g. **Shatter Crack.** Initiation of a transverse fissure resulting from entrapped hydrogen gas present in a steel rail that was cooled too rapidly. Control-cooling the rails and vacuum-degassing the molten steel have practically eliminated the hydrogen problem.
- h. **Transposed Rail.** Rail that is moved from one side of the track to the other side without turning the rail so that the gage and field sides are interchanged.
- i. **Tread.** The path of wheel in contact with the running surface of the rail.
- j. **Turned Rail.** Rail with some wear that has been removed, turned, and replaced in track so the gage and field sides are interchanged.

**C-3. FIELD IDENTIFICATION OF RAIL DEFECTS.** These descriptions are presented in alphabetical order to assist in identifying defective rails in track. Refer to NAVFAC MO-103 for additional information.

**a. Bolt Hole Crack.**

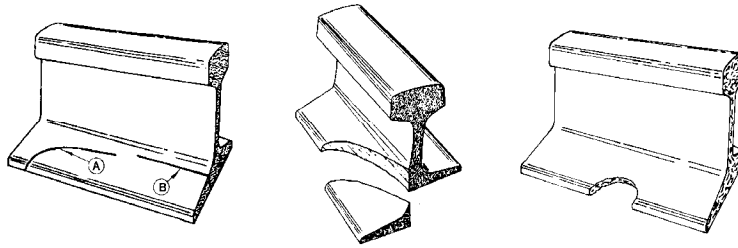
- (1) *Description.* A progressive fracture originating at a bolt hole.
- (2) *Appearance in Track.* Bolt hole cracks are not visible until a bolt or a joint bar has been removed unless the defect has progressed beyond the bar. They may be recognized by a hairline crack extending from the bolt hole ([Figure C-3](#)).



**Figure C-3. General Appearance of Bolt Hole Cracks**

**b. Broken Base.**

- (1) *Description.* Any break in the base of the rail.
- (2) *Appearance in Track.* Generally appears as a half-moon crack break in the rail base. [Figure C-4](#) illustrates three different appearances of broken bases.

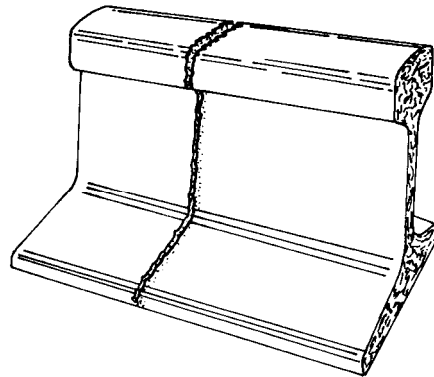


**Figure C-4. General Appearance of Broken Base**

**c. Complete Break (Broken Rail).**

(1) *Description.* A complete transverse separation of the head, web, and base of the rail in which there is no sign of a fissure and in which none of the other defects described herein are found.

(2) *Appearance in Track.* May appear as a hairline crack running completely around the rail, usually accompanied by bleeding or a separation of the rail at the break with one or both of the broken ends battered down ([Figure C-5](#)).



**Figure C-5. General Appearance of Broken Rail**

**d. Compound Fissure.** See "[Transverse Defects](#)," paragraph C-3.z.

**e. Corrosion.**

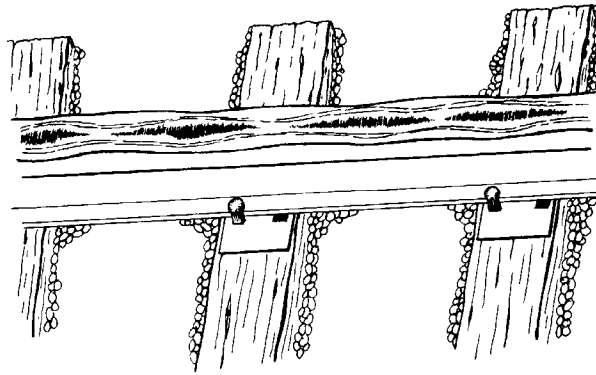
(1) *Description.* The decaying or corroding of the metal in the web or base of the rail.

(2) *Appearance in Track.* Pits or cavities in the upper base or the web of the rail. In advanced stages, a significant loss of material is evident.

**f. Corrugation.**

(1) *Description.* A repeated wavelike pattern on the running surface of the rail. Corrugations develop over a long period of time. A number of factors contribute to the development of corrugations with the actual cause dependent on the track and operating conditions.

(2) *Appearance in Track.* Small, hard, bright, short-pitch ridges along the running surface of the rail, varying anywhere from 2 to 18 inches apart and usually less than 0.0625 inch deep. Although the individual waves (ridges) are usually only a short distance apart, the corrugations may extend over a considerable distance ([Figure C-6](#)).



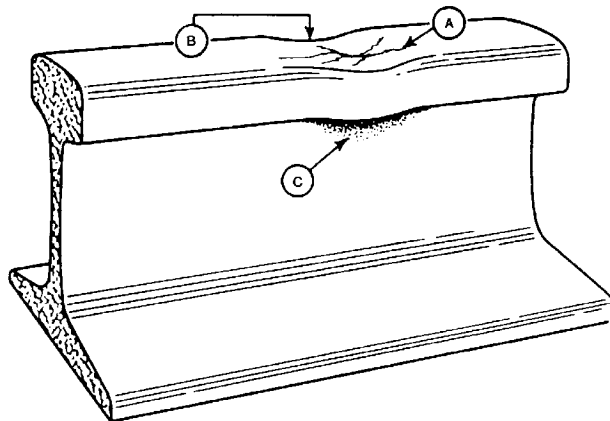
**Figure C-6. General Appearance of Corrugation**

**g. Crushed (Flattened) Head.**

(1) *Description.* The flattening of several inches of the rail head is generally caused by a soft spot in the steel. A crushed head is usually accompanied by a crushing down of the metal but with no signs of cracking in the fillet under the head. The origin of a crushed head is usually a soft spot in the steel of the head, which gives way under heavy wheel loads.

(2) *Appearance in Track.* Generally appears as:

- (a) Flattening and widening of the head for several inches with the entire head sagging.
- (b) Small cracks in a depression on the running surface.
- (c) In advanced stages, a bleeding crack may be present at the fillet under the head ([Figure C-7](#)).



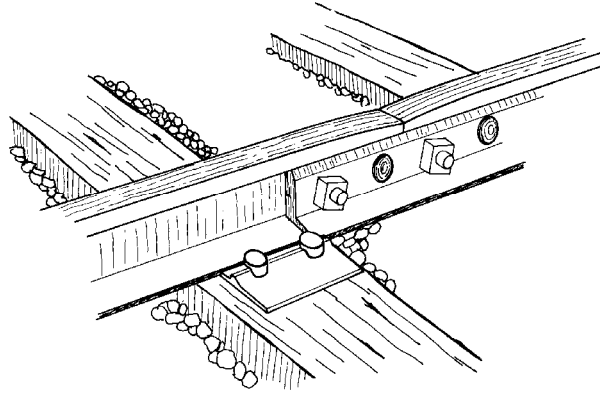
**Figure C-7. General Appearance of Crushed Head**

**h. Defective Weld.**

(1) *Description.* A progressive transverse separation within an area where two rails have been joined by welding or a rupture at a weld due to incomplete penetration of weld metal between the rail ends, lack of fusion, entrapment of slag and sand, or shrinkage cracking or fatigue cracking.

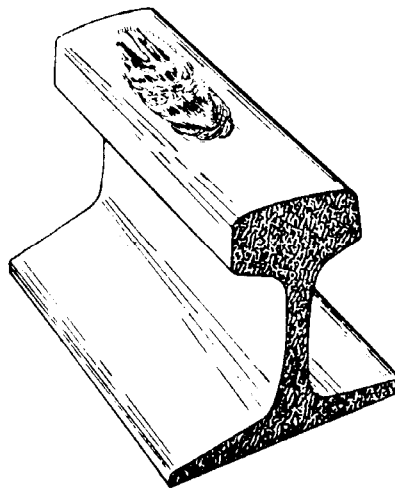
(2) *Appearance in Track.* No outward sign is visible until the separation reaches the rail surface. A defective weld may then be recognized by a vertical bleeding crack at the welded portion of the rail joint where the separation has reached the surface.

- i. **Detail Fracture.** See "[Transverse Defects](#)," paragraph C-3.z.
- j. **End Batter.**
  - (1) *Description.* Damage caused by wheels striking the rail ends.
  - (2) *Appearance in Track.* Appears as damage to or a depression in the top surface of the rail head at the ends of the rail ([Figure C-8](#)).



**Figure C-8. Rail End Batter**

- k. **Engine Burns (Burned Rail).**
  - (1) *Description.* Rail that has been scarred on the running surface by the friction of a slipping locomotive.
  - (2) *Appearance in Track.* Round or oval rough spots or holes on the tread of the running surface. Engine burns may be deep ([Figure C-9](#)).



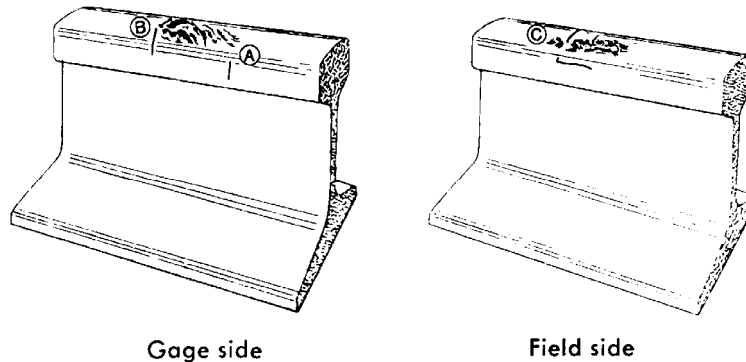
**Figure C-9. Typical Appearance of Engine Burn**

- l. **Engine Burn Fracture.**
  - (1) *Description.* A progressive fracture in the rail head starting from a point where engine wheels have slipped and burned the rail.
  - (2) *Appearance in Track.* No sign of transverse separation is visible until the defect reaches the rail surface (cracks out.) An engine burn fracture may then be recognized by one or more of the following characteristics:

(a) A hairline crack on the side of the head in the immediate vicinity of an engine burn and at right angles to the running surface. The crack may be visible on either the field or gage side of the head. An engine burn may lead to an engine burn fracture.

