Elevated Crane Trackage Inspector Training Course

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NAVFACINST 11230.1F
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NAVFAC INSTRUCTION 11230.1F

From: Commander, Naval Facilities Engineering Command

Subj: INSPECTION, CERTIFICATION, AND AUDIT OF CRANE AND RAILROAD TRACKAGE

1. Purpose. To provide procedures for inspection, certification, sustainment and restoration management and audit of crane and railroad trackage. Additional requirements and tests for special purpose/hazardous load carrying trackage may be specified in other documents.

2. Cancellation. Replaces NAVFACINST 11230.1E of 10 Aug 2009 which is cancelled.

3. Background. Crane and railroad trackage is a valuable facility asset that needs to be maintained in a safe operating condition, ready for current use or future mobilization purposes, where required. Review of in-service trackage validates the need for inspection and sustainment criteria to assist in evaluating the physical condition and ensuring the safety of all crane and railroad trackage used in support of naval operations.

4. Action. All naval activities with crane (ground and elevated) and railroad trackage on plant account shall comply with the provisions of this instruction. Activities shall establish an inspection and sustainment program or affirm or modify their existing program to encompass the criteria herein and shall take coordinated action to ensure implementation of this instruction. Naval Facilities Engineering Command (NAVFACENGCOM) shall administer this program for the Chief of Naval Operations (CNO). Activities with Navy owned cranes operating on non-Navy trackage shall inspect and certify the trackage in accordance with this instruction, as required by NAVFAC P-307. NAVFACINST 11230.1F directs, based on RIE and risk based assessment, the audit schedule for 2 year audits, 4 year audits, and 6 year paperwork audits.

5. Scope. Criteria provided in this instruction establish minimum safety standards for track use. Standard operating procedures for track shall be maintained in accordance with criteria in Unified Facilities Criteria (UFC) 4-860-03 and herein to ensure safe use. This instruction is aligned with BMS B15.21, Trackage Audits.

6. Exceptions. Deviations from the standards set forth herein shall be submitted via the activity's region commander or major claimant to NAVFAC ESC for approval. Point of contact is Tyler Vander Schuur, NAVFAC Trackage SME at (805) 982-6093.

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RECORD OF CHANGES

CHANGE NUMBER	DATE OF CHANGE	DATE ENTERED	BY WHOM ENTERED

INSPECTION, CERTIFICATION AND AUDIT
OF CRANE AND RAILROAD TRACKAGE

ATTACHMENTS

REFERENCED DOCUMENTS

ANSI/ASNT CP189	2001 ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel
AREMA Manual	American Railway Engineering and Maintenance-of-Way Association - Manual for Railway Engineering
DOT FRA Standards (CFR)	The Department of Transportation (DOT), Code of Federal Regulations Title 49 Transportation, Chapter II Federal Railroad Administration, Part 213 Track Safety Standards
DOT Highway Standards	The Department of Transportation (DOT), Code of Federal Regulations (CFR) Title 23 Highways, Part 650, Subpart C National Bridge Inspection Standards
NAVFAC MO-104.2	Specialized Underwater Facilities Inspection
NAVFAC MO-312.2	A Field Guide for The Receipt and Inspection of Treated Wood Products by Installation Personnel
NAVFAC MO-321	Facilities Management
NAVFAC MO-322 Vol I	Vol I: Inspection of Shore Facilities
NAVFAC MO-322 Vol II	Vol II: Inspection of Shore Facilities
NAVFAC P-300	Management of Transportation Equipment
NAVFAC P-301	Navy Railway Operating Handbook
NAVFAC P-307	Management of Weight Handling Equipment
OPNAVINST 5102.1D	Navy & Marine Corps Mishap and Safety Investigation, Reporting, and Record Keeping Manual
OPNAVINST 5100.23G	Navy Safety and Occupational Health (SOH) Program Manual
UFC 4-150-07	Maintenance of Waterfront Facilities
UFC 4-860-03	Railroad Track Maintenance & Safety Standards
UFC 4-152-01	Piers and Wharves
UFC 3-320-07N	Weight Handling Equipment
UFGS 05 12 00	Structural Steel
UFGS 34 11 00	Railroad Track and Accessories
UFGS 34 11 19.00 20	Welding Crane and Railroad Rail - Thermite Method
UFGS 41 22 13.33	Portal Crane Track Installation

INSPECTION, CERTIFICATION AND AUDIT OF CRANE AND RAILROAD TRACKAGE

SECTION 1. GENERAL

1.0 Railroad and crane trackage inspections, certifications and audits shall be performed at the frequencies and in the detail specified in this instruction. Where not specifically described in this instruction, the inspection and maintenance management program for trackage shall comply with appropriate NAVFAC Maintenance Manuals, including MO-321, MO-322, MO-103 and UFC 4-860-03 "Railroad Maintenance & Safety Track Standards". In general, inspections shall consist of observing the functioning of the trackage as related to safety, maintenance and design parameters. Examination will be by sight, sound, feel, instrumentation and non-destructive testing. Inspection, certification and audit of trackage includes rails, ties, subgrade, supports, foundations, drainage appendages and accessories. Primary emphasis shall be given to ensuring maximum safety by maintaining all facilities in a safe and sound condition. Since there is a difference in program or procedure, trackage is divided into three Major Trackage Systems as defined below and discussed separately herein.

1.0.1 RAILROAD TRACKAGE. Railroad trackage applies to all track systems used by engines/locomotives, railcars, locomotive cranes, or hi-rail trucks including narrow gage systems.

1.0.2 GROUND-LEVEL CRANE TRACKAGE. Ground-level crane trackage applies to tracks for all weight handling equipment that operates at an activity. This includes but is not limited to trackage systems for portal, gantry, and the ground level rail for semi-gantry cranes.

1.0.3 ELEVATED CRANE TRACKAGE. Elevated crane trackage applies to all trackage systems attached to or suspended from side walls, columns, buildings, roofs or separate superstructures. This includes trackage for overhead or bridge cranes, wall cranes, and semi-gantry cranes.

NOTES: 1. Rail inspections for monorails; jib crane rails; "H" Beam, "I" Beam, or other structural steel shape rail supporting underhung crane systems; and trolley trackage for jib or other type hoists are conducted by the crane inspector in accordance with NAVFAC P-307. Guidelines for inspection, certification and audit for these types of rail systems are not included in this instruction. Top running cranes using rubber tires running directly on I-beam or other steel shapes are also not covered.

2. Top running bridge cranes with single or double flanged steel wheels operating on steel shapes such as square, rectangular or triangular rails shall be inspected and certified in accordance with this instruction, but specific inspection requirements for the rail fastening and joining shall be developed locally based on the engineering design guidance.

3. When there is a Navy crane, that requires certification in accordance with NAVFAC P-307, operating on track that is not on Navy plant account, the trackage system will be inspected and certified in accordance with the provisions of this instruction.

4. Rail systems used for stacker cranes are not included in this program. Stacker cranes and associated runway systems are procured as Class 3 property. Large cab operated stacker cranes are inspected and certified in accordance with MO-118, “Vertical Transportation Equipment”.

5. Rail systems used by fixed load bridge systems, typically X-ray units, may be part of the Class 2 property plant account but the bridge is not a considered weight handling equipment in accordance with P-307. These trackage systems shall be inspected and certified in accordance with this instruction.

1.1 INSPECTION. Inspection and testing of trackage shall be performed by qualified activity personnel or by contract with assistance of Naval Facilities Engineering Service Center (NAVFAC ESC) personnel when requested. The responsibility for providing qualified trackage inspection is typically assigned to a Public Works Department of a Regional Facilities Engineering Command (FEC) or a weight handling department of commands not aligned with NAVFACENGCOM. Inspectors may designate a proposed degree-of-hazard (catastrophic, critical, or marginal) of a section or subsystem based on criteria contained herein and their judgment. Where there is any doubt regarding the seriousness of a defect, or a questionable safety condition, all use shall be stopped over the section of trackage involved until the deficiencies are corrected or until safe use is determined (see paragraph 1.3). Deficiencies designated as "catastrophic" or "critical" by inspection personnel shall be evaluated by the cognizant engineering or facilities management organization to determine corrective action and interim precautionary measures including "non-certification" or "restricted certification." Inspections shall be conducted according to the interval stated herein or more often when deemed necessary by the work supervisor or as directed by the Certifying Official.

1.2 TRACK INSPECTORS QUALIFICATIONS. Track Inspectors are responsible for conducting safety inspections (paragraphs 2.1.3, 3.1.3 and 4.1.3) and detailed inspections (paragraphs 2.1.4, 3.1.4, and 4.1.4) including visual and operational inspections. These inspections are more inclusive and exacting than scheduled maintenance inspections and shall be conducted by trained personnel. The Certifying Official shall designate qualified persons to inspect track for defects. Each person designated must have:

(1) At least -

(a) 1 year of experience as an inspector working under the tutelage of a qualified experienced inspector performing normal track inspection duties at assigned activity.

and

(b) Attended NAVFACENGCOM Trackage Inspector Training Course or any equivalent course offered by the private industry or other government agencies. Activities with local crane training programs may offer an elevated crane trackage inspector training course for their track inspectors, if the course training plan is approved and the instructor is authorized by NAVFAC ESC OP64. The course instructor shall have attended the NAVFACENGCOM elevated crane trackage course at least every five years. Activities providing local elevated crane track inspector training shall provide a list of attendees (name/position/code/telephone number) at the completion of each course to NAVFAC ESC.

(2) Attend a refresher course in 1b above at least once every five years.
(3) Demonstrates to the Certifying Official that as an inspector -
  (a) Knows and understands the requirements of this instruction and the Federal Railroad Administration (FRA) Track Safety Standards.
  (b) Can detect deviations from those requirements; and
  (c) Can prescribe appropriate remedial action to correct or safely compensate for those deviations.
(4) The designation of the track inspector(s) by the Certifying Official shall be in writing and include the basis for each designation. Basis of designation, as a minimum, shall include number of years of experience and dates the training course was attended to show that qualifications have been met and are current. In addition, the Certifying Official shall provide written authorization to the track inspector to prescribe remedial actions to correct or safely compensate for deviations from the requirements of this instruction.

1.3 CERTIFICATION. All in-service trackage shall have a current certification according to one of the classifications shown herein, signed and dated by the Certifying Official. All out of service trackage shall be documented as non-certified for use or documented by the Certifying Official that it is inactive status. Certification shall be made and documented at intervals not to exceed two years. The two year interval for track certification and operational inspection (paragraph 4.1.4.3) for elevated crane trackage may be based on the crane certification date at the discretion of the Certifying Official as long as it does not exceed the track certification date by over 45 days. The track certification shall indicate the date of crane certification. Also see paragraph 1.3.1 regarding extension of certification. Current and previous certification for each section of trackage shall be readily maintained on file. Restrictions for restricted certification shall be documented and on file. Inspection methods and tests described or referenced herein shall be used as the basis for trackage certification. At any time during the two year period of the certification, the annual visual or two/five year operational inspections become over due, the certification will be cancelled in accordance with paragraph 1.3.4. At which time overdue inspection(s) are accomplished, certification/recertification will be in accordance with paragraph 1.3.4. Attachments (2-2), (3-2) and (4-2) provide minimum requirements for a certification documents for each of the three major trackage systems and may be used; however, activities have the option to use locally developed forms. For inactive trackage or trackage used infrequently, certification may be performed just prior to use. When there is any doubt as to the degree-of-hazard over a given section of trackage, a certification shall not be given until a detailed investigation and engineering evaluation have been completed to determine whether or not the section of trackage involved can be certified safe, or whether or not restricted operations may continue pending restoration.

1.3.1 Extension of Certification. Tracks with a Full Certification may have the certification extended for a period not to exceed 30 days for railroad and ground level crane track and a period not to exceed 45 days (corresponds with extension allowed for cranes in accordance with the P-307) for elevated crane track. The Certifying Official shall document the length of certification extension in writing. In addition to requiring a full certification for track certification to be extended, the following shall apply:

a. Track shall have a current detailed inspection within two weeks prior to extension;

b. Elevated crane track shall receive a “No load test” in accordance with paragraph 4.1.4.3.2 of this document and Appendix E, NAVFAC P-307.

c. Track shall have been active and seen normal use during the certification period and

d. There shall be no indication of subgrade or support structure degradation.

1.3.2 Certifying Official. The Certifying Official shall:

(1) Be designated as responsible for the sustainment/restoration and inspection of trackage, in writing, by the Commanding Officer of the regional FEC or local activity Commanding Officer. Alternate Certifying Official(s) may also be designated, in writing to act in the absence of the Certifying Official. Routinely, certification shall be made by the Certifying Official. The alternate Certifying Official should only certify track due to lengthy absence of the Certifying Official or when production delays would occur. The Certifying Official shall be made aware of all certifications performed during the Certifying Official’s absence

(2) Approve all certifications.

(3) Be responsible for safety and shall insure the visual supervision of each operation over the defective sections when necessary to use non-certified trackage.

(4) Insure a visual examination of the cause of non-certification is accomplished prior to use to determine if the trackage can be used for emergency or temporary traffic.

(5) Indicate, in writing, mandatory precautions and restrictions to be enforced when a section of restricted or non-certified trackage is used.

(6) Delegate the authority to visually supervise movement on noncertified trackage, except for movement of hazardous or nuclear material, provided that defects have been examined to ensure they have not progressed or changed and that occasional movements can be made safely. The Certifying Official shall supervise movement on non-certified trackage of hazardous or nuclear material.

1.3.3 Certification Classifications

1.3.3.1 Full Certification. Trackage systems with minor deficiencies classified as "marginal" (paragraph 1.4.3) or no defect may be fully certified for all operations. These sections shall be repaired, when practical, during regularly scheduled track work operations. Records of un-repaired marginal rail defects and substandard trackage shall be kept current and the trackage continually observed during all future inspections to identify any further degradation which might result in "critical" defects.

1.3.3.2 Restricted Certification. Trackage systems with "Critical" rail defects (paragraph 1.4.2) or potentially dangerous sections of trackage may be scheduled for restricted operation at the discretion of the Certifying Official, provided FRA Trackage Safety Standards Paragraph 213.113 is complied with or all of the following actions are taken:

(1) Replacement or repair is scheduled.

(2) Deficient areas are clearly and specifically marked with warning signs when practical, or specified in written instructions and restrictions.

(3) Operators are informed to proceed with extreme caution.

(4) Reduced speed operation is approved following an engineering inspection.

(5) Defect or defects are carefully reinspected during safety inspections at intervals prescribed by FRA or intervals of not more than every six months, whichever is less. (For infrequently used trackage, inspections may be made just prior to use.)

1.3.3.3 Non-Certification. Trackage systems which have "catastrophic" rail defects (paragraph 1.4.1) or dangerous sections of trackage shall not be certified. Usage shall be stopped until the section or sections of trackage have been repaired or replaced and certified. Emergency use of non-certified trackage is discussed in paragraph 1.3.2. Sections of trackage that are defective, damaged, misaligned or otherwise failing to meet the standards established in the FRA Track Safety Standards or this instruction shall be barricaded or marked with warning signs when practical and service shall be discontinued. When a catastrophic defect is found which cancels the certification of a specific section of track, service shall be discontinued over the defect and the problem area shall be isolated with barricades when practical. In addition to discontinuing service and isolating the problem area, the following actions shall be done to ensure maximum safety:

(1) Advise all concerned.

(2) When repaired, re-examine the specific section of trackage. An operational inspection is not a mandatory action. (See paragraphs 2.1.4.2.4, 3.1.4.2.3, and 4.1.4.3.3)

(3) Recertify the repaired section. (See paragraph 1.3.4)

(4) Update documentation to reflect defects, repair(s) made, reinspection, and recertification.

1.3.4 Cancelled Certification. Tests or inspections made between certifications that indicate previously unreported catastrophic defects, critical defects or other unsafe conditions shall automatically cancel certification over the specific section of trackage involved. The term "specific section" refers to the immediate area in which a defect occurs and not to the entire section of trackage certified. The certification of trackage on either side of such a defect may remain as classified at the discretion of the Certifying Official. If the new defect does not change the certification classification, the certification should not be changed. For example: If a critical defect is discovered in a section of trackage with restricted certification, the certification remains the same and is not cancelled. If the defect found would require a more restrictive certification than the entire section of trackage under certification, the certification over the specific section would change and appropriate actions, as discussed above, taken. This change in certification shall be documented and made known to the Certifying Official. The method used to remove the specific section of trackage from service is an activity option, provided all defects are recorded in history files and users of subject trackage are apprised of trackage defects and special precaution to take while using. Upon completion of investigation and temporary or permanent restoration, the specific section shall be reinspected. If the classification of certification is the same as for the entire section, the exception for the specific section involved may be cancelled and the original certification used.

1.4 Trackage Defect Classification. Defect hazards are grouped into three categories - (1) Catastrophic, (2) Critical, and (3) Marginal. These categories are as recommended in MIL-STD 882D. Defects are listed in the hazard category in which they normally occur. Exceptions and variations are expected; therefore, experience or engineering judgment must be used to determine the degree of hazard for each defect. Guidelines to assist inspectors and certifying officials in determining the degree of hazard of a defect are described below and summarized in Attachments (2-1), (3-1) and (4-1).

1.4.1 "Catastrophic". Sections of trackage with catastrophic defects involved shall not be used until repaired, except as noted in paragraph 1.3.3.3. Catastrophic defects include unsafe track conditions based on engineering judgment and experience, and defects requiring immediate change out of rail. The following defects are considered catastrophic and all traffic shall be stopped until repairs are made:

(1) Any breakout in the railhead.
(Exception as detailed in Note 6, Attachment (3-1), for ground level crane rail.)
(2) Rail defects accumulating three feet or more in any l0 feet.
(3) Broken base exceeding six inches.
(4) For railroad trackage any defect exceeding FRA Class 1 Track Safety Standards, catastrophic defects listed in Attachment 2-1, or “no operation” defects listed in UFC 4-860-03.

Specific criteria for evaluating the consequences of defects outside the range designated as critical for crane rail are not available. The activity shall evaluate the severity of each such defect and shall classify the degree-of-hazard based on engineering judgment and experience. Temporary or emergency repair of defective rails may reduce the degree-of-hazard to critical, marginal or no defect depending on the severity of the defect.

1.4.2 "Critical". Trackage with critical defects may continue in use provided that all actions addressed in paragraph 1.3.3.2 are complied with. Any defect exceeding FRA Class 2 Track Safety Standards or “restricted operation” defects addressed in UFC 4-860-03 are considered critical. Guidelines for classifying critical defects are provided in Attachments (2-1), (3-1) and (4-1).

1.4.3 "Marginal". Marginal defects are deficiencies that will not cause damage to the trackage system or operating equipment, or endanger personnel safety and that should be scheduled for routine sustainment and restoration. The intent in recording marginal or minor defects is to ensure that defects which may grow are monitored. In accordance with Note 8, Attachment (2-1) and Note 5, Attachments (3-1) and (4-1), certain internal rail defects may be categorized as marginal provided the defect is inspected six months after discovery and annually thereafter to ensure that the defect is not progressing.

1.5 AUDIT. Naval Facilities Engineering Service Center (NAVFAC ESC) shall schedule and conduct audits of maintenance management of trackage at each activity.

1.5.1 Purpose. The audit evaluates the effectiveness of trackage management at each activity, including Sustainment, Restoration, and Modernization (SRM), to ensure the safety and reliability of the facility's trackage and to furnish the activity and claimant with an appraisal of the track management program. The audit team shall review procedures and make recommendations for improving trackage management. Portions of the trackage system shall be inspected and results compared with the activity's inspections. The audit will be directed to affirm that the trackage management, including certification programs, is being conducted in a satisfactory manner and that activity instructions on implementation are adequate.

1.5.2 Frequency and Method,

1.5.2.1 On-site audits shall be conducted at two-year intervals for trackage in any of the following categories:

– Railroad trackage that does not have RAILER implemented and used for trackage management.
– Railroad trackage that handles nuclear material or ordnance.
– Trackage supporting Category 1 cranes with curves.
– Trackage supporting Category 1 cranes with critical or catastrophic defects at the last audit.

1.5.2.2 On-site audits shall be conducted at four-year intervals for trackage in any of the following categories:

– Railroad trackage that does not require audits at two-year intervals under paragraph 1.5.2.1.
– Trackage supporting Category 1 cranes that does not require audits at two-year intervals under paragraph 1.5.2.1.
– Trackage supporting Category 2 cranes.
– Trackage supporting Category 3 cranes handling nuclear material.

1.5.2.3 Paperwork review only audits, shall be scheduled at six-year intervals and conducted at NAVFAC ESC for trackage supporting Category 3 cranes that do not require audits at four-year intervals under paragraph 1.5.2.2. On-site audits shall be scheduled when any of the following criteria are met:

– The activity is new to the trackage program or has never had an audit for any reason.
– The activity has only one inspector and the inspector has not had one year of experience under a designated inspector at that activity.
– The audit records review indicates there are significant documentation errors such as

- 20% of cranes have had a defaulted certification within the last four years.
- 20% of records are missing signatures, inspections are not recorded or similar defects
- The NAVFAC Crane Center notes they have concerns with the rail system.

1.5.2.4 Activities with trackage supporting a mixture of Category 2 and Category 3 cranes shall be audited at the required Category 2 frequency unless their Category 2 inventory is less than 20% of the total inventory, the Category 2 cranes are infrequently used and an activity requests the lower frequency.

1.5.2.5 NAVFAC ESC may conduct audits more frequently when requested by the cognizant Navy Region or systems command, when previous audits recommend additional follow-up, or when any audit reveals that the trackage maintenance management program at an activity is not satisfactory.

1.5.3 Reports. A report on the effectiveness and adequacy of the program shall be forwarded to the cognizant Navy Region, FEC, activity Commanding Officer and system command within 45 calendar days after completion of the audit.

1.5.4 Non-Certification of Trackage. If during the performance of an audit or other track inspection the auditor determines that a serious catastrophic defect exists in any portion of the trackage and the activity is not taking appropriate measures and/or the trackage maintenance and inspection program is so poor that continued operation of the trackage is unsafe, the auditor shall issue a Trackage Audit Non-Certification form covering the affected portion, segment, track or system. The activity shall cease all operation over the identified trackage until repairs are made and the activity certifies to NAVFAC ESC that the track is now safe for use.

1.5.5 Activity Coordination. Schedules of audits will be coordinated with the activity to be audited and the activity formally notified. The activity's cognizant Navy Region, FEC, Commanding Officer and system command shall be advised of the dates that the audit will be conducted. Activities shall submit the following records in PDF format not less than 30 days before the audit to NAVFAC ESC: mishap reports, inventory, inspection reports, certification documents and other related information. Refer to NAVFAC BMS B15.21 Trackage Audits or NAVFAC ESC for the most current and complete list. To establish credibility of documents involving inspections and tests, a representative from the audit team may be present to observe a portion of the activity's operational and visual inspections and tests. The activity's inspectors shall accompany the track auditor during portions of the field examination. Activities shall ensure that all audit team findings are correct before the team members depart. The activity shall review preliminary recommendations and provide the audit team with reclamas or disagreements prior to the departure conference.

1.5.6 Response. The activity audited shall forward a plan of action to its cognizant Navy Region or systems command within 30 days after receipt of the audit report with a copy to NAVFAC ESC. Reports on the corrective actions taken on the audit report recommendations shall be submitted annually until the actions are complete.

1.5.7 Report Records. The activity shall maintain on file previous audits and activity responses until all actions on findings are complete and shown as complete on a subsequent audit report.

1.6 NON-DESTRUCTIVE TESTING (NDT).

1.6.1 Ultrasonic Testing. Ultrasonic inspection is a non-destructive test method for revealing internal discontinuities in dense homogenous materials by means of acoustic waves of frequencies above the audible range. Ultrasonic testing is the recommended method for non-destructive testing of readily accessible rail. Ultrasonic testing is an economical method of checking long lengths of trackage and rail encased in pavement. Generally ultrasonic testing of elevated crane rails is not required; however, elevated crane rails may be ultrasonically tested at the discretion of the Certifying Official.

1.6.1.1 Ultrasonic Equipment Operators. Operators of the ultrasonic equipment shall be certified to a Level I qualification in accordance with the American Standards Institute (ANSI)/American Society for Nondestructive Testing (ASNT) Standard CP189-2001 "ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel"

1.6.1.2 Ultrasonic Equipment. The ultrasonic equipment operated by qualified personnel (para. 1.6.1.1) shall be able to detect, but not be limited to, the following discontinuities in the rail.

Transverse fissures or other centrally located transverse defects representing approximately 10% of the cross-sectional area of the rail head.

Detail fractures representing approximately 15% of the cross-sectional area of the rail head and not masked from above by the shallow horizontal separations sometimes associated with shells.

Engine burn fractures or transverse separations developing from thermal cracks underneath the driver burns representing approximately 20% of the cross-sectional area of the rail head.

Horizontal split heads at least two inches in length, extending at least halfway through the rail head and located one-half inch or more below the running surface of the rail.

Vertical split heads so oriented as to interrupt an ultrasonic signal transmitted centrally through the rail section from above.

Head and web separations and split webs outside the joint bar limits at least two inches in length and progressing entirely through the rail web.

Joint defects (bolt hole cracks and head and web separations inside the joint bar limits) at least one-half inch in length and progressing entirely through the rail web.

Defective welds (plant or field) - with centrally located transverse defects, voids or inclusions in the rail head representing approximately 10% of the cross-sectional area of the rail head; with transverse head defects not centrally located representing approximately 15% of the cross-sectional area of the rail head; and with web defects in a generally horizontal plane at a rail weld approximately two inches in length or longer with penetration more than halfway through the rail web.

1.6.1.3 Calibration. Ultrasonic inspection equipment shall be calibrated to ensure reliable interpretation of responses. The approximate smallest indication that can be consistently detected include, but are not necessarily limited to, the following simulated, "marginal" defects.

(1) A one-quarter (1/4) inch diameter hole drilled horizontally through the rail head.
(2) A bolt hole through the web.
(3) A horizontal one-half (1/2) inch long sawn crack between the head and the web.
(4) A vertical one-half (1/2) inch long sawn crack in the web (optional depending on equipment available).

1.6.2 Sounding. Sounding with a hammer is one of the best and least expensive methods of testing rail, and is a practical way to inspect elevated crane trackage or relatively short sections (1,000 feet or less) of ground level trackage, where it was impractical to perform an ultrasonic inspection or inaccessible during the ultrasonic inspection and other trackage systems where ultrasonic testing is impractical. Light tapping with a 12 - 24 ounce steel hammer about every six inches will reveal looseness between rail and anchor plate, and defects before they become serious. Similar to ultrasonic testing, all non-standard responses should be investigated and recorded for future comparison. If sounding is used, rails shall be tested for defects upon activation and at annual intervals. This interval may be extended to a 2-4 year schedule based on an engineering analysis accomplished by the activity. The engineering analysis shall be in writing and take into account rail usage, age, history, and experience in determining a frequency other than an annual.

1.6.3 Other Non-Destructive Tests. Magnetic particle, dye penetrant, and other non-destructive test methods may be advantageous in investigating potential defects indicated by other inspections. Eddy current, x-ray or other approved, non-destructive test methods brought about by state-of-the-art advances may be used to supplement ultrasonic testing or sounding based on local conditions, availability, economics, experience and engineering judgment.

1.7 MISCELLANEOUS INSPECTIONS AND TESTS. Other inspections may be used to determine the safe condition of trackage under unique or unusual circumstances or to make a detailed engineering investigation of specific, critical components of a trackage system. Prior to use, the availability, limitations and practicability of any special investigation shall be evaluated. Special inspections, such as the following, may assist in determining the condition of trackage.

1.7.1 Seismograph. Under certain conditions seismographic instruments may be beneficial in determining voids in fill material or embankments, level of water tables or location of slippage planes in the foundation below trackage systems.

1.7.2 Increment Bore. Timber trestles, piling and other wood structures should be examined for soundness when deterioration is suspected or when necessary to make an engineering analysis. In addition, this test may be required to help determine adequacy of treatment of new material.

1.7.3 Strain Gages. When the structural analysis for the anticipated maximum loading of a structure indicates certain members may be overstressed or marginal, a load test (duplicating or exceeding maximum total moment and shear experienced in-service) with stress and strain instrumentation is appropriate.

1.8 UNDERWATER INSPECTION. Underwater inspections of waterfront structures supporting crane or railroad trackage shall be conducted in accordance with guidelines contained in MO-104.2 Specialized Underwater Facilities Inspection, MO-311 Marine Biology Operational Handbook, and MO-322 Vol II Inspection of Shore Facilities. Inspections of piers, wharfs, quaywalls, and bulkheads shall include, but are not limited to: bearing or plumb piles, batter piles, pile caps, stringers, adjacent seawalls, riprap, sheet piling, abutments, and other subcomponents.

1.8.1 Frequency. Underwater and below deck inspections of support structures are required as follows:

(1) At intervals not to exceed six years. In historically polluted waters which are being radically cleaned, all wood structures should be inspected every three years. An engineering analysis of each structure should be made to determine the appropriate inspection interval.
(2) After obvious overload or structural damage
(3) After a major storm.
(4) Following a ship collision.
(5) When recommended by other investigations, evaluations, and engineering judgment based on age of the structure, material condition, deterioration rate, biofouling growth, and suspected damage or deficiencies.

1.8.2 Assistance. The NAVFAC ESC will provide technical guidance, specifications, and assistance when requested for in-house or contract underwater inspections.

1.9 MISHAP INVESTIGATION. Activities shall investigate and keep records of all trackage related accidents, incidents or minor mishaps including derailments, safety violations, personal injury, and property damage. Activities shall keep investigation records for all accidents and incidents related to trackage until data is verified during an audit review. When necessary, investigations and reporting shall be made in accordance with OPNAVINST 5102.1D, Mishap and Safety Investigation, Reporting, and Record Keeping Manual and OPNAVINST 5100.23G, Navy Safety and Occupational Health (SOH) Program Manual and reported to the Naval Safety Center. Additional guidelines for detailed investigation of trackage systems are included in NAVFAC MO-103, Change 1. Completed mishap reports shall be forwarded to NAVFAC ESC (CIFSI) within 30 days of mishap. Based on information learned from mishap reports, recommended sustainment and changed procedures to enhance mishap prevention shall be discussed at track conferences or distributed to all concerned. Investigation records shall include, but are not limited to:

(1) Date and time.
(2) Location and weather.
(3) Description of event.
(4) Type system and property involved.

(5) Type of operation and speed.
(6) Estimated cost of damage.
(7) Reported injuries.
(8) Track conditions.
(9) Factors leading to mishap.
(10) Corrective action(s) taken.
(11) Investigators

1.10 RECORDS.

1.10.1 In order to manage and administer trackage inspections, sustainment/restoration programs, and design, the following information should be available in a usable condition so that it may be referred to easily and readily. Where documents do not exist, a program with milestones for establishing missing data should be initiated to obtain data on trackage systems. Generally, missing information is obtained simultaneously with repairing or upgrading sections of trackage. It is expected that the information required in this section will be obtained routinely with minimal disturbance of operations. Activity needs and priority for production and manpower should be considered prior to scheduling any survey work. In addition, track geometry information should be obtained when any of the conditions noted in paragraphs 2.2.3, 3.2.3 and 4.2.3 exist and when spot check measurements are required to verify the visual observations discussed in paragraphs 2.1.4.3, 3.1.4.3 and 4.1.4.3. Specific requirements for maintaining records of required inspections are addressed in specific paragraphs related to those inspections.

1.10.2 TRACK CHARTS. Track charts, plans, maps or plats shall be maintained as part of the real property records. They shall be kept up to date and used for programming future work, scheduling current work, indicating abnormal conditions and recording maintenance and inspection data. Track charts can be in any format, filed to suit activity needs, and shall be usable as a working document.

1.10.3 PLAN AND PROFILE. Detailed plan and top of rail profile or grades of crane and railroad track systems shall be kept current and may be shown on the track chart or separately. Size and type of rail, switches, degree of curvature for RR trackage alignment, frogs and other rail appurtenances should be indicated on the plan. Structures and other features which control or mandate alignment or grade, and reference points for location and elevation checks should be accurately referenced.

1.10.3.1 Top of Rail Profile. A detailed top of rail profile has a very low priority except where grades approach the allowable limits. In most cases the grade may be determined using a hand level and rod. The resulting estimated profile may be considered adequate until an accurate survey is required. A long range program to accomplish profile surveys is not required provided they are conducted when related problems are investigated or when new rail is installed.

1.10.3.2 Elevated Crane Rail Systems. The profile of elevated crane trackage may be considered level and the plan may be assumed to be a straight line provided the system alignment is straight and none of the conditions listed in paragraph 4.2.3 exist. A long range program to accomplish surveys is not required; however, when detailed surveys are conducted they shall be recorded.

1.10.3.3 Rail Identification. When rail is encased in pavement or otherwise unidentifiable, the size and type of rail should be estimated based on random uncovering or activities' experience. When positive identification cannot be made, that fact should be documented on the records. When an unidentified rail is repaired or replaced, the size and type of rail should be obtained and recorded on the plan or track chart and in the historical records file.

1.10.4 CROSS SECTION. Cross sections of substructures shall be maintained, when known and available, especially the substructures under tracks around piers, drydocks, trestles, and wet areas.

1.10.5 HISTORICAL DATA. Historical data on each system shall be retained and shall include the following:

(1) Dates that the system was installed.

(2) Weight of rail, gage of track.

(3) History of sustainment, restoration, major replacement and realignment.

(4) Replacement of rail and major tie replacement.

(5) Methods of accomplishing previous work.

(6) Design information, justification and background:

(a) Maximum capacity - where designs do not exist, load limits may be established based on engineering judgments and weight tests.

(b) Engineering calculations to establish maximum loading. When available, original or updated design calculations shall be maintained. If not available, original engineered structural drawing(s) that indicates the capacity/load limit the design was based on may be used. When none of these are available, a statement describing the basis used to determine the maximum load limit should be included in the historical data.

(c) Supporting Structures. Valid structural analysis for all supporting structures based on or exceeding current maximum loading. Structural safety verification shall be on file for supporting substructures. When original or updated design calculations are not available, original engineered structural drawing(s) of the support structure that indicates the capacity/load limit the design was based on may be used. As a minimum, especially for massive structures, an engineering certification based on visual observations, historical performance, and, when necessary, basic calculations on critical components should be available.

(d) For trackage encased in pavement, an accurate as-built description, certification or pictures shall be obtained. Tie spacing including number and pattern of spikes or tie down bolt spacing shall be verified.

(7) NAVFACENGCOMHQ approval of railroad curves and turn-outs.

(8) Justification or exceptions to standards (waivers).

(9) Other pertinent information.

1.10.6 PROPOSED PROJECTS. Maintain a list of pending work including: major sustainment and restoration projects (approved, submitted and needed), minor work to be accomplished with local funding and major replacement projects which are being considered for MCON funding. Use "multi-year" renewal programs for rail or tie replacement when practical.

SECTION 4. ELEVATED CRANE TRACKAGE

4.1 INSPECTION

4.1.1 CONTINUOUS OPERATOR INSPECTION. Daily or prior to use safety checks listed in activity regulations shall be conducted. In addition, on-the-job observations shall be performed in accordance with P-307 at all times when equipment is working. Crane operations personnel (operators, riggers, etc.) shall be encouraged to observe and report track problems, deficiencies, obstructions and the "feel" of the track.

4.1.2 PREVENTIVE MAINTENANCE (PM) - PM SERVICE AND PM INSPECTION.

4.1.2.1 PM is a continuous working inspection, examination of component parts, lubrication, adjustment, and minor repair. PM service and inspection are normally conducted by the crews assigned to or operating the equipment, by the track walkers, by Maintenance Shop personnel, and/or by contract. The PM Inspections and Services are scheduled as directed by the Public Works Officer or Activity Commander. Flexibility exists in the frequency of PM inspections based on usage, climatic conditions, history, and experience; therefore, the Public Works Officer or Activity Commander shall establish PM schedules. On systems where lubrication of moving parts, adjustments to electrical or mechanical systems, tightening of loose bolts, and other minor repairs are minimal, the PM service requirements may be identified during the annual detailed inspection and PM service and repair work scheduled. When possible, deficiencies are corrected during the inspection and recorded. Uncorrected deficiencies shall be reported to the supervisor for action, inclusion in the repair work schedule, adjustment of operating speed and consideration for closure of a section of trackage. Minimum information to be provided in PM reports is detailed in paragraph 4.1.2.2. PM inspections are visual inspections which include, but are not limited to, such items as loose or missing bolts or fasteners, defective rail, settlement, condition of supporting columns and misalignment.

4.1.2.2 PM Inspection Reports. Local formats in existence may be used. As a minimum PM Inspection reports should include:

(1) Date.
(2) Sections of trackage inspected.
(3) Corrected and uncorrected deficiencies.
(4) Number of and size of broken or missing parts.
(5) Suspected misalignment or defect.
(6) Guides and instructions used for the inspection.

4.1.3 SAFETY INSPECTION. The purpose of this inspection is to identify critical and catastrophic defects affecting the safety of the track being inspected. Scheduled safety inspection of crane trackage is not required due to the rigid support structure involved. If condition(s) prevail in the crane trackage that dictate the need for a more frequent inspection (see paragraph 1.3.3), a scheduled safety inspection program may be established. If a safety inspection is required, guidance provided in paragraph 2.1.3 shall be followed.

4.1.3.1 Special Safety Inspections. The Certifying Official shall determine the requirements on providing special safety inspections for unusual occurrences such as accident, flood, fire, earthquake, hurricane, severe storm, or other occurrence that could have an adverse effect on the track structure.

4.1.4 DETAILED INSPECTION SUPPLEMENTED BY ENGINEERING EVALUATIONS. Detailed Inspections are to be conducted annually or more frequently when required by climatic conditions or other unusual circumstances. Annual inspection shall mean that sections of trackage are scheduled as part of the facilities inspection program in accordance with MO-322. Inspection for each track section shall be scheduled and accomplished during a specific month each year and routinely scheduled in a 12 month period. Annual inspection exceeding a 13 month period since the previous annual inspection on the particular track section will cause the existing certification to be default and result in the track section being non-certified for use. The annual inspection during the biennial certification year may be based on the on the crane certification date at the discretion of the Certifying Official as long as it does not exceed the track certification date by over 45 days. The track certification shall indicate the date of crane certification. Engineering evaluations shall be conducted whenever there is any doubt of physical condition. In addition, Detailed Inspection or Engineering Evaluation criteria shall be used to supplement investigations and evaluations after any derailment. Additional testing or inspection shall be conducted when the condition of any portion of the trackage system is doubtful.

4.1.4.1 Visual Inspection. Visual inspections during the detailed inspection should include PM inspection checkpoints and observations of all trackage system components including rails, rail accessories, fasteners, joints, support structures and appurtenances. Checkpoints for elevated crane trackage inspection are provided on Attachment (4-2).

4.1.4.2 Support Structures. All foundations and support structures shall be inspected for signs of settlement or failure. Buildings/support structures for elevated crane rail shall be inspected in accordance with criteria outlined in MO-322 and the following criteria. The prescribed minimum inspection frequency for buildings is two years. In addition to the biennial inspection, supporting structures for elevated cranes shall be inspected when cranes are load tested to exceed the rated capacity of the system. This inspection maybe limited to only that portion of the support system affected by the load test. Inspection of the support system of the crane for both the biennial detailed inspection and crane load test inspection may be performed by facilities planner & estimators or inspectors or crane structural inspectors, as long as they meet the minimum qualifications required by MO-322. At activities where staffing is minimal and no one meets the qualifications required by MO-322, the Certifying Official shall assign the individual with the most structural experience/knowledge to perform the inspection. Biennial support structure inspection reports shall be reviewed and random observations made of rail supports, connections, braces, and beam to column joints for indications of movement, deterioration, or stress. Broken and defective components shall be scheduled for repair or replacement. For wood, steel or concrete columns, beams, braces, girders and other structural members, indicators of settlement, misalignment or deflection shall be recorded. Deflection, movement, or settlement under routine in-service loading exceeding the limits shown in Attachment (4-1) shall be investigated and analyzed, the degree of damage documented, and the classification of hazard determined. Structural conditions leading to restricted certification of a section of trackage shall be based on a review of the structural analysis and on a condition survey conducted by qualified engineer in sufficient detail to establish the safety of the structure.

4.1.4.3 Operational Inspection/Load Test The purpose of an operational inspection is to supplement the detailed inspection and to assist in the identification of problem areas which could develop into unsafe trackage. Conditions which may be discovered include looseness, binding or vibration.

4.1.4.3.1 Frequency. Operational inspections shall be performed at intervals not to exceed two years on active trackage systems to ensure that the trackage systems will sustain the prescribed load in a safe manner. Every four years, a full load test shall be performed in accordance with paragraph 4.1.4.3.2 and as prescribed in Appendix E, NAVFAC P-307. The interim two year operational inspection shall consist of a “No load test” performed in accordance with paragraph 4.1.4.3.2 and as prescribed in Appendix E, NAVFAC P-307. Operational inspection exceeding the two year requirement will cause the existing certification to be default and result in the track section being non-certified for use. The two year requirement for operational inspection and track certification may be based on the on the crane certification date at the discretion of the Certifying Official as long as it does not exceed the track certification date by over 45 days. The track certification shall indicate the date of crane certification. Also see paragraph 1.3.1 regarding 45 day extension of certification.

4.1.4.3.2 Loads. Loads defined below should be moved over track systems slowly enough so that observations can be made. Loads for crane certification and test procedures are prescribed in Appendix E, NAVFAC P-307. “No load test” procedures are performed prior to the load test and during the two year interim operational inspection and will include operation of the crane on the track with no load on the hook and the trolley positioned adjacent to each rail for the full distance of the runway and slowly contacting the runway rail stops. “Load test” of the crane will include operation of the crane on the track with the test load on the hook and the trolley positioned adjacent to each rail for the full distance of the runway (if space is available). If multiple cranes on the runway, track need only be certified with the heaviest crane. Trackage support systems shall be inspected after completion of the crane load test in accordance with paragraph 4.1.4. Operational inspection reports shall specify the crane used to perform the operational inspection and description of what portion of track system received “Load test” versus “No load test”.

4.1.4.3.3 Observations. A Track Inspector shall conduct or supervise the operational inspection. Trackage shall be inspected during load test or while equipment is operating. Observations for looseness, binding, deflection, or vibration shall be made by sight, sound, and feel. In addition, rail joints, general alignment, rail condition, supporting structures (see paragraph 4.1.4.2), and other accessories may be observed for deficiencies during and after the load test or operational inspection. There is no requirement for physical measurements of rail or trackage systems under load; however, when practical and accessible, rail systems shall be observed for deflection. Guidelines for maximum allowable deflections as determined by visual judgment are shown on Attachment (4-1). In the event unusual movement is observed or felt, deflections appear to be larger than the guideline limits established, or the cause of deficiency cannot be immediately determined, an investigation and engineering analysis of the immediate vicinity shall be made prior to certification. Results of the investigation and engineering evaluation, not the deflection limit per se, shall determine when use of a section of trackage must be discontinued.

4.1.4.3.4 After Repair. Operational Inspection for certification following major repair or reconstruction is not a mandatory action required by this pr; however, as a minimum a visual observation of trackage under routine traffic loading during or after repair shall be performed to ensure proper movement. In addition, it is recommended that, when practical, in-house work orders and contract documents require that elevated crane trackage shall have a crane successfully operate over the system prior to acceptance.

4.1.4.4 Measurements. The Detailed Inspection shall include visual observations and spot check measurements of grade, track gage, cross section elevation, horizontal alignment, vertical mismatch, supports and other features to insure that criteria in this instruction are met. Instrument surveys may be requested by the certifying official or his representative to verify visual observations or spot check measurements, establish new alignment, investigate problem areas and determine deviation from the established standards.

4.1.4.5 Detailed Inspection Documentation

All inspections performed under paragraph 4.1.4 shall be properly documented. Inspection records must specify track inspected, date of inspection, location and nature of deviation from requirements and remedial action taken. Detailed inspection documentation should address all marginal, critical and catastrophic deficiencies existing in the track system at the time of inspection. In addition to detailing defects detected during the annual visual inspection, outstanding defects detected during safety inspections, operational inspections, non-destructive test inspection and other inspections and engineering investigations should be included. Deficiencies not exceeding marginal criteria are recorded, as necessary. As a minimum, the inspection records shall be retained for at least two years after the inspection covered by the report. Inspections may be documented on either Attachment (4-2) or Attachment (3-3). Instructions for completion of Attachment (3-3) and a sample filled in inspection report are provided in Appendix B of UFC 4-860-3.

4.1.5 NON-DESTRUCTIVE TESTING (NDT).

4.1.5.1 Frequency: Routinely, rail shall be tested by hammer sounding in accordance with paragraph 1.6.2. Generally ultrasonic testing of elevated crane rails is not required; however, elevated crane rails may be ultrasonically tested at the discretion of the certifying official in accordance with paragraph 1.6.1. If sounding is used, all active elevated crane rails shall be tested for defects upon activation and at annual intervals or at the interval determined by an engineering analysis as discussed in paragraph 1.6.2. If ultrasonic inspection is used, rails shall be tested for defects upon activation and at five year intervals, unless maintenance problems or visual inspection dictate a necessity for more frequent testing. The term "upon activation" refers to sections of trackage which have been inactivated or not used and that have not had a non-destructive test within the frequency for each procedure stated in paragraph 1.6. All trackage that has not been non-destructively tested within the appropriate time frame from the previous NDT shall have a restricted certification or may be non-certified. Non-destructive testing of relay rail or used rail may be deferred until the next regularly scheduled interval, at the discretion of the Certifying Official, however any such deferral should be based on an engineering evaluation that considers age, expected use, and experience. During the interim period, the rail may be given full certification based on other tests, observations, and inspections required by this instruction. Criteria for unacceptable rails are included in Attachment (4-1). Appendix C, UFC 4-860-03, provides a brief description and illustration of common rail defects. New rail and accessories shall be accepted according to the latest government specifications or standard industry practice. The NDT results shall be used to establish a base line for future inspection and to identify areas requiring observation.