(b) Transverse thermal cracks extending from the burn to the gage corner and down the side of the head for at least 0.125 inch.

(c) A cracked-out horizontal separation on the field side of the rail head under the burned area often accompanied by one or more thermal cracks extending transversely to the gage corner (Figure C-10.)



**Figure C-10. General Appearance of Engine Burn Fracture**

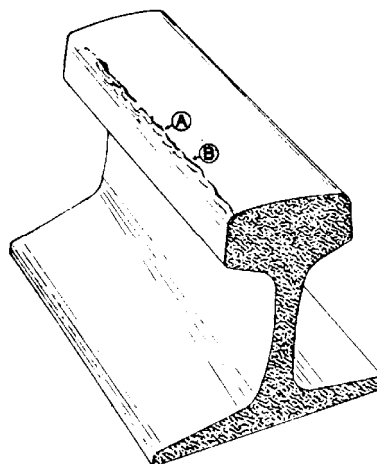
**m. Flaking.**

(1) *Description.* A progressive horizontal separation on the running surface near the gage corner, often accompanied by scaling or chipping. Flaking should not be confused with shelling as flaking occurs only on the running surface near the gage corner and is not as deep as shelling.

(2) *Appearance in Track.* Can be recognized by one or more of the following characteristics:

(a) Shallow depressions with irregular edges occurring on the running surface near the gage corner. Generally, flaking will occur within 0.25 inch of the corner of the rail.

(b) Horizontal hairline cracks along the running surface near the gage corner of the rail head, resembling small slivers (Figure C-11.)





**Figure C-11. General Appearance of Flaking**

**n. Flowed Rail.**

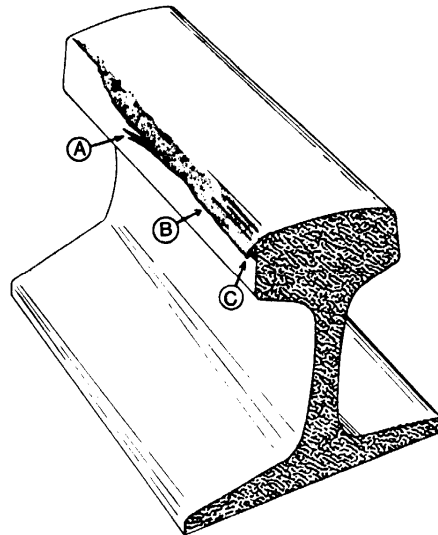
(1) *Description.* A rolling out of the tread metal beyond the field or gage corner with no breaking down of the underside of the head.

(2) *Appearance in Track.*

(a) Surface metal on the head flowed toward the field side giving a creased appearance on the running surface near the field corner.

(b) A protruding lip extending along the length of the rail.

(c) In the advanced stage, flow becomes blade-like, jagged, or nonuniform and may hang down or separate from the rail head ([Figure C-12.](#))



**Figure C-12. General Appearance of Flow**

**o. Head/Web Separation.**

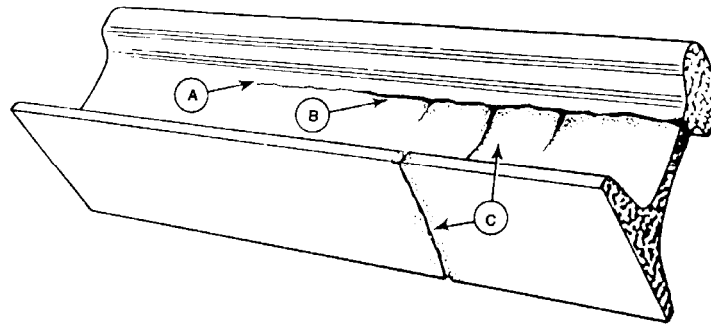
(1) *Description.* A progressive fracture separating the head and web of the rail at the head fillet area.

(2) *Appearance in Track.* Can be recognized by one or more of the following characteristics:

(a) In earlier stages, wavy lines appearing along the fillet under the head.

(b) As the condition develops, a small crack will appear along the fillet on either side, progressing longitudinally with slight irregular turns upward and downward.

(c) In advanced stages, bleeding cracks will extend downward from the longitudinal separation through the web and may extend through the base ([Figure C-13.](#))



**Figure C-13. General Appearance of Head/Web Separation**

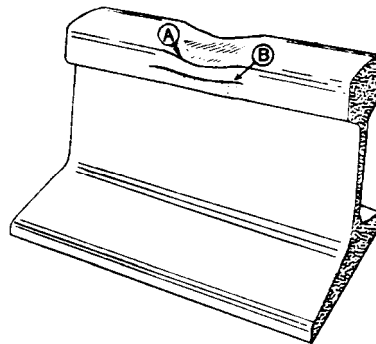
**p. Horizontal Split Head.**

(1) *Description.* A progressive longitudinal fracture in the rail head parallel to the running surface, usually 0.25 inch or more below the running surface.

(2) *Appearance in Track.*

(a) Before cracking out, a moderate size horizontal split head will appear as a flat spot on the running surface, often accompanied by a slight widening or dropping of the rail head. The flat spot will be visible as a dark spot on the bright running surface.

(b) After cracking out, the horizontal split head will appear as a hairline crack in either side or both sides of the rail head, usually 0.25 inch or more below the top of the rail head ([Figure C-14](#)).

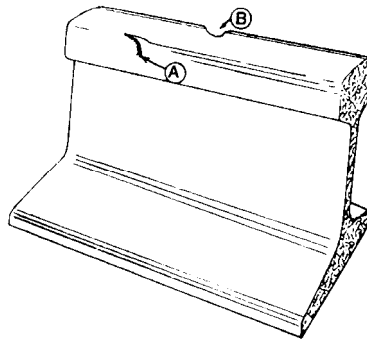


**Figure C-14. General Appearance of Horizontal Split Head**

**q. Mill Defects.**

(1) *Description.* Deformations, cavities, seams, or foreign material found in the head, web, or base of the rail.

(2) *Appearance in Track.* Any deformation in the rail, broken-out area, or inclusion ([Figure C-15](#)).



**Figure C-15. General Appearance of Mill Defects**

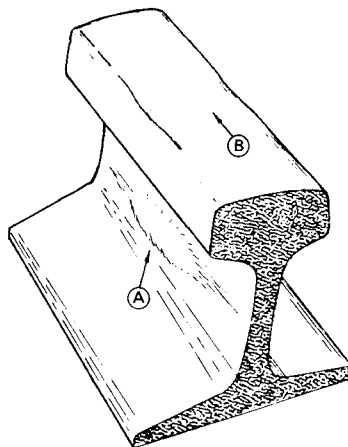
**r. Piped Rail.**

(1) *Description.* A progressive longitudinal fracture in the web of the rail with a vertical separation or seam, forming a cavity in the advanced stages of development.

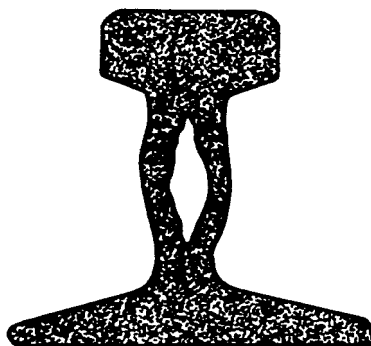
(2) *Appearance in Track.*

(a) A bulging of the web on either or both sides. Shallow cracks due to distortion may be found in the bulging surface.

(b) A slight sinking of the rail head may exist above the pipe (Figures [C-16](#) and [C-17](#)).



**Figure C-16. General Appearance of Piped Rail**

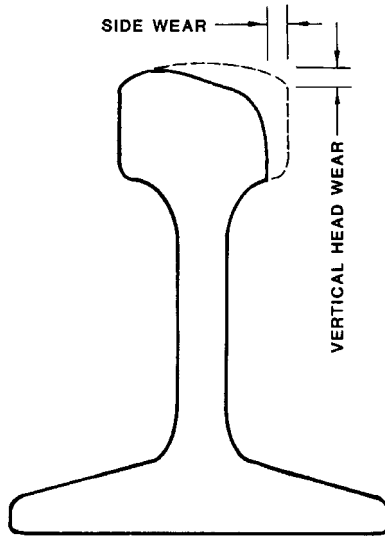


**Figure C-17. Cross-sectional View of Piped Rail**

**s. Rail Wear.**

(1) *Description.* The loss of material from the running surface and side of the rail head due to the passage of wheels over the rail.

(2) *Appearance in Track.* Rail wear appears as a rounding of the running surface of the rail head, particularly on the gage side ([Figure C-18](#)).



**Figure C-18. General Appearance of Vertical Head and Side Wear**

**t. Shelling.**

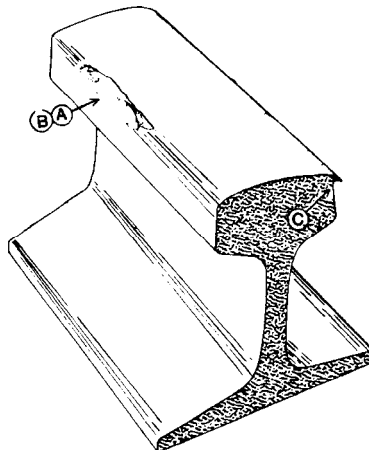
(1) *Description.* A progressive horizontal separation, which may crack out at any level on the gage side but generally at the gage corner. It extends longitudinally not as a true horizontal or vertical crack, but at an angle related to the amount of rail wear.

(2) *Appearance in Track.* Appears as one or more of the following:

(a) Dark spots irregularly spaced on the gage side of the running surface.

(b) Longitudinal separation at one or several levels in the upper gage corner with discoloration from bleeding.