4.1.5.2. Test Results. Rail inspection records must specify the date of inspection, method of testing (ultrasonic or sounding), the location and nature of any internal rail defect found, and the remedial action taken and the date thereof. Rail inspection records shall be retained until after the next rail inspection is performed or for one year after remedial action is taken, whichever is longer. All discontinuities shall be reported; the nature and size of defect estimated, and responses compared with standards or past test results. Rejection or degree-of-hazard of all potential defects shall be based on assessment of ultrasonic inspection results, visual inspection, experience, engineering judgment, the criteria shown in Attachment (4-1), and the FRA Track Safety Standards.

4.2 STANDARDS

4.2.0 The FRA Track Safety Standards Summary of Inspection Criteria, Attachments (4-1), and this section provide descriptions of tolerances and defects for guidance in deficiency classification. Deviation from the standards in the FRA Track Safety Standards or in this section may require immediate corrective action to provide for safe operations over the trackage involved. In addition, in accordance with paragraph 213.1 of the FRA Safety Standards, the requirements prescribed in the FRA Track Safety Standards and in Attachment (4-1) apply to specific track conditions existing in isolation. Therefore, a combination of track conditions, none of which individually amounts to a deviation from these requirements, may require remedial action to provide for safe operations over that track. In general, on heavily used sections of trackage, work planning should start when a deficiency on a section of trackage exceeds one-half (1/2) of the allowable deficiency so that repairs can be accomplished before deficiencies exceed the allowable standards for restricted certification. Selection, installation, inspection and maintenance of trackage systems shall be in accordance with documents referenced herein, except where criteria in this instruction provides more stringent or restrictive criteria. The summary of inspection criteria and defect classifications shown in Attachments (4-1) are guidelines establishing minimum standards allowed based on normal or average conditions.

4.2.1 TRACKAGE. The term "trackage" includes rails, rail accessories, support structures, stops, signs, and markings. Operating speeds for cranes shall be initiated and promulgated by Activity Commanders to meet local safety requirements. Categories may be assigned by type or limiting size of equipment utilizing the trackage system.

4.2.2 RAIL. Standards for rail type, acceptable defects and replacement are discussed in this section and in paragraph 213.113 of the FRA Track Safety Standard. The identification and terminology of different parts of a typical rail are shown in Appendix (C), UFC 4-860-03.

4.2.2.1 Rail Type and Size. In cases of individual rail replacement, where the existing rail does not meet the standard criteria listed herein and where the remaining track is performing satisfactorily, the same size rail may be installed. Rails must be connected at the joints so that the rails will act as a continuous girder with uniform surface and alignment. The section of rail to be used is that which has been recommended by the crane manufacturer or the equivalent to the existing rail. Rail sections shall accommodate all crane wheels.

4.2.2.2 Rail Defects. The basic rule of thumb or general guideline for determining the acceptability of a defective rail for continuing use at U.S. naval activities is one-quarter (1/4) inch of alignment variation or movement. All irregularities in top or side rail wear, differences in elevation at breaks or joints, deflections, and movement exceeding 1/4 inch should be investigated. Common rail defects are illustrated and described in Appendix C, NAVFAC UFC 4-860-03, and categorized according to operational hazard or risk in Attachment (4-1). Maintenance and safety standards for rail defects, as well as remedial action, is provided in Chapter 7, UFC 4-860-03.

4.2.2.3 Replacement. Defective rails shall be repaired or replaced according, as necessary to meet certification criteria, or as required by the FRA Track Safety Standards.

4.2.2.3.1 Jointed Rail. Remedial action for defective rail shall be in accordance with Chapter 7 and Table 7-2 of UFC 4-860-03. The minimum "rail length", when installing new rail or repairing/replacing existing rail, is ten (10) feet. The existence of a short piece of rail (less than 10 feet) is not considered a defect. The existing rail should not be shorter than that necessary to allow for proper application of joint bars to adjoining rails on both ends and allow for proper alignment of rail. The condition of the track or defect in the rail would constitute a defect. There may be some instances where it may be economical to reduce the existing rail length; for example: replacing one rail length with two lengths of an old, standard rail before the entire section is replaced. This may be done provided the minimum length of ten (10) feet is maintained, and maximum lengths of rail are used when the section is upgraded.

4.2.2.3.2 Welded Rail. In continuous welded rail, the standard minimum length of ten (l0) feet shall be maintained between welds or joints. This length is required to ensure proper alignment of rails prior to welding. Existing shorter rail lengths between welds will be maintained as is. The thermite welding process per NAVFACENGCOM specification UFGS-34 11 19.00 or a welding procedure approved by NAVFACENGCOMHQ should be used. Proper maintenance practice is to crop (remove) the ends of rail with bolt holes prior to welding joints. Existing welded joints with bolt holes for joint bars in either piece of rail are considered no defect unless the weld or bolt holes contain critical defects. Existing rail holes, such as old gage rod holes, may be maintained as is, provided there are no other critical defects in the immediate area.

4.2.3 TRACK GEOMETRY. Horizontal alignment, vertical alignment (grade or profile), cross section elevation and gage shall be investigated when any of the following conditions exist:

(1) There are indications of abnormal wear on the rail heads or on wheel flanges.
(2) New rails are being installed or any portion of a rail is realigned.
(3) Operating crane binds on trackage, has difficulty in starting or has trouble with movement.
(4) When a potential deficiency of trackage can be observed, heard or felt.
(5) There are indications of substructure settlement, failure or other structural changes.
(6) Visual observations indicate that the acceptable limits may exceed those shown in Attachment (4-1).
(7) Tests, inspection, experience or engineering judgment indicate operation or rail alignment problems.
(8) Cranes roll after stopping.

Minimum safety standards provided in Attachment (4-1) in association with tolerances provided for construction/replacement of new crane rail in Crane Manufactures Association of America (CMAA) Specification #70 "Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes" shall be used to assess track geometry.

4.2.3.1 Installation and Realignment. Existing systems, not conforming to grade standards, may be maintained as is, provided a record is on file describing each deviation from the standard and necessary operating restrictions are imposed. Restrictions shall be tailored to each specific situation and may include such items as maximum speed, use of auxiliary couplers and maximum car/engine combination. When major replacements are necessary, the new work shall comply with the standards of the CMAA Specification #70 "Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes".

4.2.3.2 Horizontal Alignment. Maximum out of line limits for elevated crane trackage shall be according to those shown in Attachment (4-1). Alignment of elevated crane trackage including stops shall be investigated and corrections made when any of the conditions listed in paragraph 4.2.3 exist.

4.2.3.3 Grade. Profile grades shown on Attachment (4-1) are the maximum allowable, except as noted below. The rail should be kept near level grade. The rail gradient must be kept below the slope that will cause the crane to roll freely and present problems in starting or stopping the crane.

4.2.3.4 Cross-Section Elevation. Vertical differences between rails shall be within the limits shown in Attachment (4-1). The cross-sectional difference in elevation of rails shall not exceed the limits established by the activity based on engineering judgment for each specific trackage system or the tolerance recommended by the manufacturer when known. Cross-sectional elevation differences should be checked when the conditions described in paragraph 4.2.3 exist.

4.2.3.5 Span. Span for two rail elevated crane trackage is measured center to center of railheads. The span of trackage shall be held within the tolerances specified by the crane manufacturer or as computed from the existing crane wheel spacing. Span of elevated crane trackage only needs to be measured when circumstances listed in paragraph 4.2.3 are not caused by other problems.

4.2.4 MISCELLANEOUS. Classification of defects listed in this section shall be made based on evaluation by the Activity and appropriate action shall be taken.

4.2.4.1 Joint Bars and Other Accessories. Cracked, broken, loose or otherwise defective accessories that do not permit excessive rail movement may be considered as no defect and repaired according to normal work schedules.

4.2.4.2 Safety Items. Safety features apply to all trackage systems and may also be included in the crane, building, or other inspection reports. There shall be no missing, loose or broken components, bad welds, accumulation of debris, heavy corrosion or severe deterioration of the following trackage appurtenances:

(1) Ladders, Platforms and Hand Rails.
(2) Rail Stops or Bumpers.
(3) Warning signs.
(4) Any other features that could cause a mishap.

4.2.4.3 Bolts. Missing, broken, deteriorated or worn bolts which permit movement of rails may be considered a marginal defect, provided that the criteria in paragraphs 213.115 and 213.121 of the FRA Track Safety Standards are complied with. Track bolts should be oiled when installed and each time they are tightened. The recommended frequency for bolt tightening is once every two years after the three month tightening for elevated cranes. Tightening of loose bolts should be an ongoing task. Loosening of bolts is somewhat directly related to traffic and loading and may also be caused by defects; therefore, a more frequent program for bolt tightening and PM based on usage and experience may be required by the Certifying Official. It is conceivable that where there is a good PM and inspection program, annual tightening of all bolts may be unnecessary. Tightening of bolts will be accomplished, as required, based on condition noted during the annual detailed inspection

4.2.4.4 Housekeeping. Keep trackage systems clear of obstructions that could cause mishap. Accumulations of debris, dirt, grease, paint, etc., shall be removed.

4.2.4.5 Clearances. Impaired clearances shall be recorded and corrective actions taken to insure safety when the minimum clearances (vertical clearance of three inches and horizontal clearance of two inches between the crane and any obstructions) required by Occupational Safety and Health Administration (OSHA) Standard 29 CFR 1910.179 are violated.

4.2.5 SUBSTRUCTURE. Foundation deficiencies which upon failure could cause dropping, shifting, and movement shall be considered critical or catastrophic.

SUMMARY OF IN-SERVICE
ELEVATED CRANE TRACKAGE INSPECTION CRITERIA

TRACK SAFETY STANDARDS	CRITICAL DEFECTS	INSTRUCTION REFERENCE
<u>GENERAL</u>	See Note 1	1.0 and 4.0
OPERATIONAL TEST DEFLECTION	Over 1/4 in. See Note 2	4.1.4.2 and 4.1.4.3
<u>TRACK GEOMETRY</u>	See Note 3	
ALIGNMENT: Tangent, Mid Offset per 62 ft.	Over 1/2 in.	4.2.3.2
Profile, Grade	Over 1%	4.2.3.3
TRACKAGE SURFACE: Profile @ Mid-ordinate of 62' chord, Cross level deviation, and Cross level difference in 62'	Over 1". See Note 3	4.2.3.3 4.2.3.4
<u>TRACK STRUCTURES</u>		
SUPPORT STRUCTURE	Deformation, Misalignment or movement exceeding 1/2 in. See Notes 2 and 4	4.1.4.2
RAIL FASTENINGS: Hold Down Fastenings	The distance between non-defective fastening on either side of the rail is more than 48 in.	
DEFECTIVE RAILS Transverse fissure Compound fissure	More than 20% of railhead cross section weakened by defect. See Note 5	4.2.2.2 and Appendix C, UFC 4-860-03
Detail fracture Engine Burn fracture Ordinary Break	Breakout in railhead with over 1/4 in. movement.	

SUMMARY OF IN-SERVICE
ELEVATED CRANE TRACKAGE INSPECTION CRITERIA

TRACK SAFETY STANDARDS	CRITICAL DEFECTS	INSTRUCTION REFERENCE
DEFECTIVE RAILS (Cont'd)		
Horizontal Split Head	More than 4". See Note 5	
Vertical Split Head		
Split Web, Piped Rail		
Head Web Separation		
Bolt Hole Cracks	More than 1-1/2 in. See Note 5	
Broken Base	More than 6 in.	
DAMAGED RAIL:		
Shelling, Head Checks, Engine Burn, Mill Defect, Flaking-slivered, Corrugated-corroded	Depth over 3/8 in.	4.2.2.2 and Appendix C, UFC 4-860-03
Flowed Rail	Roll exceeding 5/16 in.	
WORN RAIL:		
Rail section (pounds per yd)		4.2.2.1 and 4.2.2.2
Web-Base Thickness Reduction:		
Up to 70	Over 1/8 in.	
Over 70	Over 1/4 in.	
Vertical Head Wear:		
Up to 70	Over 1/4 in.	
71 to 134	Over 3/8 in.	
135 and larger	Over 1/2 in.	
Horizontal Side Wear:		
30 to 50	Over 3/8 in.	
60 to 70	Over 1/2 in.	
71 to 134	Over 5/8 in.	
135 and larger	Over 3/4 in.	
RAIL END MISMATCH:		
On tread or running surface	Over 1/4 in.	
On side of railhead	Over 3/16 in.	
RAIL JOINTS:		4.2.4.1
Gap Rail Joints	Over 1/2 inch, See Note 6	
Gap Expansion Joints	Over 1 inch, See Note 6	

SUMMARY OF IN-SERVICE
ELEVATED CRANE TRACKAGE INSPECTION CRITERIA

TRACK SAFETY STANDARDS	CRITICAL DEFECTS	INSTRUCTION REFERENCE
RAIL JOINTS: (cont'd)		4.2.4.1
Bolt Holes (applies to any torch cut hole in rail)	Torchcut or Burned	
Joint Bars	Broken between the middle two bolt holes Torch cut or modified	
Rail Joint Bolts	Less than two/rail/joint	

NOTE 1. Criteria is shown for elevated crane rail systems that are rigidly supported, such as rails mounted on steel or concrete beams. If other types of support systems are involved, the severity of defects shall be determined based on local conditions. Specific criteria for evaluating the consequences of defects outside the range designated as critical are not available. The activity shall evaluate the severity of each such defect and shall classify the degree-of-hazard based on engineering judgment and experience.

NOTE 2. Guidelines are for visual observation only. Deviations may be estimated and measurement is not required unless it is necessary for supplemental investigation. Deflection for rail systems on flexible supports, such as wood should not exceed 3/4 inch.

NOTE 3. Tolerances provided in Crane Manufactures Association of America (CMAA) Specification #70 "Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes" for new construction/replacement and minimum safety standards provided herein shall be used to assess geometry condition.

NOTE 4. Building supports, pile foundations, caps, beams, etc. shall be investigated when movement, sag, deformation, or other alignment problems of component members exceeds one-half (1/2) inch. The final classification of defects shall be based on engineering evaluation.

NOTE 5. Defects smaller than those noted may be classified as marginal provided the defect is inspected six months after discovery and annually thereafter to ensure that the defect is not progressing. Defects accumulating three feet or more in any 10 feet are considered catastrophic.

NOTE 6. Joint gaps over 1/4 inch and less than 1/2 inch may be classified as no defect provided the joint is tight with no movement. Joint gaps between 1/2 inch and the defect limit indicated shall be classified as marginal or a more serious classification if the joint is loose or if there are other defects present. Gaps measured at defect limits when the air temperature is over 30 degrees C (86 degrees F) shall be remeasured when the air temperature drops below 0 degrees C (32 degrees F).

INSPECTION/CERTIFICATION DOCUMENT FOR ELEVATED CRANE TRACKAGE

Building/Crane No:	Type:	Manufacturer:	Capacity:

Detailed Visual Inspection	Operational (Check appropriate box)			Current NDT	
Date:	Date:	"No Load"	"Load"	Date:	Type:

Item No.	Items to be Inspected	Condition			
		Satisfactory	Restricted	Unsatisfactory	Not Applicable
1	Rails				
2	Rail Joints				
3	Rail Bolts				
4	J-Bolts, Clips, Tie Plates, Misc. Fasteners				
5	Gage				
6	Rail Alignment				
7	Cross Section				
8	Rail Stops				
9	Clearances				
10	Signs and Appurtenances				
11	Support Structure				

Remarks (Item No.): Note any deficiencies and level (Marginal, Critical or Catastrophic) or "No defects noted."

This crane trackage support structure has been inspected in accordance with NAVFACINST 11230.1F, Paragraph 4.1.4.2. after 4 year load test and is ☐ Satisfactory ☐ Unsatisfactory (see Remarks)

Structural Inspector (signature)	Date:

This section of trackage covered by the inspection report above meets the applicable standards and is certified as follows:

☐ FULL CERTIFICATION ☐ RESTRICTED CERTIFICATION ☐ NON-CERTIFICATION

		Track Inspector (signature)	Date:
		Certifying Official (signature)	Date:

Attachment (4-2)

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

	Maintenance Standard		*Safety Standard*	
	Maximum Defect Category for Track Category		*Restricted (10mph) Operation*	*Close to Traffic*
Defect Type	***A***	***B***		
Bolt hole crack	RI	0.75”	GT 1.5”	BO
Bolt Hole – torch cut [3]	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 [1]	20%	20%	GT 20%	GT 40%
Fissure-compound [1]	RI	RI	GT 20%	GT 40%
Fissure-Transverse [1]	RI	RI	GT 20%	GT 40%
Fissure-detail [1]	RI	RI	GT 20%	GT 40%
Fracture-engine burn [1]	RI	RI	GT 20%	GT 40%
Head/web separation	RI	2”	GT 4”	BO [2]
Piped rail	RI	2”	GT 4”	BO [2]
Horizontal split head	RI	2”	GT 4”	BO [2]
Vertical split head	RI	2”	GT 4”	BO [2]
Split web	RI	2”	GT 4”	BO [2]
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

	Remedial Actions		
Defect Type	Replace Entire Defective Rail	Crop Defect (2, 3)	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 (3)
Complete break - rough or angled	Preferred	Allowed	Not Allowed (4)
Crushed head	Preferred	Allowed	Not Allowed (4)
Defective weld	---	Allowed	Preferred
End Batter	Allowed	Allowed	---
Fissure-compound (5)	Preferred	Allowed	Allowed (3)
Fissure-transverse (5)	Preferred	Allowed	Allowed (3)
Fracture-engine burn (5)	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
			Not Allowed
Torch cut bolt hole	Allowed	Allowed	
Wear	REQUIRED (6)	---	---
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

inches either side of the defect.
3. Not allowed if results in a rail length of less than 13 feet (see "Short Rail" below).
4. May be allowed as an emergency measure until defect is removed, provided train operations are speed-restricted.
5. If broken through or cracked out, rules for rough or angled complete break apply.
6. Rail with wear on only one side may be transposed if the horizontal wear does not exceed 0.375 inch.
7. Short lengths of flow may be ground off.

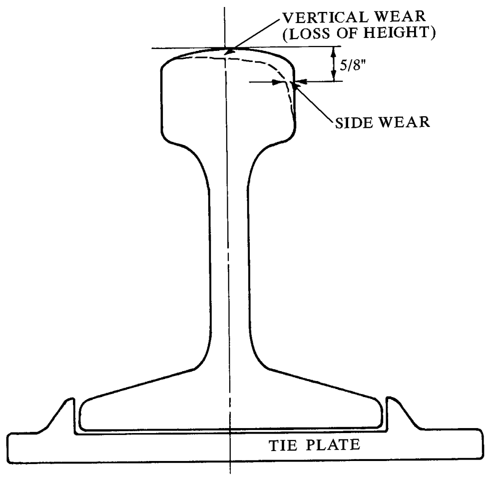


Figure 7-1. Rail Wear Measurement

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.

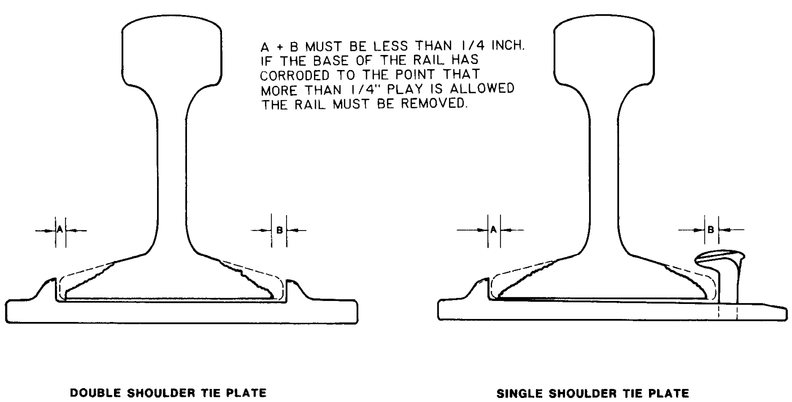


Figure 7-2. Rail Base Corrosion Measurement

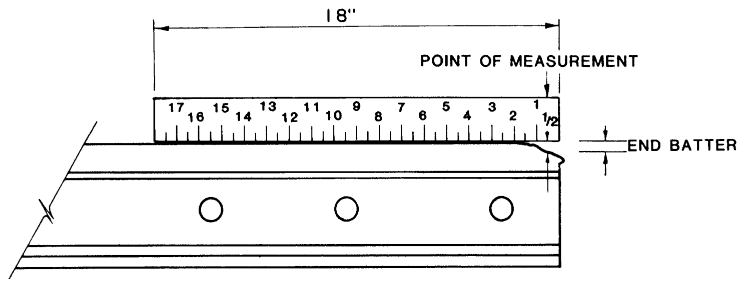


Figure 7-3. End Batter Measurement

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.

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.

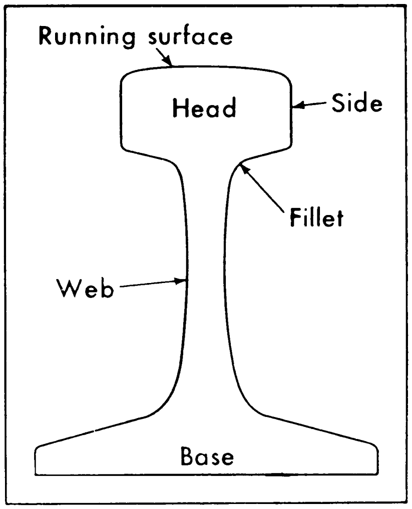


Figure C-1. Rail Nomenclature

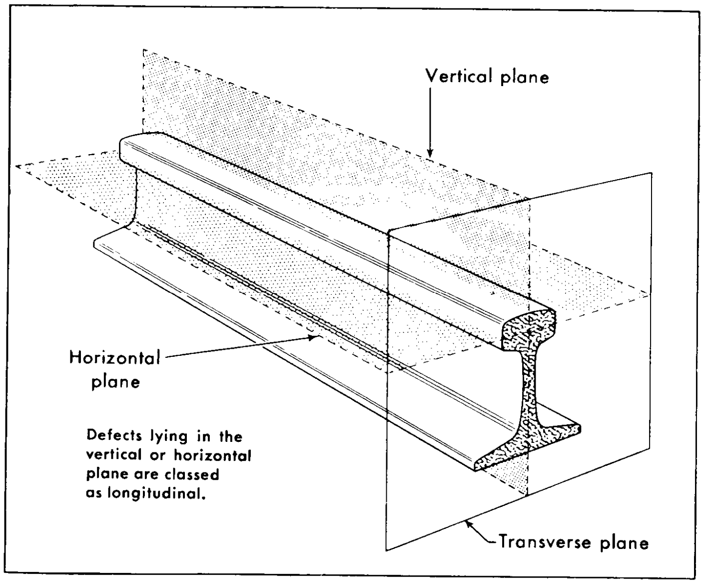


Figure C-2. Relative Positions of Planes Through a Rail

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. **S*hatter 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).

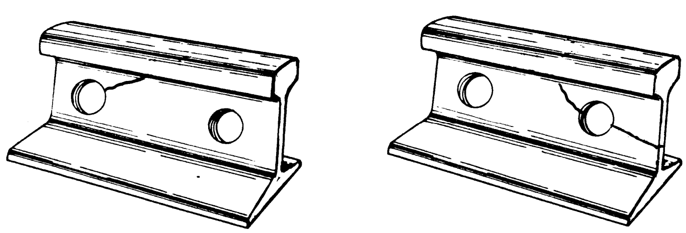


Figure C-3. General Appearance of Bolt Hole Cracks

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.

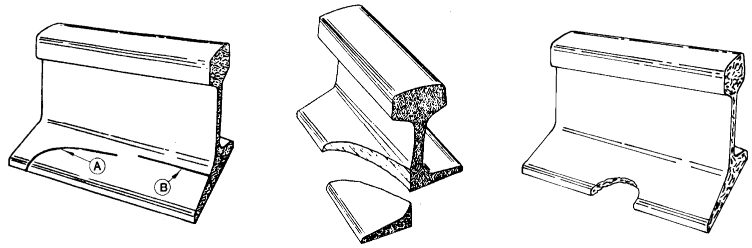


Figure C-4. General Appearance of Broken Base

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).

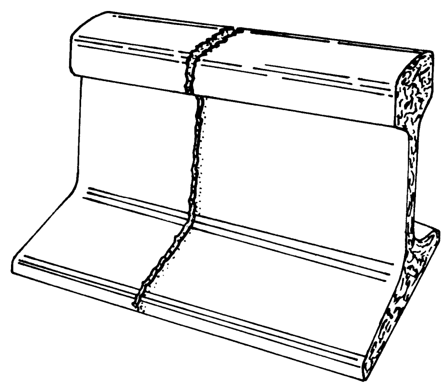


Figure C-5. General Appearance of Broken Rail

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).

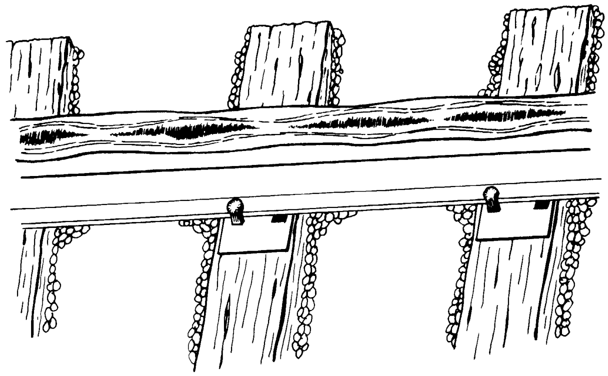


Figure C-6. General Appearance of Corrugation

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).

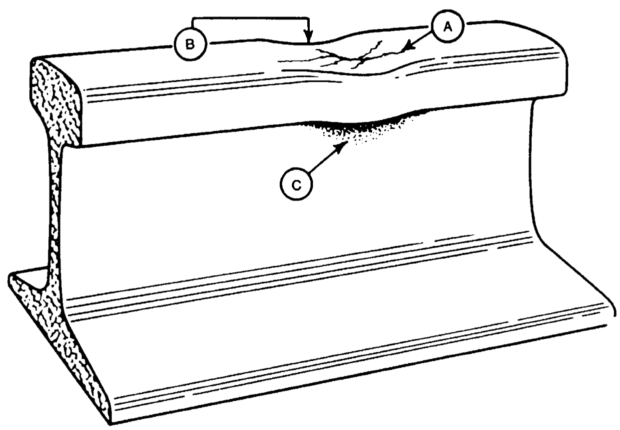


Figure C-7. General Appearance of Crushed Head

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, entrainment 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).

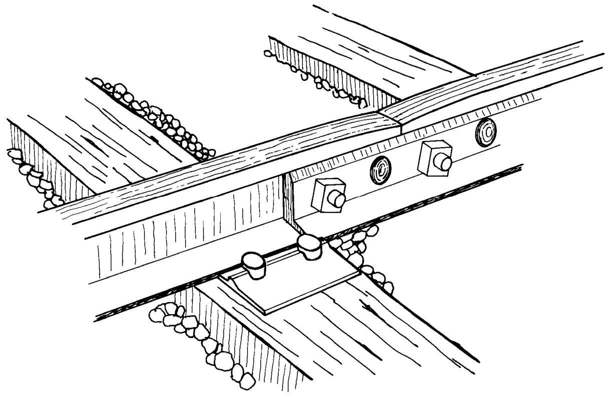


Figure C-8. Rail End Batter

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).

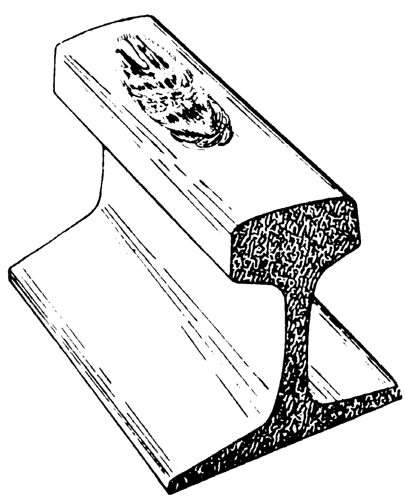


Figure C-9. Typical Appearance of Engine Burn

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.)

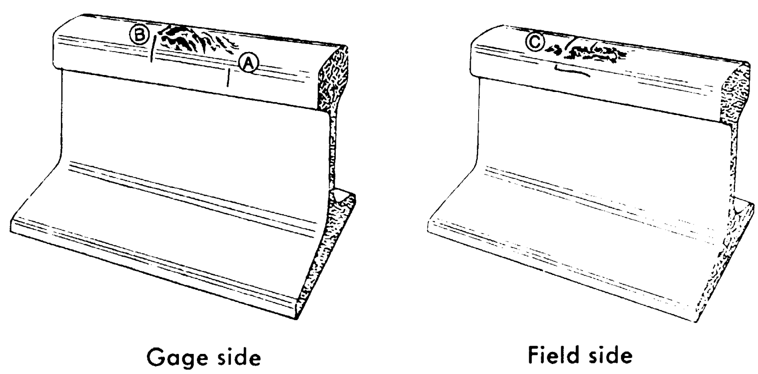


Figure C-10. General Appearance of Engine Burn Fracture

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.)

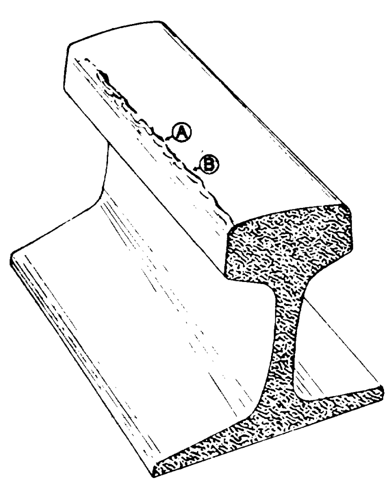


Figure C-11. General Appearance of Flaking

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.)

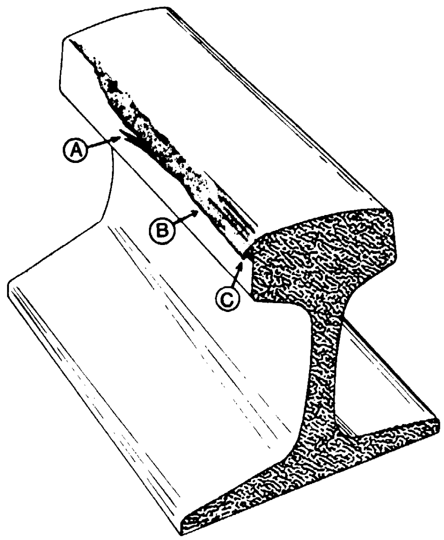


Figure C-12. General Appearance of Flow

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).

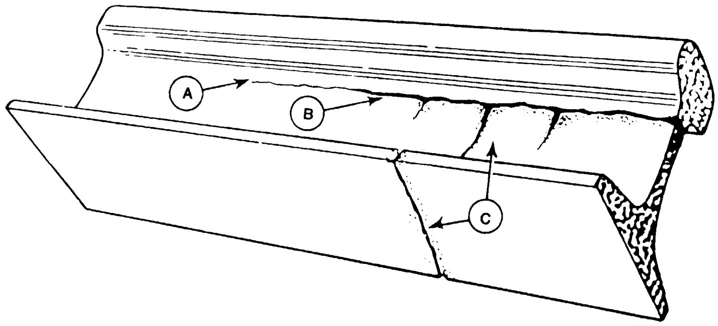


Figure C-13. General Appearance of Head/Web Separation

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).

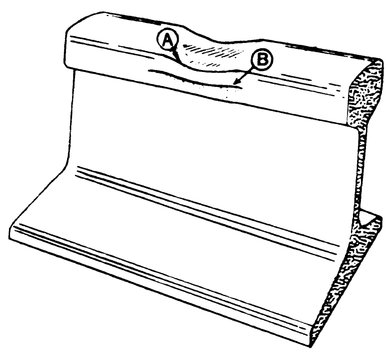


Figure C-14. General Appearance of Horizontal Split Head

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).

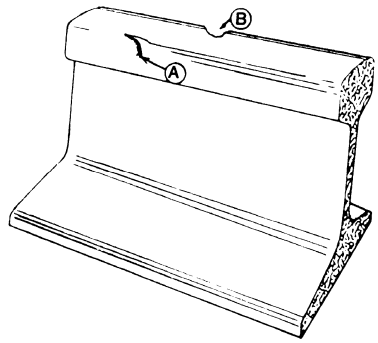


Figure C-15. General Appearance of Mill Defects

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).

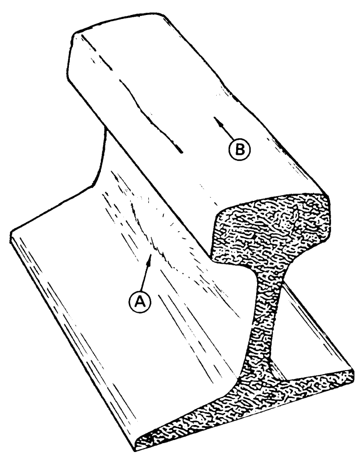


Figure C-16. General Appearance of Piped Rail

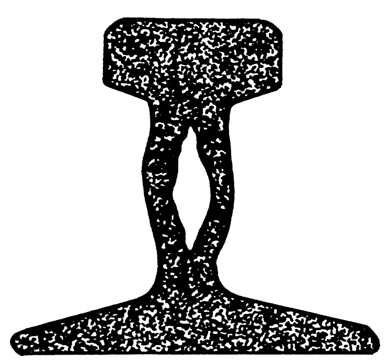


Figure C-17. Cross-sectional View of Piped Rail

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).

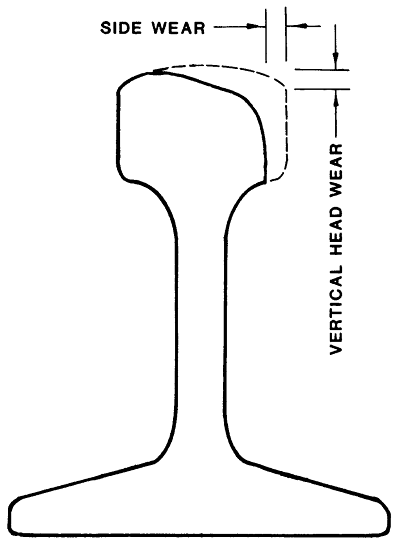


Figure C-18. General Appearance of Vertical Head and Side Wear

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).

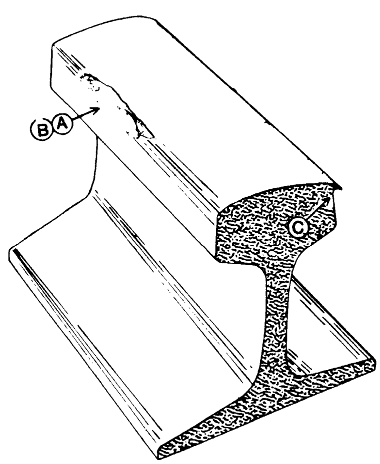


Figure C-19. General Appearance of Shelling

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).

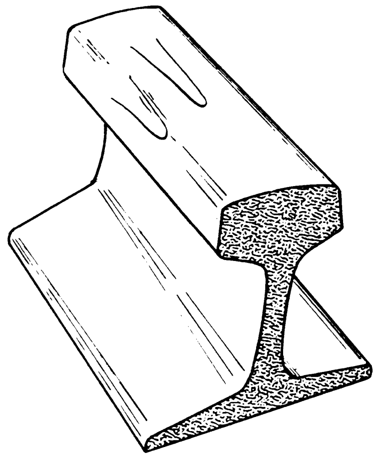


Figure C-20. General Appearance of Slivers

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).

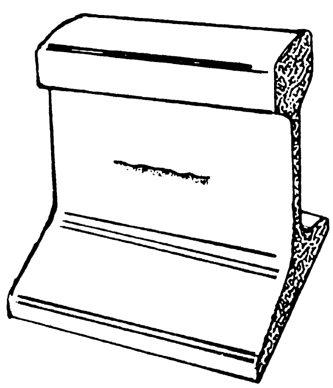


Figure C-21. General Appearance of Split Web

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).

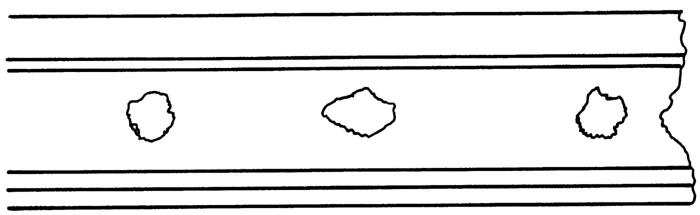


Figure C-22. General Appearance of Torch-Cut Rail

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).

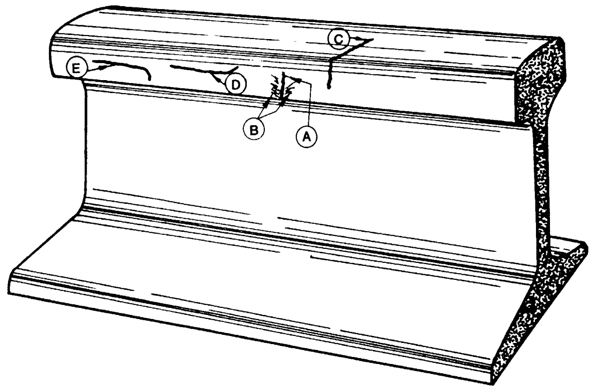


Figure C-23. General Appearance of Transverse Defects

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).

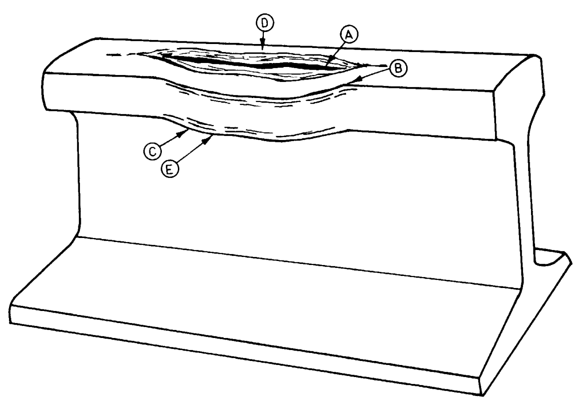
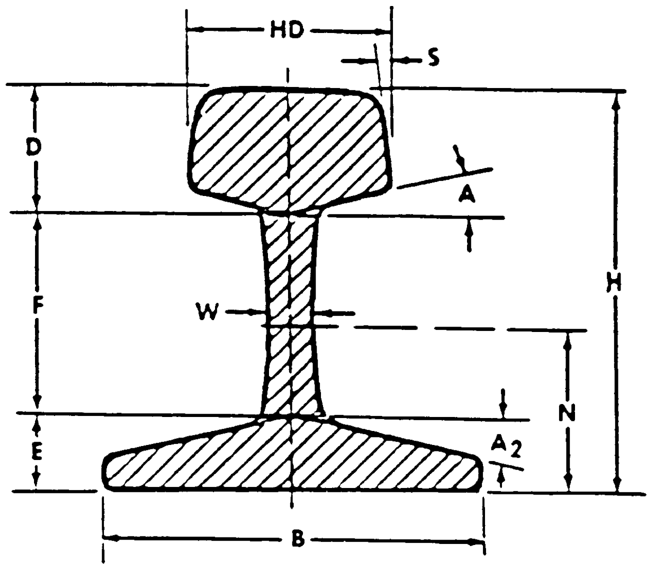


Figure C-24. General Appearance of Vertical Split Head

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

		Manufacturer's Brand							Rail Dimensions (Inches)										
Section	Weight Per yard	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_2)	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)

		Manufacturer's Brand							Rail Dimensions (Inches)									
Section	Weight Per yard	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 (A₂)	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	10130	--	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	75/128	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)

		Manufacturer's Brand							Rail Dimensions (Inches)									
Section	Weight Per yard	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 (A2)	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	1-23/64	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)**

5.4.3 CONTINUOUS WELDED RAIL (CWR) (1988)

a. To provide effective anchoring to resist temperature induced stresses and longitudinal stresses due to train movement in CWR territory, every other tie should be box anchored throughout the full length of the welded rail string. Whenever any discontinuity in the CWR is encountered such as rail joints, turnouts, grade crossings, and railroad crossings, all ties should be box anchored for 200 feet in both directions. On those railroads that consider a field weld without safety straps to be a discontinuity, all such ties should be similarly box anchored for 200 feet in each direction.

b. Where CWR joins conventional jointed rail, all ties except those supporting the rail joint should be box anchored for 200 feet in each direction.

c. On curves, additional rail anchors may be required.

5.4.4 TURNOUTS (1988)

a. Every tie in each track of the turnout should be box anchored wherever possible, i.e. when anchors are applied to one rail, anchors are also required on the opposite rail of the same track. Rail anchors should be applied on the gage side of the rail except where insufficient clearance restricts the use of the anchor or application tool, in which case anchors may be applied from the field side of the rail where clearance permits.

b. In addition to the mainline, the diverging track should be anchored a sufficient distance to prevent rail movement from disturbing the switch point and frog.

c. In jointed track territory on the approach ahead of the head block, all cross ties should be box anchored for a minimum distance of 78 feet. On each track beyond the turnout, all cross ties should be box anchored for 78 feet.

d. In CWR territory, every cross tie should be box anchored for 200 feet ahead of the head block and 200 feet behind the frog on each welded track on each side of the turnout. Turnouts in other than mainline track should be anchored as required.

5.4.5 OPEN DECK BRIDGES (1988)

NOTE: See Chapter 15, Steel Structures, Part 8, Miscellaneous, Section 8.3, Anchorage of Decks and Rails on Steel Bridges, for anchoring rails on steel bridges.

When open deck bridges are not equipped with rail anchors both approaches should have additional anchoring. For jointed track, the number of rail anchors that would normally be applied to the track over the length of the bridge should be used to box anchor additional ties from both ends of the bridge. In CWR territory, every tie should be box anchored for a distance of 200 feet on each approach to open deck bridges. Rail anchors may be placed on open deck bridges only with the special permission of the Chief Engineer.

SECTION 5.5 TRACK BOLT TENSION PRACTICE (1988)

5.5.1 PURPOSE (1988)

The purposes of providing tension in track bolts are:

a. To draw the joint bars into place when they are first applied. An initial bolt tension when bars are first applied of from 20,000 to 30,000 lb per bolt is of value in overcoming the roughness of the fishing surfaces, thereby providing a proper seating of the bars.

b. To hold the joint bars in place throughout actual service conditions and to produce an integral action of the two bars of a joint in resisting bending in the vertical or horizontal planes. A minimum bolt tension of 10,000 lb per bolt for the long-toe joint bar, or 5,000 lb per bolt for the short-toe joint bar is sufficient to accomplish these purposes.

c. To provide sufficient reserve tension to carry over the period between tightenings. This requires that the applied tension shall be high enough to withstand the loss in bolt tension under traffic for the period between tightenings and still be sufficient at the end of the period to insure proper action of the joint bars. Bolt tension loss is relatively rapid immediately following the application of joint bars until the mill scale has disappeared from the fishing surfaces, and averages from 5,000 to 10,000 lb per bolt the first month. After the second month, the rate of bolt tension loss averages from 500 to 1,000 lb per bolt per month. Loss of tension is not uniform at each joint and some bolts may lose twice the above amounts; others lose scarcely any. Bolt tension loss is principally due to a decrease in distance between the two bars of a joint as a result of fishing surface wear. This decrease varies from joint to joint and averages approximately 0.015 inch per year. Traffic density has little effect on this decrease except that on very heavy traffic density lines the decrease at the mid-length of the bars may average 0.025 inch to 0.030 inch per year. The use of spring washers will help to maintain bolt tension as this inward movement of the joint bars occurs.

d. To provide necessary joint bar support without unduly restricting slippage of the rail ends with temperature change. The slippage resistance of a rail end within its joint bars is affected by the amount of bolt tension. Thus in general, high bolt tension produces high joint bar restraint.

5.5.2 PRACTICES (1988)

The following practices are recommended to accomplish these purposes:

a. The applied bolt tension should be within a range of 20,000 to 30,000 lb per bolt for the initial tightening and within a range of 15,000 to 25,000 lb for subsequent tightenings.

b. Track bolts should be retightened as required, preferably from 1 to 3 months after the joint bars are applied, and at intervals of 1 year thereafter. More frequent tightening is unnecessary and therefore uneconomical. Less frequent tightening requires too high an applied bolt tension to carry over the longer period.

c. Corrosion resistant lubricant should be applied to bolt threads prior to the application of the nuts. This will reduce the variation in thread friction and promote the uniformity of tension obtained.

SECTION 5.6 GAGE[1] (1980)

5.6.1 GENERAL (1988)

a. The gage tool shall indicate standard track gage.

b. The rail shall be held to gage while line spikes are being driven.

[1] References, Vol. 5, 1904, pp. 533, 563; Vol. 6, 1905, pp. 749, 757, 759; Vol. 7, 1906, pp. 654, 662; Vol. 10, 1909, part 1, pp. 398, 467; Vol. 11, 1910, part 2, pp. 934, 944; Vol. 12, 1911, part 1, pp. 402, 465; Vol. 16, 1915, pp. 732, 1145; Vol. 37, 1936, pp. 467, 1017; Vol. 41, 1940, pp. 556, 867; Vol. 53, 1952, pp. 770, 1123; Vol. 54, 1953, pp. 972, 1398, Vol. 63, 1962, pp. 489, 753.