(c) If the rail has been turned, the shelly spots will appear on the field side with an irregular overhanging lip of metal similar to flowed rail ([Figure C-19](#)).

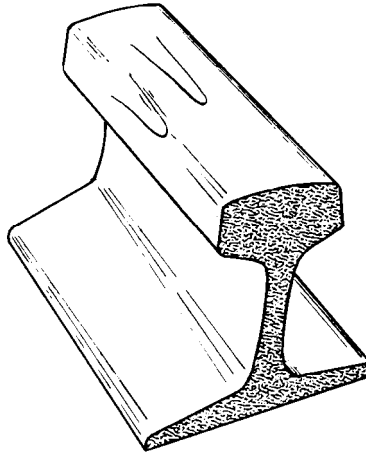


### **Figure C-19. General Appearance of Shelling**

#### **u. Slivers.**

(1) *Description.* A sliver is the separation of a thin, tapered mass of metal from the surface of the head, web, or base of a rail.

(2) *Appearance in Track.* Thin slivers on the surface of the rail head and parallel to the rail length similar to wood slivers ([Figure C-20](#)).

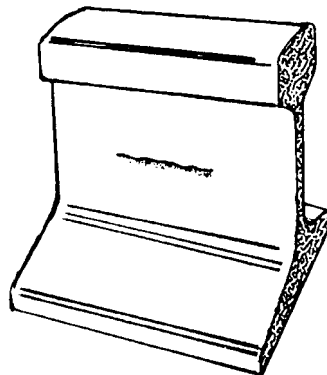


**Figure C-20. General Appearance of Slivers**

#### **v. Split Web.**

(1) *Description.* A progressive fracture through the web in a longitudinal and/or transverse direction.

(2) *Appearance in Track.* Horizontal and/or vertical bleeding cracks in the web ([Figure C-21](#)).



**Figure C-21. General Appearance of Split Web**

#### **w. Surface Bent Rail.**

(1) *Description.* The permanent downward bending of the rail ends due to long-term passage of traffic over track with loose or poorly supported joints. Surface bent rail cannot be corrected without replacing the rail.

(2) *Appearance in Track.* A downward bending of the rail head near the rail ends giving the appearance of low joints. When track with surface bent rail is surfaced

(raised and tamped), the rail ends soon return to a lower elevation. In the more serious cases the vertical curve in the rail head is still visible after surfacing.

**x. Surface Damage.**

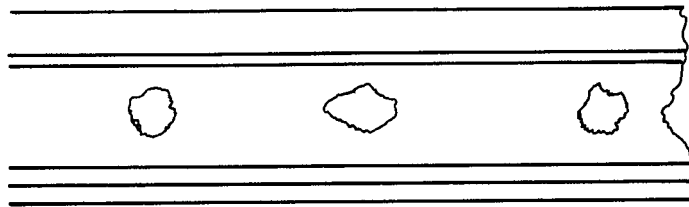
(1) *Description.* Any damage to the surfaces of the rail, both the running surface and the external surfaces, caused by deep engine burns (running surface) or by striking the rail. Surface damage may lead to detail fractures or engine burn fractures.

(2) *Appearance in Track.* Deep engine burns, dents, nicks, cuts, or other abnormalities on the surface of the rail.

**y. Torch Cut Rail.**

(1) *Description.* Any rail that is cut or otherwise modified (including bolt holes) using an acetylene torch or other open flame.

(2) *Appearance in Track.* Irregular or rough rail ends and/or bolt holes ([Figure C-22](#)).



**Figure C-22. General Appearance of Torch-Cut Rail**

**z. Transverse Defects.** Compound fissure, transverse fissure, and detail fracture.

(1) *Description.* Any progressive fracture occurring in the rail head having a transverse separation, however slight. The exact type of transverse defect cannot be determined until after the rail is broken for examination.

(2) *Appearance in Track.* Not visible until the defect reaches an outer surface. A transverse defect may be recognized by one or more of the following characteristics:

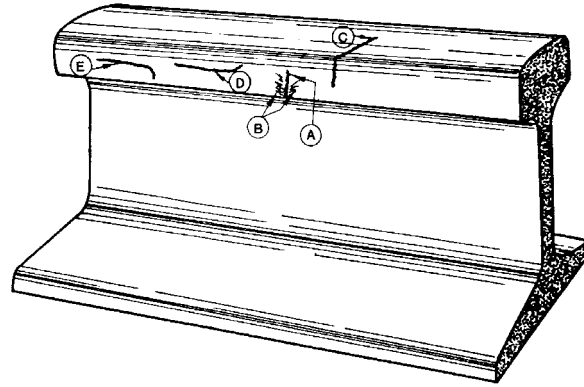
(a) A hairline crack on the side of the head at right angles to the running surface, at the fillet under the head, and occasionally on the running surface.

(b) Bleeding (rust streaking) at the crack.

(c) A hairline crack at the gage corner of the rail head. On turned rail, this condition may occur at the field corner. Numerous small gage cracks or head checks are often present but should not cause suspicion unless a single crack extends much farther down the side and/or across the running surface.

(d) A horizontal hairline crack in the side of the rail head turning upward or downward at one or both ends, usually accompanied by bleeding. Under such conditions a flat spot will generally be present on the running surface.

(e) A hairline crack extending downward at right angles from a horizontal crack caused by shelling of the upper gage corner of the rail head ([Figure C-23](#)).



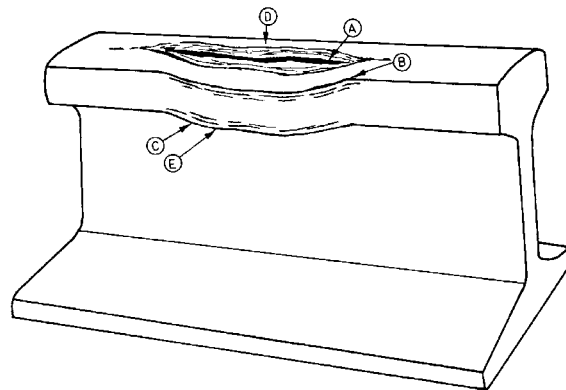
**Figure C-23. General Appearance of Transverse Defects**

**aa. Vertical Split Head.**

(1) *Description.* A progressive longitudinal fracture in the head of the rail perpendicular to the running surface and is visible to a track inspector.

(2) *Appearance in Track.* Can be recognized by one or more of the following:

- (a) A dark streak on the running surface.
- (b) Widening of the head for the length of the split. The cracked side of the head may show signs of sagging.
- (c) Sagging of the head causing a rust streak to appear on the fillet under the head.
- (d) A hairline crack near the middle of the rail head.
- (e) In advanced stages, a bleeding crack is apparent on the rail surface and in the fillet under the head ([Figure C-24](#)).

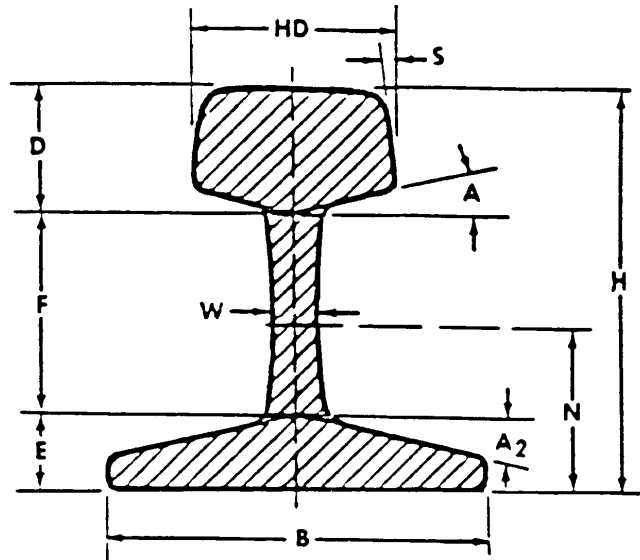


**Figure C-24. General Appearance of Vertical Split Head**

## APPENDIX D

### DETAILS OF RAIL SECTIONS

D-1. [Table D-1](#) of this appendix presents a listing of dimensions and properties for various rail sections. This table can be used with [Figure D-1](#) to assist in identifying rail sections and estimating amounts of rail wear.



(See Table D-1 for key)