Bolt Tightening

AREMA Section 5-5-19
MO-103 Paragraph 3-25.2.2
UFC   6-4.d

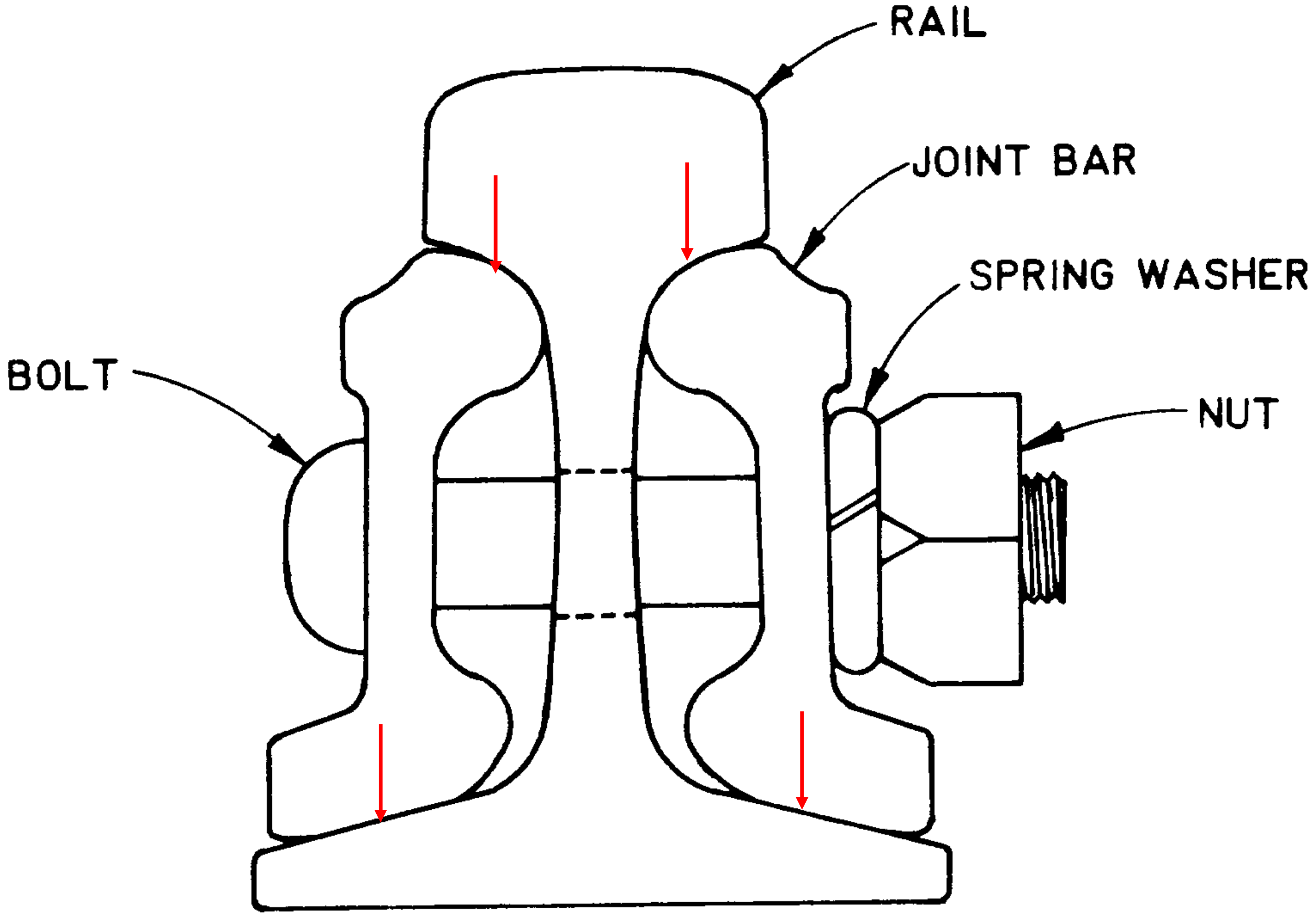
<u>Initial Bolt Tension</u>

20,000 - 30,000 pounds per bolt

Overcome roughness of fishing surfaces to provide proper seating of bars

<u>Subsequent Tightening</u>

15,000 - 25,000 pounds per bolt



FISHING SURFACES

PURPOSE OF TRACK BOLT TENSION

1. Draw joint bars into place
2. Hold joint bars in place throughout
   service conditions - 5,000 lbs /bolt
3. Integral action of two joint bars
   to resist bending - 5,000 lbs/bolt
4. Provide sufficient reserve tension
   to carry over between tightening
5. Provide necessary joint bar support
   without restricting slippage of rail
   ends with temperature change
   High bolt tension - Higher restriction

Flatten Spring Washer

Spring Washers for 7/8 and 1 inch Bolts

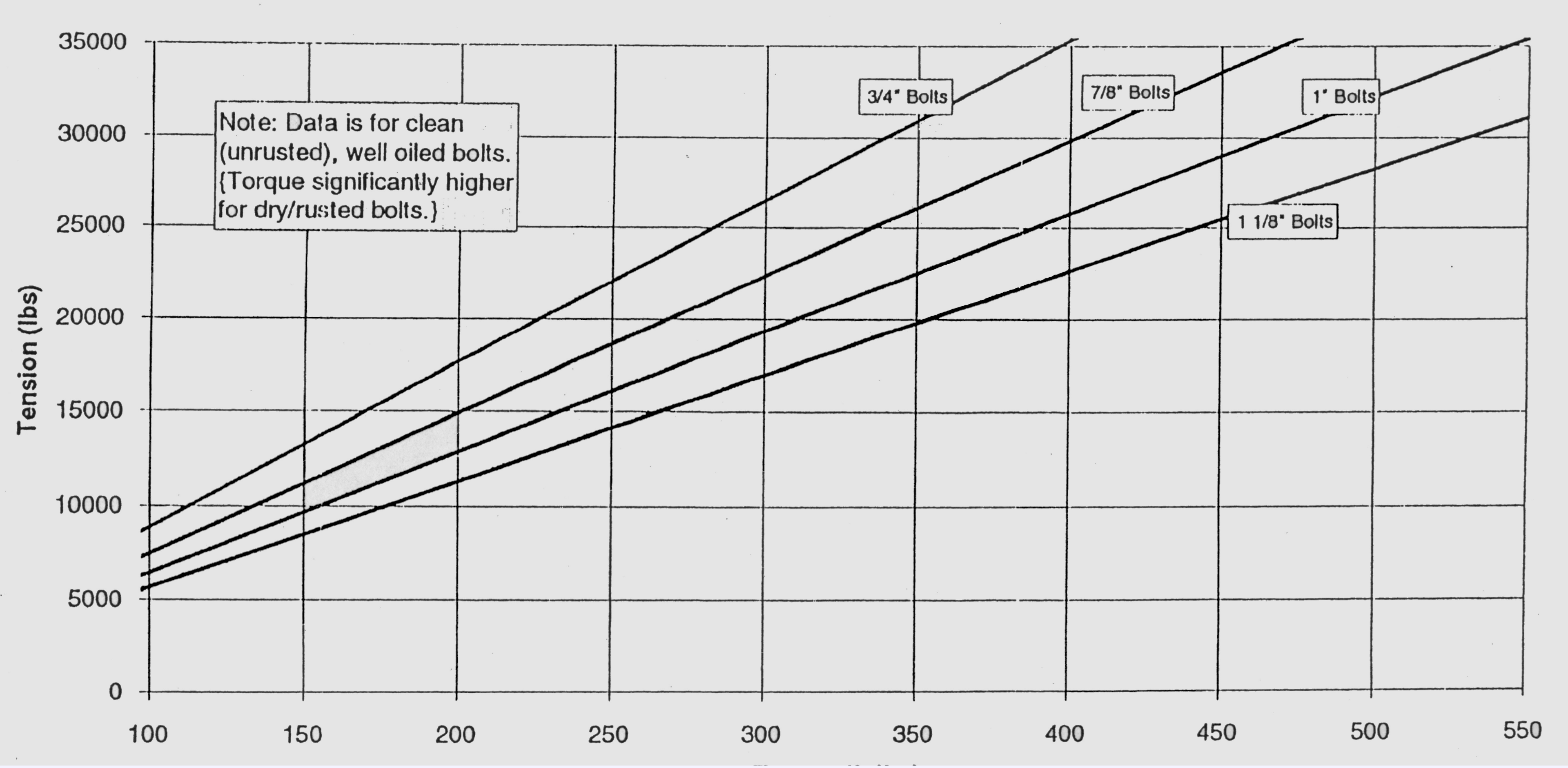
AVG 3,000 pounds to flatten

Far from 15,000 pounds

If Spring Washer is not flat
Nut is not tight

If Spring Washer is flat
Nut may not be tight

TRACK BOLT TENSION vs. TORQUE



Torque (ft-lbs)

AREA recommends 20-30 kips for new, tight bolts

AREA recommends 15-25 kips for retightening

CAR MOVEMENT REPORT

Tuesday, January 20, 2009

CUSTOMER: 446 ALLEN ENGINEERING REPORT NUMBER: 20A CAR NUMBER: 816

REGION / DIVISION: NEBO SUB_ DIVISION: YERMO

LINE / BRANCH: MAIN LINE PREFIX: SUFFIX: STATE: CA

		LOCATION			MILES		TIME (minutes)							
C	TIME	TRK	D	MILEPOST	TEST	RUNLT	TEST	RUN	TRNS	TRFC	RRDEL	RPR	SRS	REMARKS
1	05:30	RD	U	803.00										BARSTOW, CA.
4	06:00	RD	U	813.00		10.00			30					MOTEL TO JOB
3	06:25	RD	U	813.00							25			ORDERS/PILOT
4	06:35	RD	U	818.00		5.00		10						JOB TO JOB
3	06:45	RD	U	818.00							10			JOB BRIEFING
3	06:45	RD	U	818.00							0			JOB BRIEFING
8														BEGIN NEW LOCATION
9	06:45	SI	U	0.00	Reg: NEBO Sub: YERMO Ln: MAIN LINE St: CA									
5	07:15	YD	U	0.30	0.30		30							2ND TRACK
4	07:20	YD	D	0.00		0.30		5						PRE TEST
5	07:55	YD	U	0.79	0.79		35							TRACK 1
4	08:05	WY	U	0.40		0.39		10						YARD MOVE
5	08:15	WY	U	0.35	0.05		10							LEFT LEG WYE
4	08:25	YD	U	0.33		0.02		10						PRE TEST
5	08:40	WY	U	0.20	0.13		15							R LEG WYE
3	09:10	WY	U	0.20							30			ORDERS
5	09:15	WY	U	0.23	0.03		5							R LEG WYE
5	09:15	XO	U	0.06	0.17		0							#1 SEWER XO
4	09:20	XO	D	0.00		0.06		5						YARD MOVE
5	10:55	YD	U	1.41	1.41		95							LEAD
4	11:00	YD	D	1.23		0.18		5						YARD MOVE
5	11:25	YD	U	0.35	0.88		25							DUTCHMATE TRK
4	11:30	YD	D	0.00		0.35		5						YARD MOVE
4	11:40	YD	U	0.44		0.44		10						YARD MOVE
5	12:10	YD	U	0.44	0.00		30							485 TRK
4	12:20	YD	U	0.14		0.30		10						YARD MOVE
5	12:30	YD	U	0.14	0.00		10							LEFT 485 TRH
4	12:35	YD	U	0.31		0.17		5						YARD MOVE
5	12:40	YD	U	0.14	0.17		5							LEFT 485 TRACK
3	12:55	YD	U	0.00						15				
5	13:05	YD	U	0.18	0.18		10							POWER 485 TRK
4	13:25	YD	U	1.00		0.82		20						YARD MOVE
5	14:30	YD	U	0.86	0.14		65							20 STR. R
4	14:35	YD	D	0.75		0.11		5						YARD MOVE
5	14:55	YD	U	1.11	0.36		20							20 STREET LEFT
4	15:10	YD	D	0.98		0.13		15						YARD MOVE
8														BEGIN NEW LOCATION
9	15:10	RD	U	830.00	Reg: NEBO Sub: YERMO Ln: MAIN LINE St: CA									
4	15:30	RD	U	840.00		10.00			20					JOB TO MOTEL
2	15:30	RD	U	840.00										BARSTOW, CAL

CAR MOVEMENT REPORT

Tuesday, January 20, 2009

CUSTOMER: 446 ALLEN ENGINEERING REPORT NUMBER: 20A CAR NUMBER: 816

TOTALS:	4.61	28.27	355	115	50	15	65	0	0	*(Minutes)*

* Traffic / Other Comments: 12:55 SWITCHER

TOTALS FOR REPORT

RR Totals			SRS Totals					
TIME	MILES		TIME	MILES	TOTAL PICKS:	0	TESTING STOPS: 74	TOTAL DEFECTS FOUND: 14
					CHASE CAR ASSIGNED:	No		LESS THAN 8 HRS SERV TO RR CODE:
5:55	4.61	TESTING		0.00	CHASE REPAIR TIME	0		TOTAL RR SERVICE TIME: 9:10
1:55	8.27	RUNLT		0.00	CHASE COMMENT			RR SERVICE TIME - RR TEST TIME: 3:15
0:15		TRAFFIC						SPERRY HOLD:
1:05		OTHER						SPERRY REPAIR:
9:10	12.88	TOTALS		0.00	TRANSIT TIME / MILES:	0:50	20.00	TOTAL HOURS WORKED: 10:00

END OF SERVICE REMARK:

OPERATOR IN CHARGE:

Harman, Robert F Initials [signature] Signature

RAILROAD REPRESENTATIVE:

Name and Title

ST 05.18.03

DEFECTIVE RAIL REPORT

Tuesday, January 20, 2009

CUSTOMER: 446 ALLEN ENGINEERING REPORT NUMBER: 20A CAR NUMBER: 816

REGION / DIVISION: NEBO SUB_DIVISION: YERMO STATE: CA

LINE / BRANCH: MAIN LINE PREFIX: SUFFIX:

DEF NUM	DEFECT TYPE	DTX	SIZE	LOCATION MILEPOST	TRACK	RAIL	LATITUDE	LONGITUDE	WGT	PRO FILE	RAIL INFO MTL	RC	AL	YR	MFG	REMARKS	R A	DATE

NO DEFECTS FOUND FOR THIS LOCATION

TOTAL DEFECTS FOR LOCATION = 0

REGION / DIVISION: NEBO SUB_DIVISION: YERMO STATE: CA

LINE / BRANCH: MAIN LINE PREFIX: SUFFIX:

DEF NUM	DEFECT TYPE	DTX	SIZE	LOCATION MILEPOST	TRACK	RAIL	LATITUDE	LONGITUDE	WGT	PRO FILE	RAIL INFO MTL	RC	AL	YR	MFG	REMARKS	R A	DATE
15	BHJ		8	0.09	YD	L			100	RE		J	T	1925	IL	#2 TRK		
16	BHJ		4	0.04	WY	L			100	RE		J	H	1925	IL	RLWYE		
17	TDD		20%	0.26	YD	R			100	RE		J	T	1925	IL	34 LEAD TRK		
18	BHJ		2	0.37	YD	R			100	RE		J	T	1925	IL	LEAD		
19	BHJ		4	0.45	YD	L			100	RE		J	T	1925	IL	LEAD		
20	BHJ		3	0.48	YD	R			100	RE		J	T	1925	IL	LEAD		
21	BHJ		2	0.84	YD	L			100	RE		J	T	1925	IL	LEAD		
22	TDC		50%	0.06	YD	R			100	RE		J	H	1925	IL	34		
23	TDC		50%	0.27	YD	R			100	RE		J	T	1926	IL	034		
24	TDC		25%	0.31	YD	L			100	RE		J	L	1925	IL	3 485 TRK		
25	TDC		20%	0.37	YD	L			100	RE		J	T	1925	IL	34 485 TRK		
26	BHJ		4	0.46	YD	R			100	RE		J	T	1925	IL	L 20		
27	BHJ		10	0.5	YD	R			100	RE		J	T	1925	IL	L 20 TRK		
28	BHJ		2	0.94	YD	R			100	RE		J	T	1918	OT	20 LEFT TR		

TOTAL DEFECTS FOR LOCATION = 14

REGION / DIVISION: NEBO SUB_DIVISION: YERMO STATE: CA

LINE / BRANCH. MAIN LINE PREFIX: SUFFIX:

DEF NUM	DEFECT TYPE	DTX	SIZE	LOCATION MILEPOST	TRACK	RAIL	LATITUDE	LONGITUDE	WGT	PRO FILE	RAIL INFO MTL	RC	AL	YR	MFG	REMARKS	R A	DATE

NO DEFECTS FOUND FOR THIS LOCATION

TOTAL DEFECTS FOR LOCATION = 0

DI CTIVE RAIL REPORT

Tuesday, . ary 20, 2009

CUSTOMER: 446 ALLEN ENGINEERING

REPORT NUMBER: 20A

CAR NUMBER: 816

DEFECT SUMMARY

	TD	EBF	HSH	VSH	DW	HWO	MSC OUT	JOINT DEFECTS BHJ	HWJ	MSC	TOTAL DEFECTS	HAND TESTS	JOINT	OTHER	DEFECT COMPARISON	TD	JT	OT
RIGHT RAIL	3	0	0	0	0	0	0	5	0	0	8	POS	9	5	THIS	5	9	0
LEFT RAIL	2	0	0	0	0	0	0	4	0	0	6	NEG	18	9	PREV	0	0	0
TOTALS	5	0	0	0	0	0	0	9	0	0	14		27	14				

CHIEF OPERATOR: [signature]
Name

RR REP:
Name and Title

REPAIRS VERIFIED BY:
Name and Title

ST 05.01.06

RAIL TESTING EXCEPTIONS

CUSTOMER: NEBO CAR: 816 DATE: 01/15/2009 REPORT NUMBER: 816015A09

LOCATION	TRK	FROM MP	TO MP	DIR	SIDE	LOCATION CODE	EXCEPTION CODE	COMMENTS
Reg: NEBO Sub: YERMO Line: MAIN LINE	YD	0	0.1	U	R	1	OT	RUSTY RAIL/FOURTH TR
Reg: NEBO Sub: YERMO Line: MAIN LINE	YD	0	0.1	U	L	1	OT	RUSTY RAIL

EXCEPTION CODES:

SR	SHELLY RAIL	HC	HEAD CHECKED
CR	CORRUGATED RAIL	RS	RAIL SLIVERS
SP	SPALLED RAIL	TR	TRANSPOSED RAIL
VH	VERTICAL HEADLOSS	CE	CHIPPED OR BATTERED
GF	GAGE FACE LOSS	RE	RAIL ENDS
GR	GREASE/CONTAMINANTS	PJ	PUMP JOINTS

RAIL LOCATION CODES

1 TANGENT
2 LOW
3 HIGH
4 SWITCH / RR XING
5 ROAD XING
6 BRIDGE, TUNNEL, ETC

OPERATOR IN CHARGE: R F Harman ROADMASTER DATE:

Robert F Harman

D' ECTIVE RAIL REPORT Wednesda nuary 21, 2009

CU...MER: 446 ALLEN ENGINEERING REPORT NUMBER: 21A CAR NUMBER: 816

REGION / DIVISION: NEBO SUB_ DIVISION: YERMO STATE: CA

LINE / BRANCH: YARD TRACKS PREFIX: SUFFIX:

DEF NUM	DEFECT TYPE	DTX	SIZE	LOCATION MILEPOST	TRACK	RAIL	LATITUDE	LONGITUDE	WGT	PRO FILE	RAIL INFO MTL	RC	AL	YR	MFG	REMARKS	R A	DATE

NO DEFECTS FOUND FOR THIS LOCATION

TOTAL DEFECTS FOR LOCATION = 0

REGION / DIVISION: NEBO SUB_ DIVISION: YERMO STATE: CA

LINE / BRANCH: YARD TRACKS PREFIX: SUFFIX:

DEF NUM	DEFECT TYPE	DTX	SIZE	LOCATION MILEPOST	TRACK	RAIL	LATITUDE	LONGITUDE	WGT	PRO FILE	RAIL INFO MTL	RC	AL	YR	MFG	REMARKS	R A	DATE
29	VSJ		3	0.14	YD	R			100	RE		J	T	1925	IL	18 LEFT		
30	BHJ		2	0.02	YD	R			100	RE		J	L	1925	IL	17RIGHT		
31	VSH		36	0.13	YD	L			100	RE		J	T	1925	IL	0 17 RIGHT		
32	VSJ		2	0.02	YD	R			100	RE		J	L	1925	IL	16 RIGHT		
33	TDC		20%	0.22	YD	R			100	RE		J	T	1925	IL	34 14 LEFT		
34	TDD		20%	0.22	YD	L			100	RE		J	T	1925	IL	34 14 LEFT		
35	TDD		100	0.22	YD	R			100	RE		J	T	1925	IL	34 14 LEFT		
36	HWJ		2	0.36	YD	R			100	RE		J	T	1925	IL	14 LEFT		
37	BHJ		2	0.45	YD	R			100	RE		J	T	1925	IL	14 LEFT		
38	TDC	3	25%	0.11	YD	R			100	RE		J	L	1925	IL	334 17 RIGHT		

TOTAL DEFECTS FOR LOCATION = 10

REGION / DIVISION: NEBO SUB_ DIVISION: YERMO STATE: CA

LINE / BRANCH: YARD TRACKS PREFIX: SUFFIX:

DEF NUM	DEFECT TYPE	DTX	SIZE	LOCATION MILEPOST	TRACK	RAIL	LATITUDE	LONGITUDE	WGT	PRO FILE	RAIL INFO MTL	RC	AL	YR	MFG	REMARKS	R A	DATE

NO DEFECTS FOUND FOR THIS LOCATION

TOTAL DEFECTS FOR LOCATION = 0

CRANE RAILS

GENERAL NOTES

The A.S.C.E. rails and the 104 to 175 pound crane rails listed below are recommended for crane runway use. For complete details and for profiles and properties of rails not listed, consult manufacturers' catalogs.

Rails should be arranged so that joints on opposite sides of the crane runway will be staggered with respect to each other and with respect to the wheelbase of the crane. Rail joints should not occur at crane girder splices. Light 40 pound rails are available in 30 foot lengths, 60 pound rails in 30, 33 or 39 foot lengths, standard rails in 33 or 39 foot lengths and crane rails up to 60 feet. Consult manufacturer for availability of other lengths. Odd lengths, which must be included to complete a run or obtain the necessary stagger, should not be less than 10 feet long. For crane rail service, 40 pound rails and crane rails are furnished to manufacturers' specifications and tolerances. 60 and 85 pound rails may be furnished to manufacturers' specifications and tolerances, or to ASTM A1. Rails will be furnished with standard drilling (see page 1-107 in both standard and odd lengths unless stipulated otherwise on order. For controlled cooling, heat treatment and rail end preparation, see manufacturers' catalogs. Purchase orders for crane rails should be noted "For crane service."