**Figure D-1. Details of T-Rail Section**



Table D-1. Details of Rail Sections

| Section | Weight Per yard | Manufacturer's Brand   |   |                   |                             |                             |                     |                    |            | Rail Dimensions (Inches) |           |         |                   |                    |                   |                |                              |                 |
|---------|-----------------|------------------------|---|-------------------|-----------------------------|-----------------------------|---------------------|--------------------|------------|--------------------------|-----------|---------|-------------------|--------------------|-------------------|----------------|------------------------------|-----------------|
|         |                 | Ill. Steel Co. Old No. | Ill. Steel Co. Carnegie Steel Co. T C & I Co. Inland steel Co. Ill. Steel Co. | Midvale Steel Co. | Bethlehem Steel Co. Old No. | Bethlehem Steel Co. New No. | Lackawana Steel Co. | Colorado F & I Co. | Height (H) | Base (B)                 | Head (HD) | Web (W) | Depth of Head (D) | Fishing Height (F) | Depth Of Base (E) | Head angle (A) | Base angle (A <sub>2</sub> ) | CL of bolts (N) |
| AREA    | 140             | --                     | --  | --                | --                          | 140RE                       | --                  | --                 | 7-5/16     | 6                        | 3         | 3/4     | 2-1/16            | 4-1/16             | 1-3/16            | 3 to 1         | 4 to 1                       | 4               |
| AREA    | 136             | --                     | --  | --                | --                          | 136RE                       | --                  | 1360               | 7-5/16     | 6                        | 2-15/16   | 11/16   | 1-15/16           | 4-3/16             | 1-3/16            | 4 to 1         | 4 to 1                       | 3-3/4           |
| AREA    | 133             | --                     | 13331   | --                | --                          | 133RE                       | --                  | 1330               | 7-1/16     | 6                        | 3         | 11/16   | 1-15/16           | 3-15/16            | 1-3/16            | 3 to 1         | 4 to 1                       | 3-3/4           |
| AREA    | 132             | --                     | 13225   | --                | --                          | 132RE                       | --                  | 1321               | 7-1/8      | 6                        | 3         | 21/32   | 1-3/4             | 4-3/16             | 1-3/16            | 4 to 1         | 4 to 1                       | 3-7/8           |
| AREA    | 131             | --                     | 13128   | --                | --                          | 131RE                       | --                  | 1311               | 7-1/8      | 6                        | 3         | 21/32   | 1-3/4             | 4-3/16             | 1-3/16            | 4 to 1         | 4 to 1                       | 4-1/4           |
| AREA    | 130             | --                     | 13025   | --                | --                          | 130RE                       | --                  | 1300               | 6-3/4      | 6                        | 2-15/16   | 21/32   | 1-27/32           | 3-11/16            | 1-7/32            | 4 to 1         | 4 to 1                       | 3-3/8           |
| AREA    | 119             | --                     | --  | --                | --                          | 119RE                       | --                  | 1190               | 6-13/16    | 5-1/2                    | 2-21/32   | 5/8     | 1-7/8             | 3-13/16            | 1-1/8             | 4 to 1         | 4 to 1                       | 3-1/4           |
| AREA    | 115             | --                     | 11525   | --                | --                          | 115RE                       | --                  | 1150               | 6-5/8      | 5-1/2                    | 2-23/32   | 5/8     | 1-11/16           | 3-13/16            | 1-1/8             | 4 to 1         | 4 to 1                       | 3-1/4           |
| AREA    | 112             | --                     | 11228   | --                | --                          | 112RE                       | --                  | 1121               | 6-5/8      | 5-1/2                    | 2-23/32   | 19/32   | 1-11/16           | 3-13/16            | 1-1/8             | 4 to 1         | 4 to 1                       | 3-3/4           |
| AREA    | 110             | --                     | 11025   | --                | --                          | 110RE                       | --                  | 1100               | 6-1/4      | 5-1/2                    | 2-25/32   | 19/32   | 1-23/32           | 3-13/16            | 1-1/8             | 4 to 1         | 4 to 1                       | 3-1/8           |
| AREA    | 100             | --                     | 10025   | --                | --                          | 100RE                       | --                  | 10025              | 6          | 5-3/8                    | 2-11/16   | 9/16    | 1-21/32           | 3-9/32             | 1-1/16            | 4 to 1         | 4 to 1                       | 2-31/32         |
| ARA-A   | 100             | 10020                  | 10020   | 565               | 163                         | 100RA                       | 10031               | --                 | 6          | 5-1/2                    | 2-3/4     | 9/16    | 1-9/16            | 3-3/8              | 1-1/16            | 4 to 1         | 4 to 1                       | 2-3/4           |
| ARA-A   | 90              | 9020                   | 9020  | 563               | 170                         | 90RA                        | 9031                | 902                | 5-5/8      | 5-1/8                    | 2-9/16    | 9/16    | 1-15/32           | 3-5/32             | 1                 | 4 to 1         | 4 to 1                       | 2-37/64         |
| ARA-A   | 80              | 8020                   | 8020  | --                | 169                         | --                          | 8031                | 801                | 5-1/8      | 4-5/8                    | 2-1/2     | 33/64   | 1-7/16            | 2-23/32            | 31/32             | 4 to 1         | 4 to 1                       | 2-21/64         |
| ARA-A   | 70              | 7020                   | 7020  | --                | --                          | --                          | --                  | --                 | 4-3/4      | 4-1/4                    | 2-3/8     | 1 / 2   | 1-11/32           | 2-1/2              | 29/32             | 4 to 1         | 4 to 1                       | 2-5/32          |
| ARA-A   | 60              | 6020                   | 6020  | --                | --                          | --                          | --                  | --                 | 4-1/2      | 4                        | 2-1/4     | 15/32   | 1-15/64           | 2-29/64            | 13/16             | 4 to 1         | 4 to 1                       | 2-5/128         |
| ARA-B   | 100             | 10030                  | 10030   | 564               | 161                         | 100RB                       | 10032               | 1002               | 5-41/64    | 5-9/64                   | 2-31/32   | 9/16    | 1-45/64           | 2-55/64            | 1-5/64            | 13°            | 13°                          | 2-65/128        |
| ARA-B   | 90              | 9030                   | 9030  | 561               | 162                         | 90RB                        | 9032                | 905                | 5-17/64    | 4-49/64                  | 2-9/16    | 9/16    | 1-39/64           | 2-5/8              | 1-1/32            | 13°            | 13°                          | 2-11/32         |
| ARA-B   | 80              | 8030                   | 8030  | 569               | 171                         | --                          | 8032                | --                 | 4-15/64    | 4-7/16                   | 2-7/16    | 35/64   | 1-15/32           | 2-15/32            | 1                 | 13°            | 13°                          | 2-15/64         |
| ARA-B   | 70              | 7030                   | 7030  | --                | 174                         | --                          | --                  | --                 | 4-35/64    | 4-3/64                   | 2-3/8     | 33/64   | 1-23/64           | 2-17/64            | 59/64             | 13°            | 13°                          | 2-7/128         |
| ARA-B   | 60              | 6030                   | 6030  | --                | --                          | --                          | --                  | --                 | 4-3/16     | 3-11/64                  | 2-1/8     | 31/64   | 1-1/4             | 2-1/16             | 7/8               | 13°            | 13°                          | 1-29/32         |
| ASCE    | 100             | 10001                  | 10040   | 536               | 247                         | 100AS                       | 1000                | --                 | 5-3/4      | 5-3/4                    | 2-3/4     | 9/16    | 1-45/64           | 3-5/64             | 31/32             | 13°            | 13°                          | 2-65/128        |
| ASCE    | 90              | 9002                   | 9040  | 535               | 245                         | 90AS                        | 900                 | --                 | 5-3/8      | 5-3/8                    | 2-5/8     | 9/16    | 1-19/32           | 2-55/64            | 59/64             | 13°            | 13°                          | 2-45/128        |
| ASCE    | 85              | 8504                   | 8540  | 531               | 235                         | 85AS                        | 850                 | 851                | 5-3/16     | 5-3/16                   | 2-9/16    | 9/16    | 1-35/64           | 2-3/4              | 57/64             | 13°            | 13°                          | 2-17/64         |
| ASCE    | 80              | 8004                   | 8040  | 530               | 251                         | 80AS                        | 800                 | 800                | 5          | 5                        | 2-1/2     | 35/64   | 1-1/2             | 2-5/8              | 7/8               | 13°            | 13°                          | 2-3/16          |
| ASCE    | 75              | 7506                   | 7540  | 529               | 214                         | 75AS                        | 750                 | 753                | 4-13/16    | 4-13/16                  | 2-15/32   | 17/32   | 1-27/64           | 2-35/64            | 27/32             | 13°            | 13°                          | 2-15/128        |
| ASCE    | 70              | 7010                   | 7040  | 532               | 237                         | 70AS                        | 700                 | 701                | 4-5/8      | 4-5/8                    | 2-7/16    | 33/64   | 1-11/32           | 2-15/32            | 13/16             | 13°            | 13°                          | 2-3/64          |
| ASCE    | 65              | 6507                   | 6540  | 534               | 236                         | 65AS                        | 650                 | 653                | 4-7/16     | 4-7/16                   | 2-13/32   | 1 / 2   | 1-9/32            | 2-3/8              | 25/32             | 13°            | 13°                          | 1-31/32         |
| ASCE    | 60              | 6015                   | 6040  | 533               | 244                         | 60AS                        | 600                 | 603                | 4-1/4      | 4-1/4                    | 2-3/8     | 31/64   | 1-7/32            | 2-17/64            | 49/64             | 13°            | 13°                          | 1-115/128       |
| ASCE    | 55              | 5501                   | 5540  | 537               | 130                         | 55AS                        | 550                 | --                 | 4-1/16     | 4-1/16                   | 2-1/4     | 15/32   | 1-11/64           | 2-11/64            | 23/32             | 13°            | 13°                          | 1-103/128       |
| ASCE    | 50              | 5005                   | 5040  | 542               | 129                         | 50AS                        | 500                 | --                 | 3-7/8      | 3-7/8                    | 2-1/8     | 7/16    | 1-1/8             | 2-1/16             | 11/16             | 13°            | 13°                          | 1-23/32         |

Notes: See Figure D-1 for key All dimensions in inches (Sheet 1 of 3)

Table D-1 - Details of Rail Sections (Cont'd)

| Section        | Weight Per yard | Manufacturer's Brand   |  |                   |                             |                             |                     |                    | Rail Dimensions (Inches) |          |           |         |                   |                    |                   |                |                              |                 |
|----------------|-----------------|------------------------|--|-------------------|-----------------------------|-----------------------------|---------------------|--------------------|--------------------------|----------|-----------|---------|-------------------|--------------------|-------------------|----------------|------------------------------|-----------------|
|                |                 | Ill. Steel Co. Old No. | Ill. Steel Co. Carnegie Steel Co. T C & I Co. Inland steel Co. U. S. Steel Corp. | Midvale Steel Co. | Bethlehem Steel Co. Old No. | Bethlehem Steel Co. New No. | Lackawana Steel Co. | Colorado F & I Co. | Height (H)               | Base (B) | Head (HD) | Web (W) | Depth of Head (D) | Fishing Height (F) | Depth Of Base (E) | Head angle (A) | Base angle (A <sub>2</sub> ) | CL of bolts (N) |
| AT&SF          | 90              | 9021                   | 9021   | --                | 173                         | 90SF                        | 9033                | 903                | 5-5/8                    | 5-3/16   | 2-9/16    | 9/16    | 1-15/32           | 3-5/32             | 1                 | 4 to 1         | 4 to 1                       | 2-37/64         |
| Bang & Aroost. | 70              | --                     | --   | --                | --                          | --                          | 703                 | --                 | 4-3/4                    | 4-3/4    | 2-7/16    | 1 / 2   | 1-13/32           | 2-19/32            | 3 / 4             | 12°            | 12°                          | 2-3/64          |
| Can Nor        | 80              | 8010                   | 8010   | --                | --                          | --                          | 804                 | --                 | 5                        | 5        | 2-9/16    | 35/64   | 1-13/32           | 2-11/16            | 29/32             | 13°            | 13°                          | 2-1/4           |
| Can Pac        | 85              | --                     | 8524   | --                | 176                         | 85CP                        | 856                 | --                 | 5-1/8                    | 5        | 2-1/2     | 9/16    | 1-7/16            | 2-11/16            | 1                 | 4 to 1         | 4 to 1                       | 2-11/32         |
| Can Pac        | 65              | 6508                   | 6508   | --                | --                          | --                          | 654                 | --                 | 4-31/64                  | 4-3/8    | 2-1/4     | 15/32   | 1-9/32            | 2-11/32            | 35/64             | 4 to 1         | 4 to 1                       | 2-1/32          |
| C of NJ        | 135             | --                     | --   | --                | 290                         | --                          | --                  | --                 | 6-1/2                    | 6        | 3-5/32    | 3 / 4   | 2                 | 3-9/32             | 1-7/32            | 14°            | 14°                          | 2-55/64         |
| C & A          | 70              | 7002                   | --   | --                | --                          | --                          | --                  | --                 | 4-3/8                    | 4        | 2-35/96   | 35/64   | 1-17/24           | 1-11/12            | 3 / 4             | 12°            | 12°                          | 1-17/24         |
| DL & W         | 105             | --                     | --   | --                | 105-C                       | 105DL                       | 1052                | --                 | 6                        | 5-3/8    | 2-3/4     | 5/8     | 1-23/32           | 3-1/4              | 1-1/32            | 13°            | 13°                          | 2-21/32         |
| DL & W         | 101             | --                     | 10133  | --                | 299                         | 101DL                       | 1013                | --                 | 5-7/16                   | 5-3/8    | 2-3/4     | 5/8     | 1-23/32           | 2-11/16            | 1-1/32            | 13°            | 13°                          | 2-3/8           |
| DL & W         | 91              | --                     | 9133   | --                | 91-B                        | --                          | 911                 | --                 | 5-1/4                    | 5-3/8    | 2-5/8     | 5/8     | 1-41/64           | 2-11/16            | 59/64             | 13°            | 13°                          | 2-17/64         |
| DL & W         | 75              | --                     | --   | --                | 75-C                        | --                          | 753                 | --                 | 4-11/16                  | 5        | 2-1/2     | 1 / 2   | 1-43/64           | 2-13/64            | 13/16             | 18°            | 12°45'                       | 1-117/128       |
| Dudley         | 90              | --                     | --   | --                | --                          | --                          | 901                 | --                 | 5-1/2                    | 5        | 2-21/32   | 9/16    | 1-1/2             | 3-1/32             | 31/32             | 4 to 1         | 4 to 1                       | 2-31/64         |
| EJ & E         | 100             | --                     | 10050  | --                | --                          | --                          | --                  | --                 | 5-9/16                   | 5        | 2-21/32   | 9/16    | 1-37/64           | 2-51/64            | 1-3/16            | 4 to 1         | 4 to 1                       | 2-75/128        |
| Frictionless   | 125-1/2         | --                     | --   | --                | 125.5-F                     | --                          | --                  | --                 | 7                        | 5-1/2    | 1-13/16   | 11/16   | 2-3/8             | 3-13/32            | 1-7/32            | 18°            | 14°                          | 2-3/4           |
| Frictionless   | 98              | --                     | --   | --                | 305                         | --                          | --                  | --                 | 5-27/32                  | 5        | 2-1/2     | 9/16    | 1-31/32           | 2-25/32            | 1-3/32            | 15°            | 13°                          | 2-31/64         |
| Frictionless   | 97              | --                     | --   | --                | 97-B                        | --                          | --                  | --                 | 5-7/8                    | 5-9/64   | 2-1/4     | 9/16    | 1-15/16           | 2-55/64            | 1-5/64            | 13°            | 13°                          | 2-65/128        |
| Frictionless   | 93              | --                     | --   | --                | --                          | --                          | 932                 | --                 | 6-1/8                    | 5-1/2    | 2-1/8     | 19/32   | 1-13/16           | 3-3/8              | 15/16             | 13°            | 13°                          | 2-5/8           |
| Frictionless   | 92              | --                     | --   | --                | 304                         | --                          | --                  | --                 | 5-7/16                   | 5-3/8    | 1-15/16   | 5/8     | 2-3/32            | 2-5/16             | 1-1/32            | 13°            | 13°                          | 2-3/16          |
| Frictionless   | 90              | --                     | 9039   | --                | --                          | --                          | --                  | --                 | 5-5/8                    | 5-1/8    | 2-1/4     | 9/16    | 2                 | 2-5/8              | 1                 | 13°            | 13°                          | 2-5/16          |
| Frictionless   | 90              | --                     | 9029   | --                | --                          | --                          | --                  | --                 | 6-3/32                   | 5-1/8    | 1-59/64   | 9/16    | 1-15/16           | 3-5/32             | 1                 | 4 to 1         | 4 to 1                       | 2-37/64         |
| Frictionless   | 79-1/2          | --                     | --   | --                | 79.5-C                      | --                          | --                  | --                 | 5-3/16                   | 5-3/16   | 1-15/16   | 9/16    | 2-1/32            | 2-9/32             | 7/8               | 13°            | 13°                          | 2-1/64          |
| Grt Nor        | 110             | --                     | 11036  | --                | --                          | 110GN                       | --                  | --                 | 6-1/2                    | 5-1/2    | 2-3/4     | 19/32   | 1-5/8             | 3-3/4              | 1-1/8             | 1 to 4         | 1 to 4                       | 3-1/4           |
| Grt Nor        | 100             | --                     | 10036  | --                | --                          | 100GN                       | 1008                | --                 | 5-3/4                    | 5        | 2-3/4     | 9/16    | 1-5/8             | 3                  | 1-1/8             | 1 to 4         | 1 to 4                       | 2-5/8           |
| Grt Nor        | 90              | 9010                   | 9024   | 560               | 160                         | 90GN                        | 9030                | 904                | 5-3/8                    | 5        | 2-5/8     | 5/8     | 1-1/2             | 2-7/8              | 1                 | 13°            | 13°                          | 2-7/16          |
| Grt Nor        | 90              | --                     | 9036   | --                | --                          | --                          | --                  | --                 | 5-3/8                    | 5        | 2-5/8     | 19/32   | 1-15/32           | 2-7/8              | 1-1/32            | 13°            | 13°                          | 2-13/16         |
| Grt Nor        | 85              | 8509                   | 8553   | --                | --                          | --                          | 854                 | --                 | 5                        | 5        | 2-21/32   | 21/32   | 1-19/32           | 2-1/2              | 29/32             | 14°            | 14°                          | 2-5/32          |
| Grt Nor        | 80              | 8009                   | --   | --                | --                          | --                          | 802                 | --                 | 5                        | 5        | 2-13/32   | 5/8     | 1-5/8             | 2-1/2              | 7/8               | 14°            | 14°                          | 2-1/8           |
| Grt Nor        | 77-1/2          | 77501                  | --   | --                | --                          | --                          | 775                 | --                 | 5                        | 5        | 2-3/8     | 5/8     | 1-11/16           | 2-1/2              | 13/16             | 14°            | 14°                          | 2-1/16          |
| Hock Val       | 80              | --                     | --   | 540               | --                          | --                          | --                  | --                 | 5                        | 4-59/64  | 2-31/64   | 29/64   | 1-95/128          | 2-25/64            | 111/128           | 13°            | 13°                          | 2-1/16          |
| Interb'g'h     | 100             | 10005                  | 10005  | --                | 100-E                       | 100RT                       | 1005                | --                 | 5-3/4                    | 5-3/4    | 2-7/8     | 9/16    | 1-45/64           | 3-5/64             | 31/32             | 13°            | 13°                          | 2-65/128        |
| Interb'g'h     | 90              | --                     | 9050   | --                | 90-E                        | 90RT                        | 902                 | --                 | 5                        | 5        | 2-7/8     | 11/16   | 1-25/32           | 2-11/32            | 7/8               | 13°            | 13°                          | 2-3/64          |
| Lehigh Val     | 136             | --                     | --   | --                | 136-C                       | 136LV                       | --                  | --                 | 7                        | 6-1/2    | 2-15/16   | 21/32   | 1-7/8             | 3-7/8              | 1-1/4             | 4 to 1         | 4 to 1                       | 3-1/16          |
| Lehigh Val     | 110             | --                     | 11033  | --                | 110-B                       | 110LV                       | --                  | --                 | 6                        | 5-1/2    | 2-7/8     | 19/32   | 1-7/8             | 3-1/16             | 1-1/16            | 4 to 1         | 4 to 1                       | 2-3/4           |
| Mo Pac         | 85              | 8507                   | 8550   | --                | --                          | --                          | 853                 | --                 | 5-7/32                   | 5-1/4    | 2-15/32   | 75/12   | 1-3/4             | 2-39/64            | 55/64             | 13°            | 13°                          | 2-21/128        |
| Mo Pac         | 75              | 7512                   | 7550   | 528               | 289                         | 75MP                        | 754                 | --                 | 4-3/4                    | 4-3/4    | 2-9/16    | 9/16    | 1-7/16            | 2-15/32            | 27/32             | 13°            | 13°                          | 2-5/64          |
| Nat Ry Mex     | 75              | --                     | --   | --                | 128                         | --                          | --                  | --                 | 5                        | 5        | 2-3/4     | 1 / 2   | 1-3/8             | 2-7/8              | 3/4               | 12°            | 12°                          | 2-3/16          |

Notes: See Figure D-1 for key All dimensions in inches ( Sheet 2 of 3 )