DIMENSIONS AND PROPERTIES

Type	Classification	Nominal Wt. per Yd.	d	Gage g	Base b	Base m	Base n	Head c	Head r	Web t	Web h	Web R	Properties—Axis X - X Area	I	S Hd.	S Bse.	y
		Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.²	In.⁴	In.³	In.³	In.
A.S.C.E.	Light	40	3½	1 71/128	3½	5/8	7/32	1 7/8	12	25/64	1 55/64	12	3.94	6.54	3.59	3.89	1.68
A.S.C.E.	Light	60	4¼	1 115/128	4¼	49/64	9/32	2 3/8	12	31/64	2 17/64	12	5.93	14.6	6.64	7.12	2.05
A.S.C.E.	Std.	85	5 3/16	2 17/64	5 3/16	57/64	19/64	2 9/16	12	9/16	2¾	12	8.33	30.1	11.1	12.2	2.47
Bethlehem	Crane	104	5	2 7/16	5	1 1/16	½	2½	12	1	2 7/16	3½	10.3	29.8	10.7	13.5	2.21
U.S.S.	Crane	105	5 3/16	2 13/64	5 3/16	1	13/32	2 9/16	12	15/16	2 13/32	12	10.3	34.4	12.4	14.3	2.41
U.S.S. & Beth.	Crane	135	5¾	2 15/32	5 3/16	1 1/16	15/32	3 7/16	14	1¼	2 13/16	12	13.3	50.6	17.2	18.0	2.81
Bethlehem	Crane	171	6	2 5/8	6	1¼	5/8	4.3	Flat	1¼	2¾	Vert.	16.8	73.4	24.5	24.4	3.01
U.S.S. & Beth.	Crane	175	6	2 21/32	6	1 9/64	½	4¼	18	1½	3 7/64	Vert.	17.1	70.2	23.5	23.3	3.02

For maximum wheel loadings see manufacturers' catalogs.

AISC M016

Manual of Steel Construction

1

CRANE RAILS

Splices

WELDED SPLICES

When welded splices are specified, consult the manufacturer for recommended rail end preparation, welding procedure and method of ordering. Although joint continuity, made possible by this method of splicing, is desirable, it should be cautioned that the careful control required in all stages of the welding operation may be difficult to meet during crane runway construction.

In any event, rails should not be spliced by welding straps in the webs, nor should they be attached to structural supports by welding. Rails with holes for joint bar bolts should not be used in making welded splices.

BOLTED SPLICES

It is often more desirable to use properly installed and maintained bolted splice bars in making up rail joints for crane service.

Standard rail drilling and joint bar punching, as furnished by manufacturers of light and standard rails for track work, includes round holes in rail ends and slotted holes in joint bars to receive standard oval neck track bolts. Holes in rails are oversize and punching in joint bars is spaced to allow $\frac{1}{16}$ to $\frac{1}{8}$ inch clearance between rail ends. (See manufacturers' catalogs for spacing and dimensions of holes and slots.) Although this construction is satisfactory for track and light crane service, its use in general crane service may lead to joint failure.

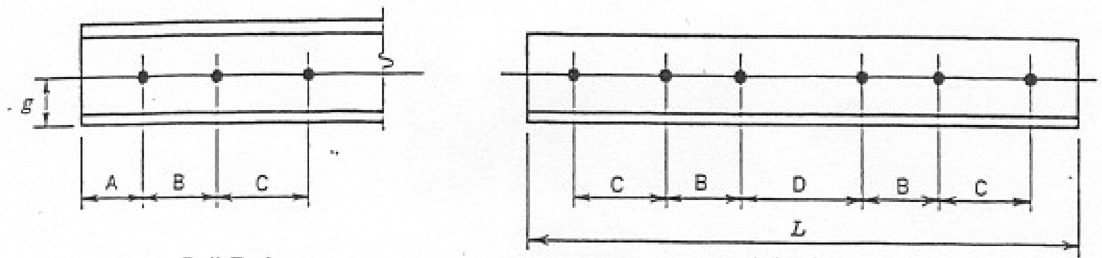
For best service in bolted splices, it is recommended that tight joints be stipulated for all rails for crane service. This will require rail ends to be finished by milling or grinding, and the special rail drilling and joint bar punching tabulated below. Special rail drilling is accepted by some mills, or rails may be ordered blank for shop drilling. End finishing of standard rails can be done at the mill; light rails must be end finished in the fabricating shop or ground at the site prior to erection. In the crane rail range, from 104 to 175 pounds per yard, rails and joint bars are manufactured to obtain a tight fit and no further special end finishing, drilling or punching is required. Because of cumulative tolerance variations in holes, bolt diameters and rail ends, a slight gap may sometimes occur in the so-called tight joints. Conversely, it may sometimes be necessary to ream holes through joint bar and rail to permit entry of bolts.

Joint bars for crane service are provided in various sections to match the rails. Joint bars for light and standard rails may be purchased blank for special shop punching to obtain tight joints. See manufacturers' catalogs for dimensions, material specifications and the identification necessary to match the crane rail section.

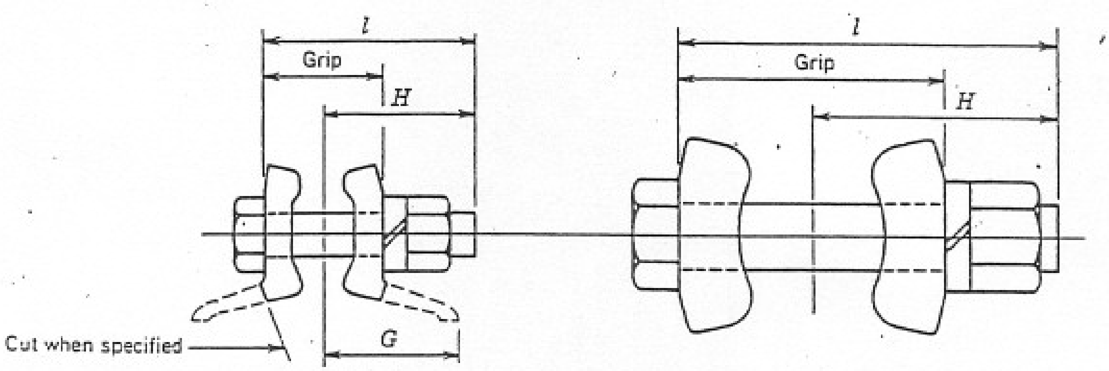
Joint bar bolts, as distinguished from oval neck track bolts, have straight shanks to the head and are manufactured to ASTM A449 specifications. Nuts are manufactured to ASTM A563 Gr B specifications. ASTM A325 bolts and nuts may be used. Bolt assembly includes an alloy steel spring washer, furnished to A.R.E.A. specification.

After installation, bolts should be retightened within 30 days and every three months thereafter.

CRANE RAILS
Splices
For tight joints



Rail End — Joint Bar



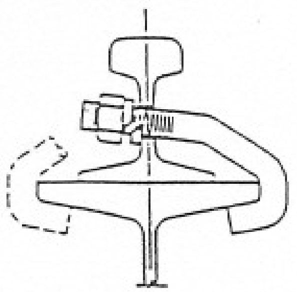
40-60-85-104 — 105-135-171-175

Rail						Joint Bar						Bolt				Washer		Wt. 2 Bars Bolts, Nuts Washers	
Wt. per Yard	Drilling					Punching				L	G	Diam.	Grip	l	H	Inside Diam.	Thickness & Width	With Flg.	Less Flg.
	g	Hole Diam.	A	B	C	Hole Diam.	D	B	C										
Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	Lb.	Lb.
40	1 71/128	* 13/16	2 1/2	5	...	* 13/16	*4 15/16	5	...	20	2 3/16	3/4	1 15/16	3 1/2	2 1/2	13/16	7/16 × 3/8	20.0	16.5
60	1 115/128	* 13/16	2 1/2	5	...	* 13/16	*4 15/16	5	...	24	2 11/16	3/4	2 19/32	4	2 11/16	13/16	7/16 × 3/8	36.5	29.6
85	2 17/64	* 15/16	2 1/2	5	...	* 15/16	*4 15/16	5	...	24	3 11/32	7/8	3 5/32	4 3/4	3 3/16	15/16	7/16 × 3/8	56.6	45.3
104	2 7/15	1 1/16	4	5	6	1 1/16	7 15/16	5	6	34	3 1/2	1	3 1/2	5 1/4	3 1/2	1 1/16	7/16 × 1/2	73.5	55.4
105	2 13/64	15/16	4	5	6	15/16	7 15/16	5	6	34	...	7/8	3 3/8	5	3 5/16	15/16	7/16 × 3/8	...	61.0
135	2 15/32	1 3/16	4	5	6	1 3/16	7 15/16	5	6	34	...	1 1/8	3 3/8	5 1/2	3 11/16	1 3/16	7/16 × 1/2	...	75.3
171	2 5/8	1 3/16	4	5	6	1 3/16	7 15/16	5	6	34	...	1 1/8	4 7/16	6 1/4	4 1/16	1 3/16	7/16 × 1/2	...	90.8
175	2 21/32	1 3/16	4	5	6	1 3/16	7 15/16	5	6	34	...	1 1/8	4 1/8	6	3 15/16	1 3/16	7/16 × 1/2	...	87.7

* Special rail drilling and joint bar punching.

CRANE RAILS
Fastenings

HOOK BOLTS

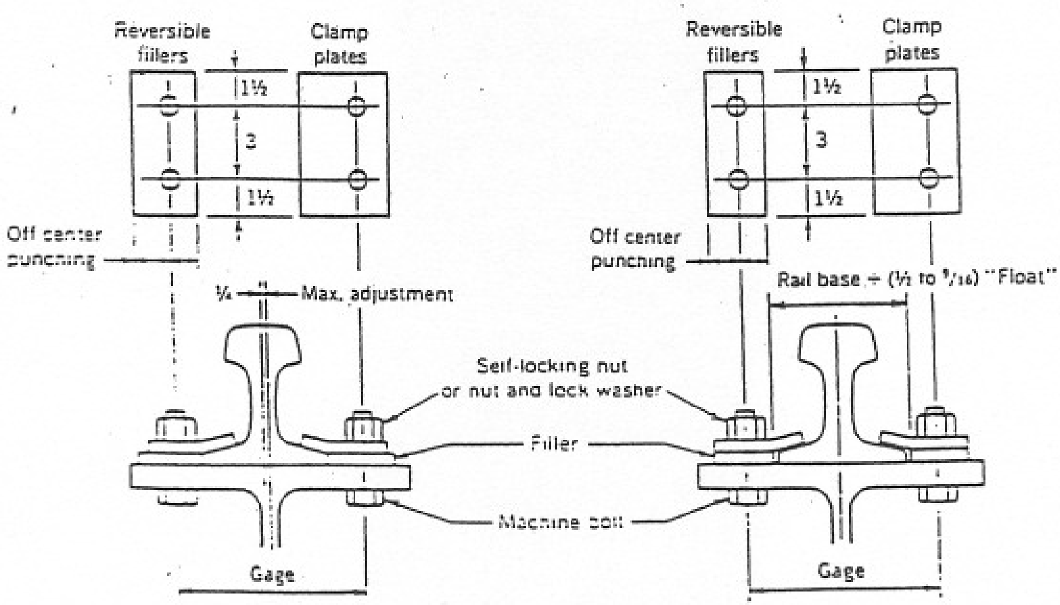


Hook bolts are used primarily with light rails when attached to beams with flanges too narrow for clamps. Rail adjustment up to ±½ inch is inherent in the threaded shank. Hook bolts are paired alternately, 3 to 4 inches apart, spaced at about 24 inch centers. The special rail drilling required is accepted by some manufacturers, or may be done at the fabricator's shop.

5/8" dia. – 30 lb rail
3/4" dia – 40 lb rail
7/8" dia – 60-90 lb rail

RAIL CLAMPS

Although a variety of satisfactory rail clamps are available from track accessory manufacturers, two, frequently recommended for crane runway use, are the fixed and floating types illustrated below. These are available in forgings or pressed steel, either for single bolts or for double bolts as shown. The fixed type features adjustment through eccentric punching of fillers and positive attachment of rail to support. The floating type permits longitudinal and controlled transverse movement through clamp clearances and filler adjustment, useful in allowing for thermal expansion and contraction of rails, and possible misalignment of supports. Both types should be spaced 3 feet or less apart.



Tight Clamp

Floating Clamp

Dimensions shown above are suggested. See manufacturers' catalogs for recommended gages, bolt sizes and detail dimensions not shown.

ENGINEERING INSPECTION CHECKLIST

FOR

CRANE RAIL SUPPORT STRUCTURES

GROUND LEVEL COLUMN SUPPORTS/FOUNDATIONS:

Concrete or steel vertical building structural columns which support rails.

Concrete or steel vertical independent columns which support rails.

Horizontal/angled building structural members which support rails.

Horizontal/angled independent members which support rails.

Structural bearing support, tie, brace and pivot points (welded, riveted, bolted, cemented or other fastenings).

TYPES OF STRUCTURAL DEFECTS:

<u>Concrete Columns</u>

Foundation	- Fissures, cracks, settlement, spalling, vertical/horizontal movement or deflection.
Columns	- Fissures, cracks, settlement, spalling, vertical/horizontal movement, misalignment or deflection.
Rail Support Pads	- Cracking, spalling or evidence of shear forces, movement under load.
Rail Support Fasteners (Steel)	- Misalignment, broken, missing or loose bolts or rivets, movement under load.

<u>Steel Columns</u>

Foundation	- Same as above plus bearing plate security, misalignment, missing or loose bolts or rivets, movement under load.
Columns	- Fissures, cracks, bent, twisted, settlement, vertical/horizontal movement, misalignment or deflection.
Brace Fasteners	- (Horizontal or angular) - cracking, evidence of shear forces at welds, bolts or rivets, missing, loose or broken welds, bolts or rivets.
Rail Support Pads	- Same as fasteners, movement under load.
Steel Brace Members	- Vertical, horizontal, angular (single or truss). Same as steel columns.

CRANE RUNWAY PROBLEM CHECKLIST

Problem	Probable Cause	Corrective Action for Corresponding Probable Cause
1. Cracks in runway rail	1. Fixed rail clamps	1. Install floating rail
2. Misaligned rail	2. Supporting structures (such as columns) displaced or deformed	2. Inspect and repair structural elements
3. Sheared rail fasteners	3. Crane out of alignment	3. Inspect and repair crane
1. Cracks in runway girder web; deformed girder	1. Diaphragm connection between column and girder web	1. Remove diaphragm-to-web connection; connect girder at top flange with sliding connection
2. Sheared or loose girder fasteners	2. Overload knee bracing	2. Remove knee bracing, making sure vertical X-bracing is adequate for load
3. Cracks in connecting material	3. Fixed rail clamps	3. Install floating rail
1. Fractures in plates or angles of vertical X-bracing	1. Vertical X-bracing too close to ends of building or to building expansion joints	1. Install X-bracing as close to center of building as possible, or to center of expansion field

Reference: "Plant Engineering" Sept 30, 1976, File 4520, page 85

Avoiding Common Crane Runway Problems

By JOHN E. MUELLER, P.E., Structural Consultant, Broad Crane & Engineering Service Co., Detroit, MI

OF ALL STRUCTURAL ELEMENTS in a plant building, crane runways are among the most susceptible to failure. These rigid structures are subjected to pounding from rigid *moving* structures, without the benefit of a cushioning intermediary, such as tires provide between car and highway.

Runways are subject to the vertical stresses of the crane weight, the horizontal stresses produced by crane movement, and impact loads resulting from chain slippage, a sudden pulling action, or lifting at an angle. Because of their length, crane runways are also susceptible to thermal expansion. Yet, they are required to maintain lateral and vertical alignment within very narrow tolerances.

Despite their apparent rigidity, crane runways are dynamic structures that must incorporate a great deal of movement and flexibility. Runway rails can slip, girders can deflect under load and their ends may rotate, and columns can be deformed by moving loads.

The most effective method of handling the complex loads that are applied to a runway is to transfer them to the outside of the system—from the girder to the runway column, and then through bracing down to the foundation.

Because this dynamic structure—the runway—has not always been well understood, engineers have sought to produce rigidity, or to restrict movement within the runway system, often doing more harm than good.

A number of errors that are commonly made during either construction of crane runways or their subsequent repair are discussed in this article. Recommended alternatives also are suggested.

Error No. 1: Excess Rigidity—In many plants, the rail is mounted to the runway girder by fixed rail clamps that bind the rail firmly against movement, Fig. 1.

This connection causes two problems: First, the horizontal thrust created by crane movement is transmitted directly to the girder. However, the girder is not designed to accept such horizontal stresses.

Second, although the rail is a continuous member, the girder underneath normally consists of individual spans that run from column to column. (A continuous welded girder would be extremely expensive.) The ends of the individual girders rotate under the moving crane load, applying a tensile force to the continuous rail. In time, the rail becomes misaligned and causes shearing of bolts. The rail or girder may also crack.

The solution to this problem is a floating rail, Fig. 1, that simply rests on the girder. It is positioned by clips that provide space for movement above the rail and to each side of it.

In this arrangement, the rail slips under the crane load and acts as a shock absorber. Any remaining impact is transmitted by the girder to the column and, through the column, down into the building's foundation.

When the ends of the girders rotate, they do not place tension upon the rail. And, there is less strain from thermal expansion because the rail is free to slide along the girder.

Because of the reduced strain, the rail tends to remain in its original alignment, and virtually no fastener maintenance is required.

A ± 1/8-in. rail tolerance for rail movement to the left or right (an industry standard) can be met, while allowing room for thermal expansion, by positioning the clips 1/16 in. to each side of the rail.

Error No. 2: Unnecessary Use of Knee Bracing—Eager to help support runway loads, many engineers add knee bracing at the junction of the runway girder and the building column. This practice is useless and may actually be harmful. Heavy bracing, in particular, can cause problems.

The knee brace draws loads to itself that would otherwise be applied to the column and the foundation. When the girder bends under load it compresses the knee brace. Making the knee brace heavier simply draws more load to it, Fig. 2.

The knee brace is never utilized if there is vertical bracing between columns. In any case, there is a high probability that fasteners will become loose or sheared, or fatigue failure will occur over time, if knee bracing is used. Furthermore, if the knee brace is compressed beyond its yield point, it may deform the girder or cause cracks in the girder web.

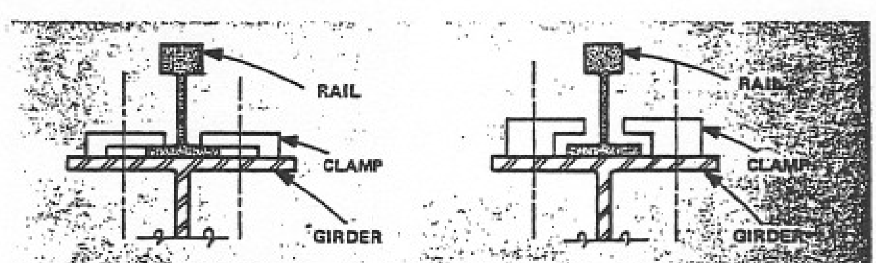


Fig. 1. Fixed rail clamp firmly binds girder and retards movement in any direction. Its use can lead to a misaligned rail, sheared bolts, and cracking in the rail or girder. A floating rail should be used instead. It is positioned by clips that provide air space above the rail and to the left and right of it for movement.

Fig. 2. Knee bracing draws loads to itself that would otherwise be transferred to the column and down into the foundation. When the girder bends under load, it compresses the knee brace. Use of a diaphragm or fastener plate also causes problems. When the girder end rotates, the diaphragm attempts to restrain the rotation. Fasteners invariably become sheared, and local tension leading to girder web cracking can occur.

Fig. 3. Direct top flange connection permits unrestricted girder rotation. Diaphragm and knee bracing are eliminated. Bolts through grider bottom flange and column cap plate must be capable of transferring resultant forces.

Fig. 4. Diaphragm connection between girder web and column, a, is frequently —and mistakenly—made on light crane runways. Girder web is subjected to reversible strain as crane movement occurs, b. The result can be a cracked and displaced web, c.

Fig. 5. Girder should be connected to column at upper flange only, using sliding connections. The arrangement prevents movement in a transverse direction, but allows complete movement longitudinally to permit the girder to rotate without restraint.

Fig 6. Cross bracing located at ends of building, top, will stretch and buckle as runway undergoes thermal expansion or contraction. If bracing is too strong to fail, it may overstress or deflect entire wall framing. Proper design, bottom, is to place cross bracing as close to center of building as possible, and eliminate end bracing. The center panel is an anchor bay that holds the center columns plumb and permits free expansion or contraction. Column bending will occur with this arrangement; therefore, columns must be strong enough to resist the force.

CRANE RUNWAY PROBLEM CHECKLIST

Problem	Probable Cause	Corrective Action for corresponding probable cause
1. Cracks in runway rail	1. Fixed rail clamps	1. Install floating rail
2. Misaligned rail	2. Supporting structures (such as columns) displaced or deformed	2. Inspect and repair structural elements
3. Sheared rail fasteners	3. Crane out of alignment	3. Inspect and repair crane
1. Cracks in runway girder web; deformed girder	1. Diaphragm connection between column and girder web	1. Remove diaphragm-to-web connection; connect girder at top flange with sliding connection
2. Sheared or loose girder fasteners	2. Overload knee bracing	2. Remove knee bracing, making sure vertical X-bracing is adequate for load
3. Cracks in connecting material	3. Fixed rail clamps	3. Install floating rail
1. Fractures in plates or angles of vertical X-bracing	1. Vertical X-bracing too close to ends of building or to building expansion joints	1. Install X-bracing as close to center of building as possible, or to center of expansion field

The best solution is to remove the knee bracing since it serves no useful purpose, Fig. 3. However, it may be wise to explain to employees why this action has been taken. There have been cases in which workers, accustomed to seeing the knee braces in place, have filed a safety grievance when they were removed.

Error No. 3: Connecting Girder to Column at the Web—When the girder end rotates under load, and the girder web is connected to a column by a diaphragm or fastener plate, the connecting plate resists rotation. As a result, fasteners are subjected to large shear forces, and cracks may occur in the diaphragm or web, Fig. 4.

These problems can be eliminated by connecting the girder to the column at the upper flange only, using sliding connections. This arrangement allows the girder end to rotate without producing strain on the connection. If a stiffener is required, it should be a simple welded stiffener, Fig. 5.

Error No. 4: Wrong Placement of Column Bracing—Vertical cross bracing between columns carries the longitudinal forces into the foundation. There is a great temptation to locate the bracing at the ends of the building, because end bracing can take up the shock of crane stops. Some engineers also feel that end bracing is best for resisting wind forces. And, when construction of the facility is begun, bracing at the two ends helps the erector plumb the building.