Table D-1 - Details of Rail Sections (Concluded)

| Section    | Weight Per yard | Manufacturer's Brand   |  |                   |                             |                             |                     |                    |            | Rail Dimensions (Inches) |           |         |                   |                    |                   |                |                              |                 |  |
|------------|-----------------|------------------------|--|-------------------|-----------------------------|-----------------------------|---------------------|--------------------|------------|--------------------------|-----------|---------|-------------------|--------------------|-------------------|----------------|------------------------------|-----------------|--|
|            |                 | Ill. Steel Co. Old No. | Ill. Steel Co. Carnegie Steel Co. T C & I Co. Inland steel Co. | Midvale Steel Co. | Bethlehem Steel Co. Old No. | Bethlehem Steel Co. New No. | Lackawana Steel Co. | Colorado F & I Co. | Height (H) | Base (B)                 | Head (HD) | Web (W) | Depth of Head (D) | Fishing Height (F) | Depth Of Base (E) | Head angle (A) | Base angle (A <sub>2</sub> ) | CL of bolts (N) |  |
| NYC        | 120             | --                     | --   | --                | --                          | --                          | 1201                | --                 | 7          | 6                        | 3         | 21/32   | 1-5/8             | 4-5/16             | 1-1/16            | 4 to 1         | 4 to 1                       | 3-7/32          |  |
| NYC        | 105             | --                     | 10522  | --                | 105-B                       | 105DY                       | 1051                | --                 | 6          | 5-1/2                    | 3         | 5/8     | 1-5/8             | 3-13/32            | 31/32             | 4 to 1         | 4 to 1                       | 3-1/8           |  |
| NYC        | 100             | 10003                  | 10022  | --                | 175                         | --                          | 1001                | --                 | 6          | 5-1/2                    | 3         | 19/32   | 1-5/8             | 3-13/32            | 31/32             | 4 to 1         | 4 to 1                       | 2-5/8           |  |
| NYC        | 95              | --                     | --   | --                | --                          | --                          | 951                 | --                 | 5-1/32     | 5-1/2                    | 3         | 5/8     | 1-9/16            | 2-15/32            | 1                 | 4 to 1         | 4 to 1                       | 2-15/64         |  |
| NYC        | 80              | 8008                   | 8022   | 543               | 220                         | 80DY                        | 801                 | --                 | 5-1/8      | 5                        | 2-21/32   | 17/32   | 1-1/2             | 2-5/8              | 1                 | 4 to 1         | 4 to 1                       | 2-5/8           |  |
| NYC & St L | 85              | 8521                   | 8521   | --                | 172                         | --                          | 8531                | --                 | 5-3/8      | 4-7/8                    | 2-17/32   | 17/32   | 1-29/64           | 2-15/16            | 63/64             | 4 to 1         | 4 to 1                       | 2-29/64         |  |
| NYNH & H   | 107             | --                     | --   | --                | 172-D                       | 107NH                       | 1072                | --                 | 6-1/8      | 5-1/2                    | 2-3/4     | 19/32   | 1-23/32           | 3-11/32            | 1-1/16            | 13°            | 13°                          | 2-47/64         |  |
| NYNH & H   | 100             | 10004                  | 10034  | --                | 100                         | 100NH                       | 1002                | --                 | 6          | 5-1/2                    | 2-3/4     | 19/32   | 1-23/32           | 3-11/32            | 1-1/16            | 13°            | 13°                          | 2-39/64         |  |
| Nor Pac    | 66              | 6602                   | 6602   | 547               | --                          | --                          | --                  | --                 | 4-17/32    | 4-1/2                    | 2-5/16    | 17/32   | 1-27/64           | 2-11/32            | 49/64             | 13°            | 13°                          | 1-15/16         |  |
| PS-Penn    | 130             | --                     | 13031  | 589               | 130-B                       | 130PS                       | 13030               | --                 | 6-5/8      | 5-1/2                    | 3         | 11/16   | 2                 | 3-13/32            | 1-7/32            | 18°            | 14°                          | 2-3/4           |  |
| PS-Penn    | 125             | --                     | 12531  | 584               | 308                         | 125PS                       | 12530               | --                 | 6-1/2      | 5-1/2                    | 3         | 21/32   | 1-7/8             | 3-13/32            | 1-7/32            | 18°            | 14°                          | 2-59/64         |  |
| PS-Penn    | 100             | 10031                  | 10031  | 558               | 96-A                        | 100PS                       | 10030               | --                 | 5-11/16    | 5                        | 2-43/64   | 9/16    | 1-13/16           | 2-25/32            | 1-3/32            | 15°            | 13°                          | 2-31/64         |  |
| PS-Penn    | 85              | 8530                   | 8531   | 559               | 67-A                        | 85PS                        | 8530                | --                 | 5-1/8      | 4-5/8                    | 2-1/2     | 17/32   | 1-21/32           | 2-15/32            | 1                 | 15°            | 13°                          | 2-15/64         |  |
| PRR        | 85              | 8503                   | 8533   | 500               | 67                          | 85PG                        | 852                 | --                 | 5          | 5                        | 2-9/16    | 17/32   | 1-3/4             | 2-3/8              | 7/8               | 13°            | 13°                          | 2-1/16          |  |
| PRR        | 70              | 7005                   | 7033   | 504               | --                          | 70PR                        | --                  | --                 | 4-1/2      | 4-1/2                    | 2-7/16    | 1 / 2   | 1-19/32           | 2-1/8              | 25/32             | 13°            | 13°                          | 1-27/32         |  |
| P & R      | 100             | --                     | 10032  | --                | 165                         | 100RG                       | 1007                | --                 | 5-5/8      | 5-3/8                    | 2-21/32   | 9/16    | 1-45/64           | 2-55/64            | 1-1/16            | 13°            | 13°                          | 2-63/128        |  |
| RG So      | 52              | --                     | --   | --                | --                          | --                          | --                  | 521                | 4          | 4                        | 2-1/8     | 25/64   | 2                 | 41/64              | 13°               | 13°            | 1-41/64                      |                 |  |
| Russian    | 67-1/2          | --                     | --   | 587               | --                          | --                          | --                  | --                 | 5-3/64     | 4-21/64                  | 2-23/64   | 15/32   | 1-29/64           | 2-11/16            | 29/32             | 1 to 3         | 1 to 3                       | 2-1/4           |  |
| Sea A Ln   | 85              | --                     | 8522   | --                | 261                         | --                          | 851                 | --                 | 5-1/4      | 5                        | 2-11/16   | 17/32   | 1-5/8             | 2-3/4              | 7/8               | 14°            | 14°                          | 2-1/4           |  |
| Sea A Ln   | 75              | --                     | 7522   | --                | 221                         | --                          | --                  | --                 | 5          | 5                        | 2-9/16    | 1 / 2   | 1-3/8             | 2-3/4              | 7/8               | 14°            | 14°                          | 2-1/4           |  |
| Soo Ln     | 85              | 8520                   | 8520   | --                | --                          | --                          | --                  | --                 | 5-3/8      | 4-7/8                    | 2-1/2     | 9/16    | 1-15/32           | 2-29/32            | 1                 | 14°02'11"      | 14°02'11"                    | 2-29/64         |  |
| UP         | 90              | 9003                   | 9023   | --                | --                          | --                          | --                  | 901                | 5-3/4      | 5-3/8                    | 2-3/4     | 17/32   | 1-1/2             | 3-3/8              | 7/8               | 13°            | 13°                          | 2-9/16          |  |
| UP         | 75              | 7513                   | 7523   | --                | 75-B                        | --                          | --                  | 754                | 5          | 5                        | 2-9/16    | 33/64   | 1-3/8             | 2-13/16            | 13/16             | 13°            | 13°                          | 2-1/4           |  |
| UP         | 75              | 7524                   | 7524   | --                | --                          | 75SP                        | --                  | 757                | 4-15/16    | 4-7/16                   | 2-7/16    | 33/64   | 1-3/8             | 2-5/8              | 15/16             | 4 to 1         | 4 to 1                       | 2-1/4           |  |
| Miscell    | 75              | --                     | --   | --                | 92                          | --                          | --                  | --                 | 5          | 5                        | 2-1/2     | 9/16    | 1-7/16            | 2-47/64            | 53/64             | 13°            | 13°                          | 2-1/8           |  |
| Miscell    | 70              | --                     | --   | --                | 97                          | --                          | 703                 | --                 | 4-3/4      | 4-3/4                    | 2-7/16    | 1 / 2   | 1-13/32           | 2-19/32            | 3 / 4             | 12°            | 12°                          | 2-3/64          |  |
| Miscell    | 67              | 6704                   | 6704   | 515               | --                          | --                          | --                  | --                 | 4-1/2      | 4-1/2                    | 2-13/32   | 1 / 2   | 1-5/8             | 2-1/8              | 3 / 4             | 13°            | 13°                          | 1-13/16         |  |
| Miscell    | 67              | --                     | 6733   | --                | --                          | --                          | --                  | --                 | 4-1/2      | 4-1/2                    | 2-13/32   | 1 / 2   | 1-5/8             | 2-1/8              | 3 / 4             | 13°            | 13°                          | 1-13/16         |  |
| Miscell    | 65              | 6501                   | --   | --                | --                          | --                          | --                  | --                 | 4-3/8      | 4-7/16                   | 2-3/8     | 29/64   | 1-1/2             | 2-5/32             | 23/32             | 14°30'         | 12°30'                       | 1-51/64         |  |
| Miscell    | 65              | 6504                   | --   | --                | --                          | --                          | --                  | --                 | 4-1/2      | 4-1/2                    | 2-7/16    | 1 / 2   | 1-31/64           | 2-19/64            | 23/32             | 13°            | 13°                          | 1-7/8           |  |
| Miscell    | 60              | 6001                   | 6051   | --                | --                          | --                          | --                  | --                 | 4-1/4      | 4-1/16                   | 2-5/16    | 1 / 2   | 1-7/16            | 2-1/8              | 11/16             | 14°            | 12°50'                       | 1-3/4           |  |
| Miscell    | 60              | 6017                   | 6033   | 503               | --                          | --                          | --                  | --                 | 4-1/4      | 4-13/64                  | 2-21/64   | 29/64   | 1-55/128          | 2-7/64             | 91/128            | 13°            | 13°                          | 1-49/64         |  |
| Miscell    | 56              | 5610                   | 5610   | --                | --                          | --                          | --                  | --                 | 4-1/4      | 3-31/32                  | 2-7/32    | 13/32   | 1-7/16            | 2-1/8              | 11/16             | 14°            | 12°50'                       | 1-13/16         |  |
| Miscell    | 56              | --                     | --   | 511               | --                          | --                          | --                  | --                 | 4          | 3-53/64                  | 2-19/64   | 29/64   | 1-51/128          | 2-59/64            | 87/128            | 12°            | 12°                          | 1-41/64         |  |
| Miscell    | 56              | 5616                   | 5633   | --                | --                          | --                          | --                  | --                 | 4-1/4      | 4-1/8                    | 2-1/4     | 3/8     | 1-27/64           | 2-1/8              | 45/64             | 13°            | 13°                          | 1-49/64         |  |
| Miscell    | 56              | --                     | --   | --                | --                          | --                          | --                  | 562                | 4-1/4      | 4-1/8                    | 2-1/4     | 58/128  | 1-7/32            | 2-17/64            | 49/64             | 13°            | 13°                          | 1-115/128       |  |

Notes: See Figure D-1 for key All dimensions in inches ( Sheet 3 of 3 )

## APPENDIX E

### FAR PART 213

[Code of Federal Regulations]  
[Title 49, Volume 4]  
[Revised as of October 1, 2003]  
From the U.S. Government Printing Office via GPO Access  
[CITE: 49CFR213.233]

#### TITLE 49--TRANSPORTATION

#### CHAPTER II--FEDERAL RAILROAD ADMINISTRATION, DEPARTMENT OF TRANSPORTATION

#### PART 213--TRACK SAFETY STANDARDS--Table of Contents

#### Subpart F--Inspection

#### Sec. 213.233 Track inspections.

(a) All track shall be inspected in accordance with the schedule prescribed in paragraph (c) of this section by a person designated under Sec. 213.7.

(b) Each inspection shall be made on foot or by riding over the track in a vehicle at a speed that allows the person making the inspection to visually inspect the track structure for compliance with this part. However, mechanical, electrical, and other track inspection devices may be used to supplement visual inspection. If a vehicle is used for visual inspection, the speed of the vehicle may not be more than 5 miles per hour when passing over track crossings and turnouts, otherwise, the inspection vehicle speed shall be at the sole discretion of the inspector, based on track conditions and inspection requirements. When riding over the track in a vehicle, the inspection will be subject to the following conditions--

(1) One inspector in a vehicle may inspect up to two tracks at one time provided that the inspector's visibility remains unobstructed by any cause and that the second track is not centered more than 30 feet from the track upon which the inspector is riding;

(2) Two inspectors in one vehicle may inspect up to four tracks at a time provided that the inspectors' visibility remains unobstructed by any cause and that each track being inspected is centered within 39 feet from the track upon which the inspectors are riding;

(3) Each main track is actually traversed by the vehicle or inspected on foot at least once every two weeks, and each siding is actually traversed by the vehicle or inspected on foot at least once every month. On high density commuter railroad lines where track time does not permit an on track vehicle inspection, and where track centers are 15 foot or less, the requirements of this paragraph (b)(3) will not apply; and

(4) Track inspection records shall indicate which track(s) are traversed by the vehicle or inspected on foot as outlined in paragraph (b)(3) of this section.

(c) Each track inspection shall be made in accordance with the following schedule--

| Class of track                             | Type of track                     | Required frequency  |
|--|-----------------------------------|---|
| Excepted track and Class 1, 2, and 3 track | Main track and sidings            | Weekly with at least 3 calendar days, interval between inspections, or before use, if the track is used less than once a week, or twice weekly with at least 1 calendar day interval between inspections, if the track carries passenger trains or more than 10 million gross tons of traffic during the preceding calendar year. |
| Excepted track and Class 1, 2, and 3 track | Other than main track and sidings | Monthly with at least 20 calendar days interval between inspections.  |
| Class 4 and 5 track                        |                                   | Twice weekly with at least 1 calendar day interval between inspections.   |

(d) If the person making the inspection finds a deviation from the requirements of this part, the inspector shall immediately initiate remedial action.

Note to Sec. 213.233: Except as provided in paragraph (b) of this section, no part of this section will in any way be construed to limit the inspector's discretion as it involves inspection speed and sight distance.

[Code of Federal Regulations]

[Title 49, Volume 4]

[Revised as of October 1, 2003]

From the U.S. Government Printing Office via GPO Access

[CITE: 49CFR213.235]

TITLE 49--TRANSPORTATION

CHAPTER II--FEDERAL RAILROAD ADMINISTRATION, DEPARTMENT OF TRANSPORTATION

PART 213--TRACK SAFETY STANDARDS--Table of Contents

Subpart F--Inspection

Sec. 213.235 Inspection of switches, track crossings, and lift rail assemblies or other transition devices on moveable bridges.

(a) Except as provided in paragraph (c) of this section, each switch, turnout, track crossing, and moveable bridge lift rail assembly or other transition device shall be inspected on foot at least monthly.

(b) Each switch in Classes 3 through 5 track that is held in position only by the operating mechanism and one connecting rod shall be operated to all of its positions during one inspection in every 3 month period.

(c) In the case of track that is used less than once a month, each switch, turnout, track crossing, and moveable bridge lift rail assembly or other transition device shall be inspected on foot before it is used.

Sec. 213.239 Special inspections.

In the event of fire, flood, severe storm, or other occurrence which might have damaged track structure, a special inspection shall be made of the track involved as soon as possible after the occurrence and, if possible, before the operation of any train over that track.

**APPENDIX F**  
**SUMMARY OF STANDARDS**

| Summary of Standards**   |  |          |                                     |                             |                            |                                |                                |
|--|--|----------|-------------------------------------|-----------------------------|----------------------------|--------------------------------|--------------------------------|
| Item   | Maintenance Standards  |          |                                     | Safety Standards            |                            |                                |                                |
|  | Deviation for Track Category                                       |          | Paragraph Reference in UFC 4-860-03 | Restricted Operation 10 mph | Close to Traffic           | Paragraph Reference in FRA TSS | Construction/Repair Tolerances |
|  | A  | B        |                                     |                             |                            |                                |                                |
| Roadway  | Pumping Track*   |          | 3-1                                 | *                           |                            | None                           |                                |
|  | Erosion or Washouts*   |          |                                     | *                           |                            |                                |                                |
|  | Slides, Slippage or Slope Instability *                            |          |                                     | *                           |                            |                                |                                |
|  | Settlement*  |          |                                     | *                           |                            |                                |                                |
|  | Washouts*  |          |                                     | *                           |                            |                                |                                |
| Drainage   | Water Diverted onto track*   |          | 3-2                                 | *                           |                            | 213.33                         |                                |
|  | Hazardous Drainage Structures*                                     |          |                                     | *                           |                            |                                |                                |
|  | Inadequate Drainage Structures*                                    |          |                                     | *                           |                            |                                |                                |
|  | Obstruction of flow*   |          |                                     | *                           |                            |                                |                                |
| Vegetation   | Interferes with visibility along Right-of-Way*                     |          | 3-3                                 | *                           |                            | 213.37                         |                                |
|  | And at Highway Crossings   |          |                                     |                             |                            |                                |                                |
|  | Obstructs drainage*  |          |                                     | *                           |                            |                                |                                |
|  | Interferes with Train Operations and/or Track Inspection*          |          |                                     | *                           |                            |                                |                                |
|  | Presents Fire Hazard*  |          |                                     | *                           |                            |                                |                                |
|  | Interferes with Personnel Walking within 8 ft of Track Centerline* |          |                                     | *                           |                            |                                |                                |
|  | Brushes Side of Rolling Stock*                                     |          |                                     | *                           |                            |                                |                                |
| Ballast  | Fouled Ballast*  |          | 4-1                                 | *                           |                            | 213.103                        |                                |
|  | Covers Top of Ties*  |          |                                     | *                           |                            |                                |                                |
|  | Insufficient Ballast*  |          |                                     | *                           |                            |                                |                                |
| Ties:  |  |          |                                     |                             |                            | 213.109                        | See 5-4.d.                     |
| Min. Nondefective Tie per 39 ft Tangent and LT 2 °<br>Curves 2 ° or GT | Less than 12<br>Less than 13                                       | 10<br>11 | 5-6.c.(1)                           | Less than 8<br>Less than 10 | Less than 7<br>Less than 9 | 213.109 (c) and (d)            |                                |

\* Operating restrictions may be needed depending on seriousness of the condition.