However, the building end is also the end of the runway's thermal-expansion field. At this location, the bracing will be subject to maximum expansion or contraction forces that occur in a long runway, Fig. 6. These forces will often overstress the bracing and cause fractures in plates or angles, and may loosen diagonal members and fasteners. If the bracing is too strong to fail, it may overstress or deflect the entire wall framing.

In general, cross bracing should be placed as close to the center of the building as possible, to permit free expansion or contraction in an outward direction, Fig. 6.

Some other runway problems are the result of hard treatment rather than poor design. Thus, a crane that is out of alignment may cause cracks in runway members or misalignment or shearing of fasteners. In one recent case, steel slabs were piled high near a column. The excessive load eventually moved the column foundation out of position, causing runway misalignment.

For complimentary copy of this article circle 262 on post card

Fig. 2

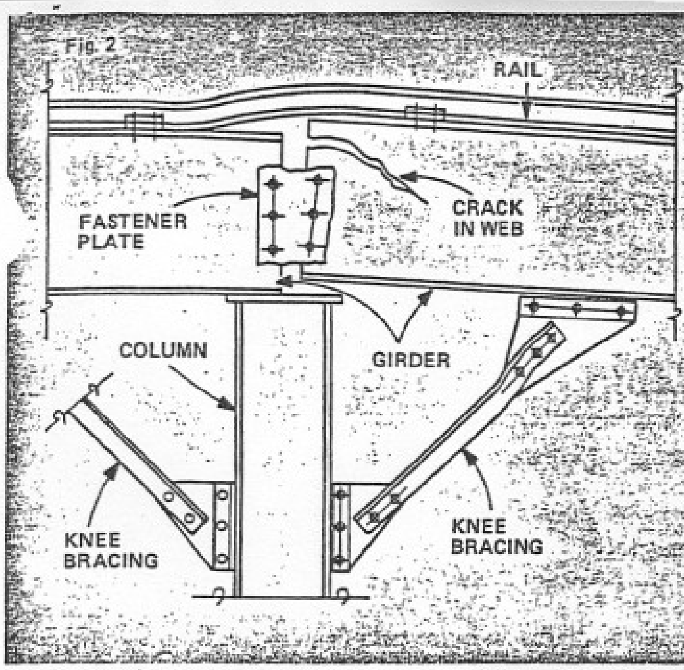


Fig. 3

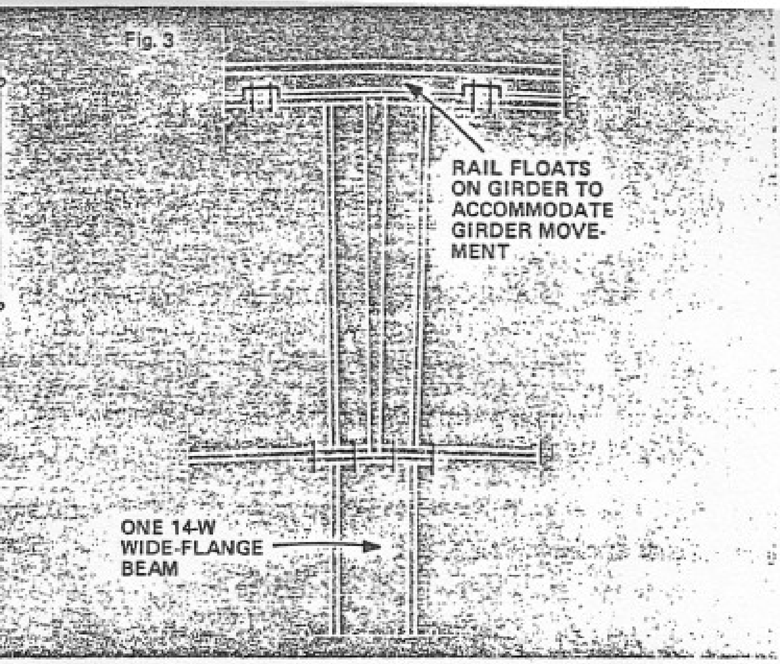


Fig. 4

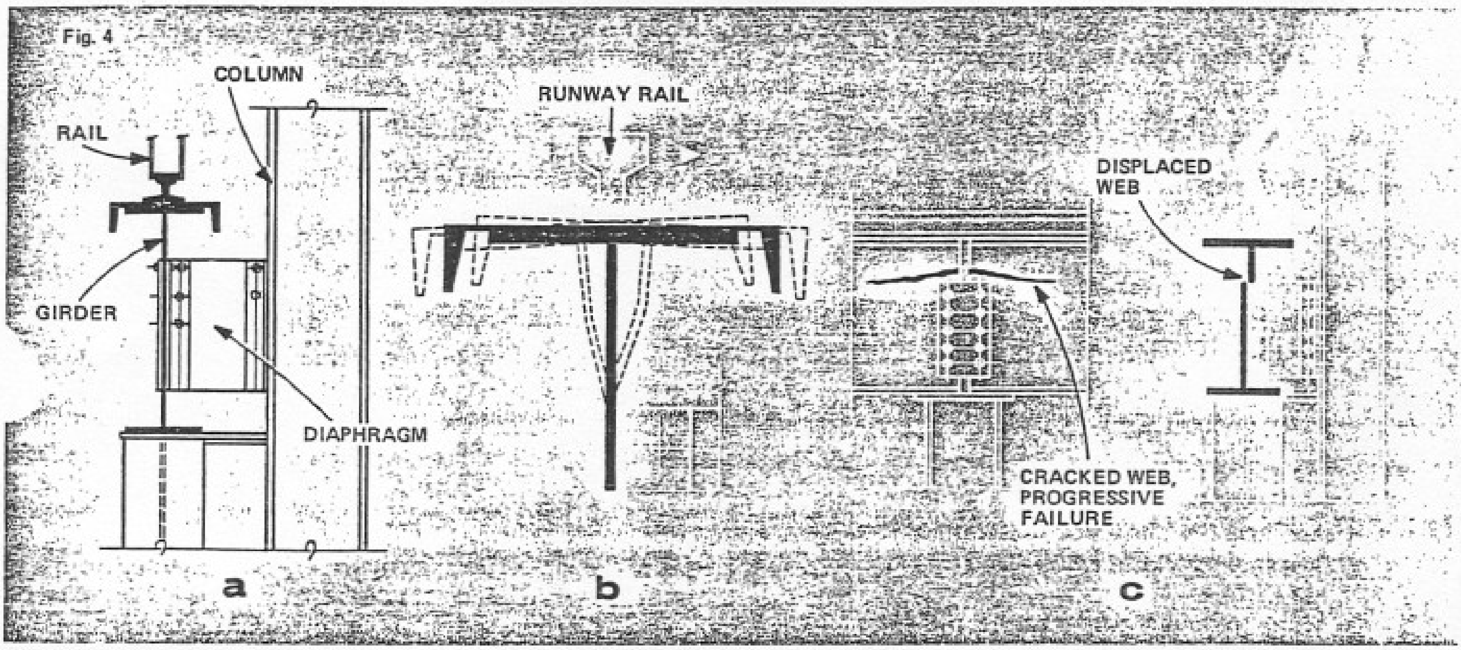


Fig. 5

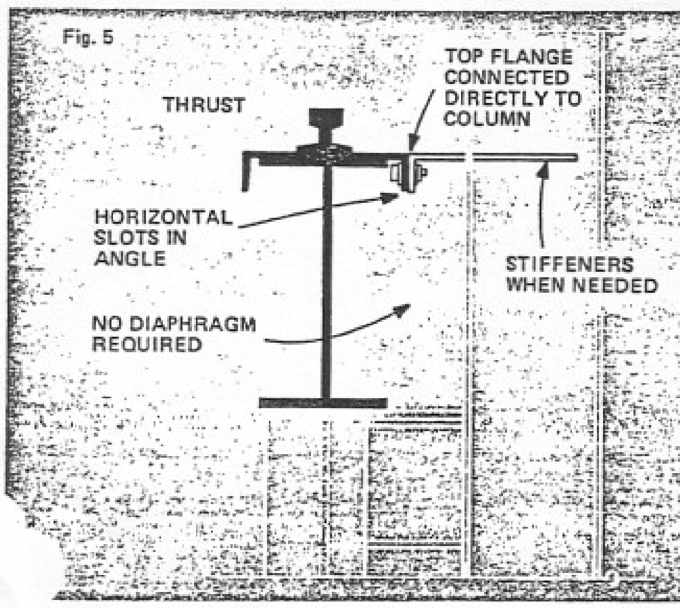
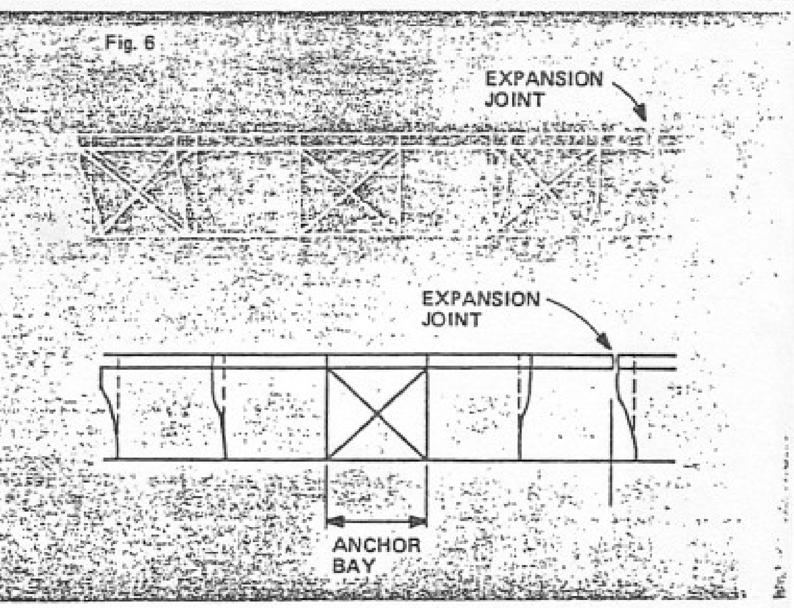


Fig. 6



INSPECTION/CERTIFICATION DOCUMENT
FOR ELEVATED CRANE TRACKAGE

Building/Crane No:	Type:	Manufacturer:	Capacity:
Bldg. 64 / Crane 1	Bridge	WRIGHT	40,000 lbs

Visual Inspection	Operational	Last NDT		Legend: Check under condition	
Date: 9/28/98	Date: 9/28/98	Date: 9/28/98	Type: Sounding	S = Satisfactory U = Unsatisfactory	R = Restricted NA = Not Applicable

Item No.	Items to be Inspected	Crane Trackage Inspection Checklist	Condition S	R	U	NA
1	Rails	Inspect for ¼" deflection, misalignment variation or movement, top or side wear or visible rail defects.	WAG			
2	Rail Joints	Inspect for damaged, cracked or broken joint bars, rail joint gap exceeding ¼", tread (1/4") and side(3/16") mismatch of rail ends.	WAG			
3	Rail Bolts	Inspect for missing, broken, deteriorated or worn bolts which permit movement of ¼". Minimum of 2 bolts/rail at joint.	WAG			
4	J-Bolts, Clips, Tie Plates, Misc. Fasteners	Inspect for loose, broken, cracked or missing rail clips or J-bolts. Tighten bolts as necessary or every two years.	(1)(2)			
5	Gage	Inspect for shifting of rail spacing, if binding or wear are noted. Measure across span, at right angles from center of the railhead.	WAG			
6	Rail Alignment	Inspect for ¼" misalignment, abnormal wear on wheel or flange, binding, and rolling after stopping.	WAG			
7	Cross Section	Inspect for profile grade (should be near level) and indication of structure settlement.	WAG			
8	Rail Stops	Inspect for loose, broken, cracked or missing clamps, bolts and end stops.	(3)			
9	Clearances	Inspect for evidence of obstruction to all vertical and horizontal clearances.	WAG			
10	Signs and Appurtenances	All capacity and warning signs are correct and clearly marked and in view of operator.	WAG			
11	Support Structure	Supporting structure for crane system shall have been inspected using the procedures and checkpoints described in MO-322 (every two years). Support structure shall be inspected when cranes are loaded tested to exceed the rated capacity of the system.	WAG			

Remarks (Item No.): Note any deficiencies and level (Marginal, Critical or Catastrophic) or "No defects noted."
RAIL – 5 ¾ INCHES BASE BY 5 ¾ INCHES HIGH – APPROXIMATELY 100 LB ASCE RAIL – No markings
7/8 INCH DIAMETER J-BOLTS SPACED APPROX EVERY 23 ½ INCHES
FOUR HOLE JOINT BARS

1. Left rail - First outside J-Bolt no nut (Marginal) Install nut and washer on bolt.
   Last J-Bolt loose. (Marginal) Tighten
2. Right Rail - Second joint from main door - Loose J-Bolt on outside.

See continuation page

This crane trackage support structure has been inspected in accordance with NAVFACINST 11230.1D, Paragraph 2.4.1.1. and is [X] Satisfactory [ ] Unsatisfactory (see Remarks)

Structural Inspector (signature) William A. Dannon — Date: 9/28/98

This section of trackage covered by the inspection report above meets the applicable standards in NAVFACINST 11230.1D and is certified as follows:

[X] FULL CERTIFICATION [ ] RESTRICTED CERTIFICATION [ ] NON-CERTIFICATION

	Track Inspector (signature)	Date:
	William A. Dannon	9/28/98
	Certifying Official (signature)	Date:

INSPECTION/CERTIFICATION DOCUMENT			
FOR ELEVATED CRANE TRACKAGE			
Building/Crane No: Bldg. 64 / Crane 1	Type: Bridge	Manufacturer: WRIGHT	Capacity: 40,000 lbs

Remarks (Item No.): (Continued) Note deficiency and level (Marginal, Critical or Catastrophic)

3. No rail stops. J-Bolts fastened to top of rail. Act as wheel stop. (Marginal) Install proper crane rail stops. Since this is a chain operated travel, this defect is not considered a critical defect.

4. Rail non-destructively tested by sounding with a hammer in accordance with para. 2.7.2 of NAVFACINST 11230.1D. No defects noted.

5. Track operationally inspected in accordance with para. 2.4.2.3.3 of NAVFACINST 11230.1D. No load on the Hook and trolley positioned adjacent to each rail. No defects noted.

6. Inspection assisted by Jose M. Ruiz , Juan A. Quiros, and Francisco Perez as training.

FACILITIES AND MAINTENANCE ENGINEERING DIVISION
PRODUCTION RESOURCE DEPARTMENT
NORFOLK NAVAL SHIPYARD

913-095-97
12 August, 1997

MEMORANDUM

From: Code 913
To: Memo To File

Subj: DESIGNATION AS TRACKAGE INSPECTOR

Ref: (a) Memo 913-171-95, dated 28 June, 1995

1. As the Certifying Official, I designate Gilbert R. Stokes, check no. 040-43189 as qualified to inspect trackage for defects.

2. The basis for approval, was satisfaction of reference (a) requirements for new trackage inspectors as follows:

a. ONE YEAR OF ASSISTING CURRENT TRACKAGE INSPECTORS WITH FIELD INSPECTIONS OF RAILROAD, GROUND LEVEL CRANE, AND ELEVATED CRANE TRACKAGE.

Sixteen months (April 3, 1996 to present) as Code 913.29 working with the rail inspectors in relation to performing and writing trackage certifications/inspections.

b. SUCCESSFUL COMPLETION OF A NAVFAC TRAINING COURSE COVERING NAVFACINST 11230.1 AND TRACKAGE INSPECTION OR EQUIVALENT COURSE APPROVED BY THE CERTIFYING OFFICIAL.

Completion of NAVFAC Crane and Railroad Trackage Inspector Training Course (November 4, 1996-November 8, 1996) given at Earle Naval Weapons Station, New Jersey.

c. SUCCESSFUL COMPLETION OF CRISP ELEVATED CRANE TRACKAGE INSPECTION COURSE.

Completion of the Crisp Elevated Crane Trackage Inspection Course (August 6, 1997)

d. DEMONSTRATION OF FIELD INSPECTION ABILITY TO A TRACKAGE CERTIFYING OFFICIAL.

Demonstrated ability to Certifying Official R.D. Ayres, on numerous occassions during the training period of April 3, 1996, to present.

e. APPROVAL BY THE CERTIFYING OFFICIAL THAT THE INSPECTOR CAN PRESCRIBE WRITTEN REMEDIAL ACTION TO CORRECT OR SAFELY COMPENSATE FOR DEVIATIONS FROM THE REQUIREMENTS OF NAVFACINST 11230.1.

This memo grants approval to Gilbert R. Stokes to prescribe written remedial action.

R.D. Ayres

R.D. AYRES

1 June 2000

MEMORANDUM

From: Certifying Official for Crane Trackage, Naval Station, Ingleside
To: Mr. Edward Beck

Subj: **TRACK INSPECTOR**

Ref: (a) NAVFACINST 11230.1D
(b) NAVFAC P-307

1. You are designated as the Track Inspector for Crane Trackage aboard Naval Station, Ingleside. Your designation is based on the following:

   a. Over one year of experience, from January 99 to present, inspecting elevated crane trackage.

   b. Successful completion of a NAFAC Crane and Railroad Trackage Inspector Training Course (24-25 February 99) given at Kings Bay, Georgia.

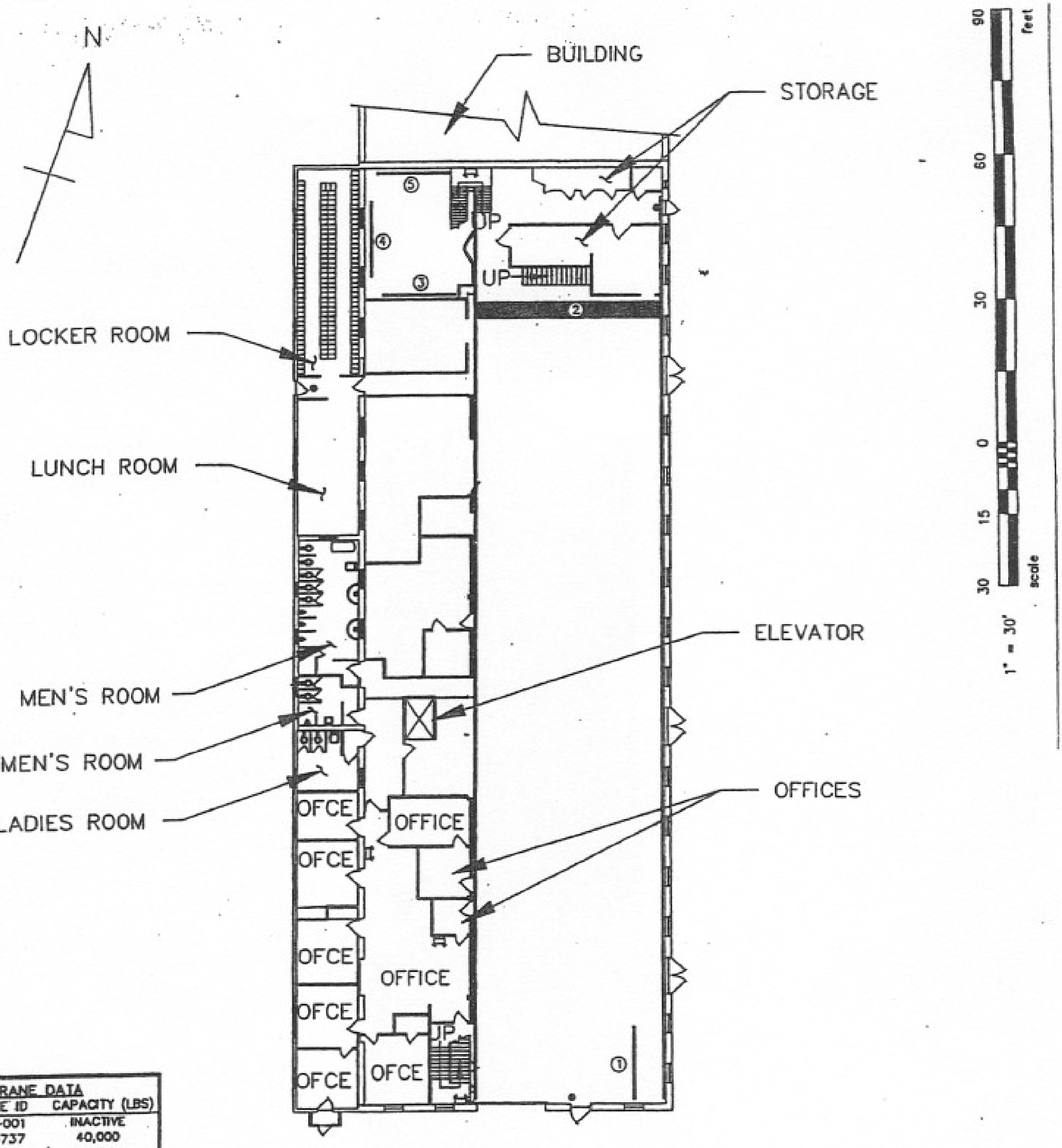
2. As Track Inspector, you are responsible for conducting safety inspections and control inspections including visual and operational inspections per reference (a) and (b). You are responsible for completing and signing Track Inspection Records and for scheduling inspections. You shall supervise movement on noncertified trackage, except for movement of hazardous or nuclear material, provided that defects have been examined to ensure they have not progressed or changed and that occasional movements can be made safely.

3. You are to familiarize yourself with the requirements of references (a) and (b) and conduct all duties associated with this designation accordingly.

4. You are authorized to prescribe remedial actions to correct or safely compensate for deviations from the requirements of reference (a).