\*\* Further information regarding classification of defects and operating restrictions is provided in NAVFACINST 11230.1.



| Summary of Standards**                      |   |   |   |                                     |   |                                      |                                       |
|---|---|---|---|-------------------------------------|---|--------------------------------------|---------------------------------------|
| Item  | Maintenance Standards   |   |   | Safety Standards                    |   |                                      | Construction/<br>Repair<br>Tolerances |
|   | Deviation for Track Category  |   | Paragraph<br>Reference in UFC<br>4-860-03 | Restricted<br>Operation<br>10 mph   | Close to Traffic                        | Paragraph<br>Reference<br>in FRA TSS |                                       |
|   | A   | B |   |                                     |   |                                      |                                       |
| Ties – Cont'd                               |   |   |   |                                     |   |                                      |                                       |
| Consecutive Defective<br>Tangent and LT 2 ° | 3   | 3 | 5-5.c.(1)                                 | 4                                   | 5 or more                               |                                      | 0                                     |
| Curves 2 ° or GT                            | 2   | 2 |   | 3                                   | 4 or more                               |                                      |                                       |
| Joint Ties:                                 |   |   |   |                                     |   |                                      | 213.109(f)                            |
| No. of Nondefective Required –<br>24" C/L   | 2   | 1 | 5-5.c.(2)                                 | 1                                   | 0                                       |                                      | 2                                     |
| Missing/Skewed                              | Tie missing or skew greater than 8 in. in 3<br>or more consecutive ties   |   | 5-5.d., 5-5.e., 5-<br>5.f.                |                                     | ---                                     | ---                                  | See 5-4.d.                            |
| Tie Plates                                  | Improper type broken flame cut or<br>defective*                           |   | 6-1 and 6-2                               | ---                                 | ---                                     | 213.123                              | See 6-2.                              |
| Spikes                                      | Improper type, broken, flame cut, or<br>defective.                        |   | 6-1 and 6-3                               | ---                                 | ---                                     | 213.127                              | See 6-3                               |
|   | Insufficient Number*  |   |   |                                     |   |                                      |                                       |
|   | Improper Installation   |   |   |                                     |   |                                      |                                       |
|   | Improper Spiking Pattern through slots in<br>angle bar                    |   |   |                                     |   |                                      |                                       |
|   | Loose or missing spikes*  |   |   |                                     |   |                                      |                                       |
|   | Spike beneath rail base   |   |   |                                     |   |                                      |                                       |
| Joint Bars                                  | Improper type, flame cut or defective*                                    |   | 6-4.a.                                    | ---                                 | ---                                     | 213.121                              | See 6-4.a.                            |
| Compromise Joints                           | Improper type, design, dimension, home-<br>made, flame cut, or defective* |   | 6-4.b.                                    | ---                                 | ---                                     | 213.121                              | See 6-4.b.                            |
| Joint Bars                                  | Cracked or broken*  |   | 6-4.c.                                    | ---                                 | Cracked<br>between center<br>bolt holes | 213.121                              | ---                                   |
| Track Bolts                                 | None loose or missing   |   | 6-4.e.                                    | LT 2 per rail or<br>All bolts loose | LT1 per rail                            | 213.121                              | None loose or<br>missing              |

\* Operating restrictions may be needed depending on seriousness of the condition.

\*\* Further information regarding classification of defects and operating restrictions is provided in NAVFACINST 11230.1.

| Summary of Standards**                |   |          |   |   |   |                                      |                                       |
|---------------------------------------|---|----------|---|---|---|--------------------------------------|---------------------------------------|
| Item                                  | Maintenance Standards   |          |   | Safety Standards                          |   |                                      | Construction/<br>Repair<br>Tolerances |
|                                       | Deviation for Track Category  |          | Paragraph<br>Reference in UFC<br>4-860-03 | Restricted<br>Operation<br>10 mph         | Close to Traffic                                    | Paragraph<br>Reference<br>in FRA TSS |                                       |
|                                       | A   | B        |   |   |   |                                      |                                       |
| Rail End Mismatch                     |   |          | 6-4.f.                                    |   |   | 213.115                              | 0"                                    |
| Tread                                 | GT 1/8"   | GT 1/8"  |   | ---                                       | GT 1/4"   |                                      |                                       |
| Gage Side                             | GT 1/8"   | GT 1/8"  |   | GT 3/16"                                  | GT 1/4"   |                                      |                                       |
| Rail Joint Gap                        | GT 3/4"   | GT 3/4"  | 6-4.g.                                    | GT 1-1/4"                                 | GT 2"   | ---                                  | ---                                   |
| Rail - Defective                      | See Table 7-1   |          | 7-1                                       | ---                                       | ---   | 213.113                              | ---                                   |
| Turnouts - General                    | Improper materials, rail not same weight/<br>section compromise joint in turnout* |          | 8-1 through 8-2                           | ---                                       | ---   | 213.133                              | ---                                   |
| - Switch Point Gap                    | 1/8"  | 1/8"     | 8-3.b.                                    | GT 1/4"                                   | GT 3/8"   | ---                                  | 213.135                               |
| - Broken/Worn Points                  | Broken/worn GT 1/2" down & 6 in back<br>from point                                |          | 8-3.c.                                    | ---                                       | ---   | 213.135                              | ---                                   |
| - Point Rail Elevation                |   |          | 8-3.c.                                    | Switch point<br>higher than stock<br>rail | Point rail lower<br>than stock rail<br>beyond taper | 213.135                              | ---                                   |
| - Lever Latches & Point Locks         | Missing damaged insecure otherwise<br>inoperative*                                |          | 8-3.d.                                    | ---                                       | ---   | 213.135                              | ---                                   |
| - Switch Stand                        | Not secure*   |          | 8-3.e.                                    | ---                                       | ---   | 213.135                              | ---                                   |
| - Connecting Rod<br>Switch Rod & Clip | Insecure damaged or shimmed   |          | 8-3.f. & 8-3.g.                           | ---                                       | ---   | 213.135                              | ---                                   |
| - Switch Heel                         | Heel not fully secure, heel bolts missing   |          | 8-3.i.                                    | Bolts loose or<br>missing---              | ---   | 213.135                              | ---                                   |
| - Rail Braces                         | Improper materials or installation  |          | 8-3.j.                                    | LT 4 per stock rail                       | ---   | 213.135                              | ---                                   |
| - Frog Point Wear/Damage              | GT 1/2" down and 6" back all categories   |          | 8-4.a                                     | GT 5/8" down and<br>6" back               | ---   | 213.137                              | 1/8" of original<br>contour           |
| - Frog Surface Wear                   | GT 5/16"  | GT 5/16" | 8-4.b.                                    | GT 3/8"                                   | ---   | 213.137                              | 1/8" of original<br>contour           |

\* Operating restrictions may be needed depending on seriousness of the condition.

\*\* Further information regarding classification of defects and operating restrictions for Navy Installation is provided in NAVFACINST 11230.1

| Summary of Standards**                 |                              |            |   |                                   |                  |                                      |                                       |
|--|------------------------------|------------|---|-----------------------------------|------------------|--------------------------------------|---------------------------------------|
| Item                                   | Maintenance Standards        |            |   | Safety Standards                  |                  |                                      | Construction/<br>Repair<br>Tolerances |
|  | Deviation for Track Category |            | Paragraph<br>Reference in UFC<br>4-860-03 | Restricted<br>Operation<br>10 mph | Close to Traffic | Paragraph<br>Reference<br>in FRA TSS |                                       |
|  | A                            | B          |   |                                   |                  |                                      |                                       |
| Turnouts - Frog Guarding Face wear     | GT 5/16"                     | GT 5/16"   | 8-4.c                                     | GT 3/8                            |                  | 213.141                              | 1/8" of original contour              |
| - Frog Flangeway Width                 | 1-5/8"                       | 1-5/8"     | 8-4.f.                                    | LT 1-5/8"                         | LT 1-1/2"        | 213.143                              | 1-7/8"                                |
| - Frog Flangeway Depth                 | LT 1-5/8"                    | LT 1-5/8"  | 8-4.g.                                    | LT 1-1/2"                         | LT 1-3/8"        | 213.137                              | 1-7/8"                                |
| - Guard Check gage                     | LT 54-3/8"                   | LT 54-3/8" | 8-5.c.                                    | LT 54-1/4"                        | LT 54-1/8"       | 213.143                              | 54-5/8"                               |
| - Guard Face Gage                      | GT 53.0"                     | GT 53.0"   | 8-5.d.                                    | GT 53-1/8"                        | GT 53-1/4"       | 213.143                              | 52-3/4"                               |
| - Guard Rail Flangeway Width           | 1-5/8"                       | 1-5/8"     | 8-5.e.                                    | LT 1-5/8"                         | LT 1-1/2"        | 213.143                              | 1-7/8"                                |
| Rail Crossing Flangeway Width          | 1-5/8"                       | 1-5/8"     | 9-2.b.                                    | LT 1-5/8"                         | LT 1-1/2"        | 213.133                              | 1-7/8"                                |
| Rail Crossing Flangeway Depth          | 1-1/2"                       | 1-1/2"     | 9-2.b.                                    | LT 1-1/2"                         | LT 1-3/8"        | 213.133                              | 1-7/8"                                |
| Road Crossing - Formed Flangeway Width | LT 2-1/2"                    | LT 2-1/2"  | 10-2.a.                                   | LT 1-3/4"                         | ---              | ---                                  | 2 1/2 to 3"                           |
| Road Crossing Flangeway Depth          | LT 2.0"                      | LT 2.0"    | 10-2.b.                                   | LT 1-1/2"                         | ---              | ---                                  | GE 2.0"                               |
| Gage - Minimum                         | LT 56-1/8"                   | LT 56-1/8" | 12-2.d.                                   | ---                               | LT 56.0"         | 213.53                               | See 12-2.c.                           |
| -Maximum                               | 57-1/2"                      | 57-1/2"    |   | GT 57-1/2                         | GT 57-3/4        |                                      |                                       |
| Cross level - Tangent                  | GT 1-1/4"                    | GT 1-1/2"  | 12-3.                                     | GT 2.0"                           | GT 3.0"          | 213.63                               | 0                                     |
| - Curves                               | GT 1-1/4"                    | GT 1-1/2"  | 12-3.                                     | GT 2.0"                           | GT 3.0"          |                                      | Designated Superelevation             |
| Warp                                   | GT 1-3/4"                    | GT 1-3/4"  | 12-4.                                     | GT 2.25"                          | GT 3.0"          | 213.63                               | 0                                     |
| Alignment- Tangent                     | GT 2"                        | GT 2"      | 12-6.                                     | GT 3.0"                           | GT 5.0"          | 213.55                               | 0                                     |
| - Curves                               | GT 2"                        | GT 2"      | 12-6.                                     | GT 3.0"                           | GT 5.0"          |                                      | Degree of curve                       |
| Profile/Surface                        | GT 2-1/4"                    | GT 2-1/4"  | 12-7.                                     | GT 2-3/4"                         | GT 3.0"          | 213.63                               | 0                                     |

• Operating restrictions may be needed depending on seriousness of the condition.

• \*\* Further information regarding classification of defects and operating restrictions for Navy Installation is provided in NAVFACINST 11230.1