5. This authorization will remain in effect until otherwise notified.

N. B. MCQUERRY



CRANE DATA

No.	CRANE ID	CAPACITY (LBS)
1	45-001	INACTIVE
2	404737	40,000
3	308735	1,000
4	45-005	1,000
5	45-006	INACTIVE

RAIL DATA

60# RAIL GAGE: 38'-5-1/2"
21'-1" AFF LENGTH: @190'

LEGEND

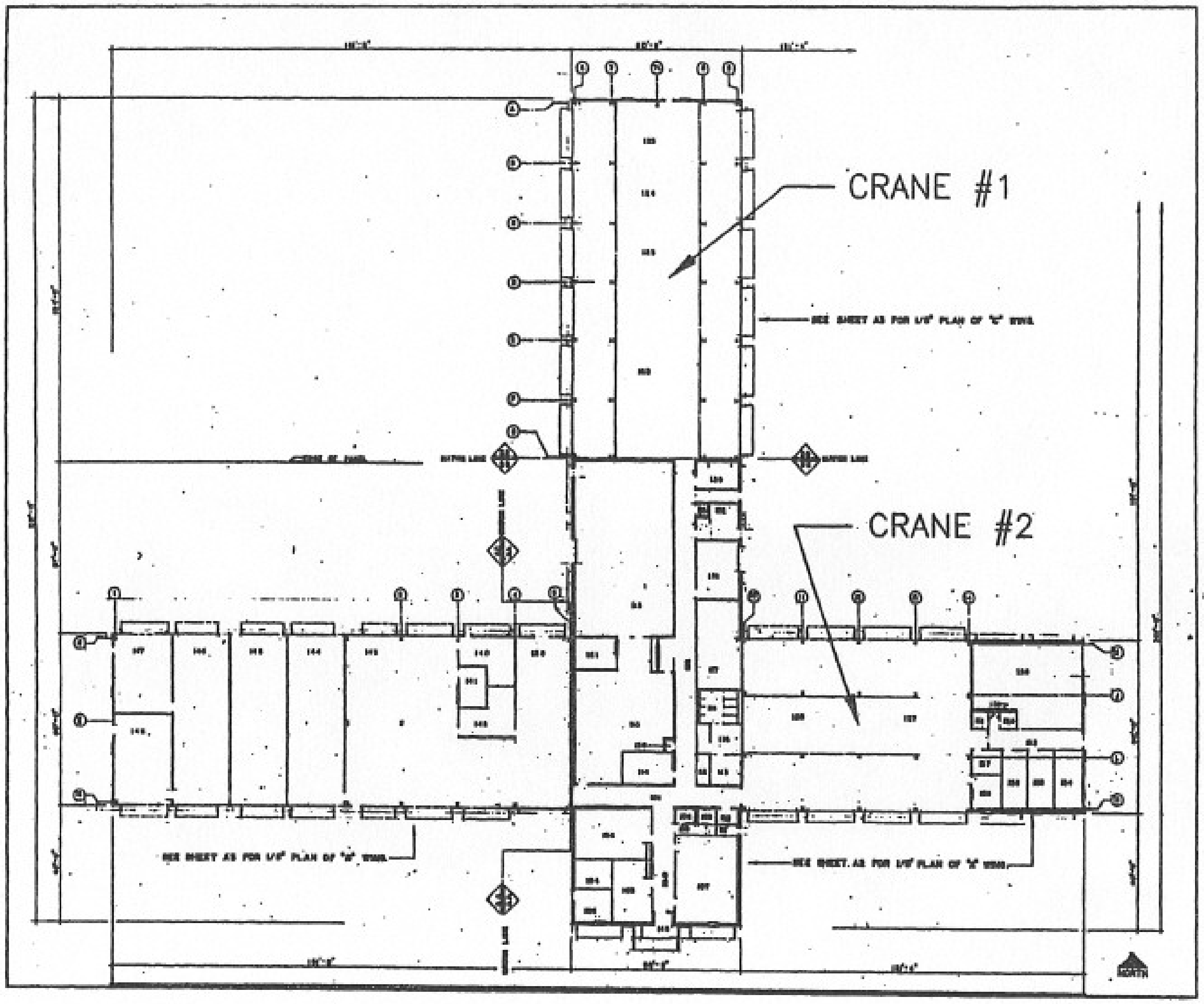
⊗ — EXIT LIGHT
— EMERGENCY LIGHT
— REMOTE LIGHT

DRAWN BY: CODE 280.2
DATE: 7/15/94

FIRST FLOOR PLAN

SCALE: 1"= 30' SHEET 1 OF 3

BUILDING 45
SHOP 99



RAIL DATA (CRANE #1)
??# RAIL
GAGE: 30 FT
LENGTH 100 FT
17'-4-1/2" AFF

AFF=ABOVE FINISH FLOOR

RAIL DATA (CRANE #2)
??# RAIL
GAGE: 20 FT
LENGTH 60 FT
17'-3-1/4"" AFF

AFF=ABOVE FINISH FLOOR

CRANE DATA

NO.	CRANE ID	CAPACITY (LBS)
1		10000
2		8000

NCBC-PUBLIC WORKS
ENGINEERING DIVISION

TITLE: BLDG 241 CRANE CHART

CLASS INFORMATION	STUDENT NOTES

Trainees should be able to:

- explain the purpose of inspecting and testing elevated rail.
- identify the frequency requirements for inspecting elevated rail.
- identify proper rail terminology.
- identify common rail defects and the three categories they fall under.
- know and understand required documentation for elevated rail inspection.
- know the methods and frequency of non-destructive testing.
- use the "Summary" to propose the potential hazards of a given rail defect.

Background

The prevention of rail service failures has been one of the greatest challenges of railroads since the early days. The causes of rail failure are many and the effects of are often serious, and sometimes, deadly. Most serious rail accidents resulting in injury and death have occured on commercial railroads. The development of field rail inspections and testing has come about because of the need to prevent rail defects from causing rail failure and possible tragedy.

Rail manufactured by todays modern methods is vastly superior to the early types of rail; but still defects occur during manufacturing. These defects can and will cause rails to fail unless detected in advance of a failure.

CLASS INFORMATION	STUDENT NOTES
As a result of the need for inspection and testing of rail to prevent failure, a Railroad safety standard was developed, and is contained in the Code of Federal Regulations, Title 49-Transportation, Part 213.	
Although this standard applies primarily to standard gage railroad track, it forms the foundation for the inspection, certification, and testing of all other trackage. The common defects found in standard gage track can also be found in elevated crane rail and ground level crane trackage. Inspection experience has shown, however, that defects develop into failures less frequently in elevated rail systems due to the more rigid support of the rail.	
The Navy document, "Inspection, Certification, and Audit of Crane and Railroad Trackage", NAVFAC Instruction 11230.1E*, establishes procedures used for all trackage at Naval facilities. The FRA standard is one of the attachments contained in the document.	**NAVFAC Instruction 11230.1E**
Note: A thorough understanding of the requirements of this instruction is necessary to become a Track Inspector for all shipyard trackage. However, this course is designed to increase the knowledge of Crane Inspectors in order to perform Elevated Rail Inspection as part of their job. Most of the defects and criteria contained in the instruction are the same for elevated rail as they are for ground level trackage.	
Aspects of elevated rail inspection are discussed in lesser detail in the NAVFAC Instruction than ground level railroad trackage and crane trackage. You will be given a modified version for "Elevated Rail" extracted from the original instruction, for use in this training course only.	

CLASS INFORMATION	STUDENT NOTES

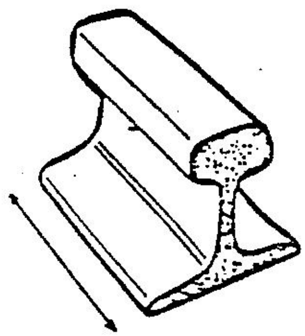
II. PRESENTATION

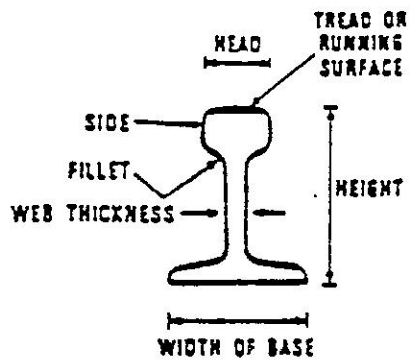
DEFINITIONS

ELEVATED CRANE TRACKAGE

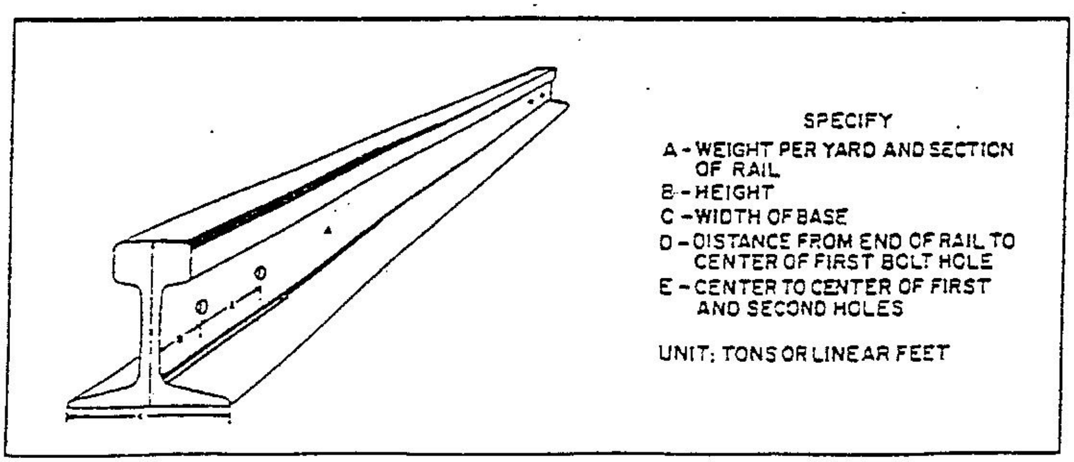
See Para 1.0.3 of NAVFACINST 11230.1E

All trackage systems attached to or suspended from side walls, columns, building, roofs, or separate superstructures. This includes trackage for overhead or bridge cranes, wall cranes, and semi-gantry cranes. The term "trackage" includes rails, rail accessories, support structures, foundations, signs, and markings.





TYPICAL RAIL TERMINOLOGY



RAIL DETAILS

Note the important specifications for identifying repacememt rail.

CLASS INFORMATION	STUDENT NOTES
RAIL DEFECT CATEGORIES	See Para 1.4 of NAVFACINST 11230.1E

1. Catastrophic (serious) defects include unsafe track conditions based on engineering judgment and experience, and defects requiring immediate replacement or repair of rail. (~~3.2.1~~) 1.4.1

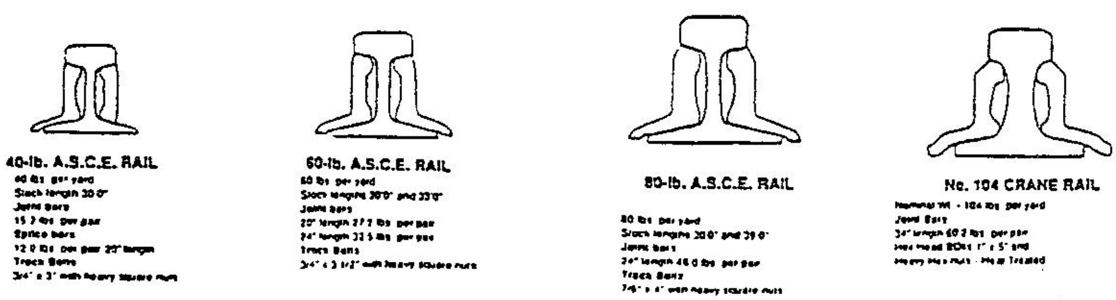
2. Critical (Potentially Serious) defects allows continued use of Trackage provided the operating speed over the defective section is reduced and the defect or defects are carefully inspected at intervals of not more than every six months. (~~3.2.2~~) 1.4.2

3. Marginal (Not Serious) defects are deficiencies that will not cause damage to the trackage system or operating equipment, or endanger personnel safety and that should be scheduled for routine maintenance and repair. (~~3.2.3~~) 1.4.3

CRANE RAIL EXAMPLES

1. Note weight per yard, standard lengths, joint bar, and track bolt specs.

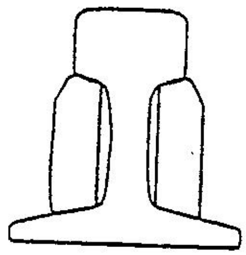
2. Note the thicker web in crane rails Compare No. 104 to the others.



CROWNED RAILS

CLASS INFORMATION	STUDENT NOTES
3. Note that No. 171# and No. 175# Crane rail is much heavier than most rail used for railroads.	

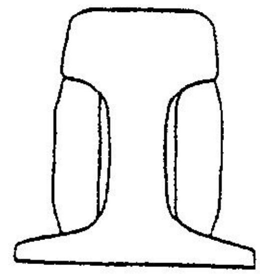
Crowned Rail



NO. 105 CRANE RAIL

Nominal Wt. - 105 lbs. per yard
Joint bars
34" length 51.6 lbs. per pair
Hex Head bolts 7/8 x 4 7/8" and
Heavy Hex nuts - Heat Treated

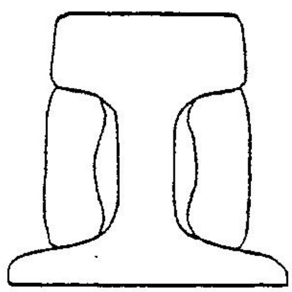
Crowned Rail



NO. 135 CRANE RAIL

Nominal Wt. - 135 lbs. per yard
Joint bars
34" length 57.8 lbs. per pair
Hex Head bolts 1 1/8 x 5 1/2" and
Heavy Hex nuts - Heat Treated

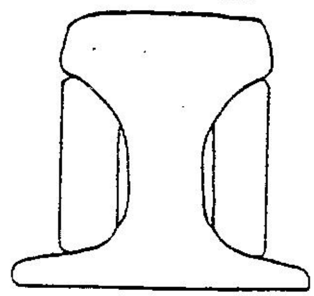
Flat Rail



NO. 171 CRANE RAIL

Nominal Wt. - 171 lbs. per yard
Joint Bars
34" length 72.1 lbs. per pair
Hex Head Bolts 1 1/8" x 6" and
Heavy Hex nuts - Heat Treated

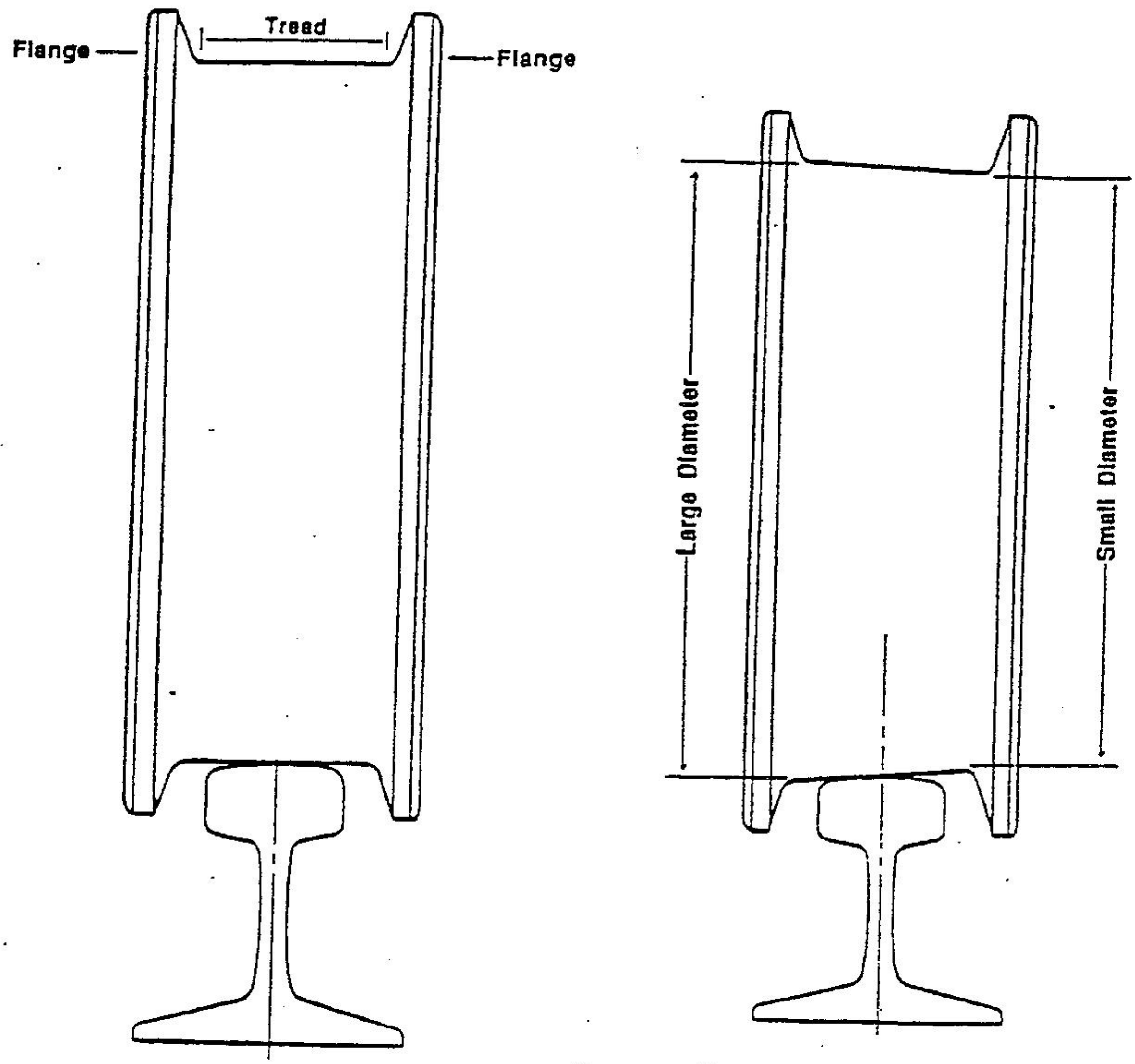
Crowned Rail



NO. 175 CRANE RAIL

Nominal Wt. - 175 lbs. per yard
Joint Bars
34" length 69.4 lbs. per pair
Hex Head Bolts 1-1/8" x 6" and
Heavy Hex nuts - Heat Treated

CLASS INFORMATION	STUDENT NOTES
4. Strait wheels are required on "Flat" rail and may be used on crowned rail. Tapered wheels may only be used on crowned rail and should only be used as drivers.	



No more than .007: variation from all Driver Wheels

STRAIGHT AND TAPERED BRIDGE WHEELS

NOTE: P&H Crane Co. recommends no more than 0.07" difference in diameters of the tapered drive wheels.

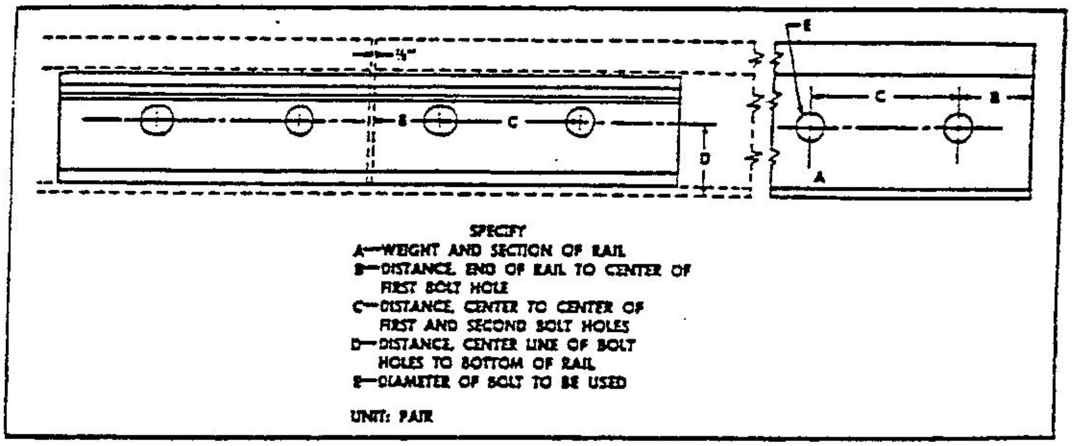
CLASS INFORMATION	STUDENT NOTES

JOINT BARS

1. Used to make the rail a continuous girder to support the crane.

2. Important specifications (as identified picture) for joint bars. Note the oval shaped holes for track bolt shoulder.

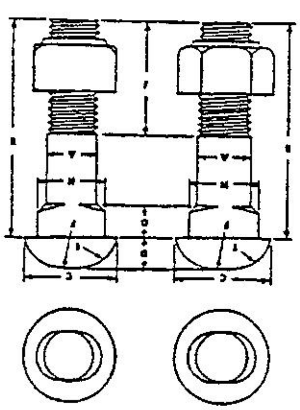
3. Ordered in pairs for specific rail sizes.



JOINT BAR DETAIL

TRACK BOLTS

1. Note the oval shoulder on the bolt and the staggered application of bolts in joint bars during installation.

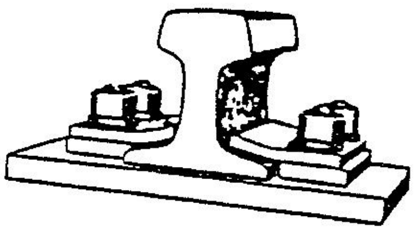


TRACK BOLT DETAIL

CLASS INFORMATION	STUDENT NOTES

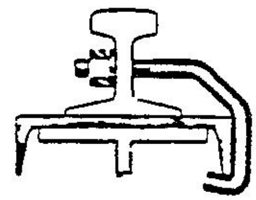
HOLD DOWN DEVICES

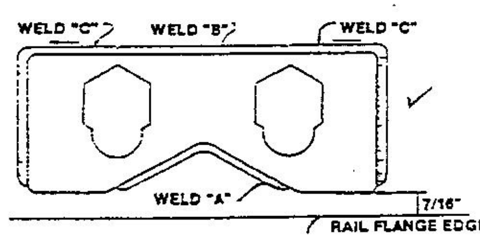
1. Rail clips may be bolted or welded. Welding is preferred. They are staggered rather than opposed. Normally spaced not more than 24" o.c. Must be installed to allow no side to side movement.



Rail Clips

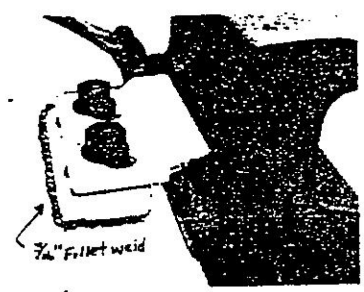
J or Hook Bolts





HOLD-DOWN DEVICES

NOTE: An exception is the Gantrex System, which has a bonded rubber surface which holds the rail and allows minor movement. This system also allows easy realignment of rail due to the adjustable design.



2. J-bolts or Hook bolts usually used only on lower capacity rail systems.

MISCELLANEOUS TERMS

Related terms associated with rail can be found in the glossary of the NAVFAC MO-103, "Maintenance of Trackage". An abbreviated glossary relative to Elevated Rail has been taken out of the NAVFAC Document for reference during this course.

CLASS INFORMATION	STUDENT NOTES

TRACK GEOMETRY

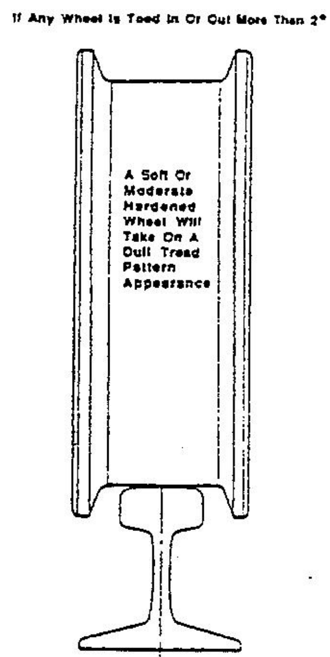
Horizontal and vertical aspects of Track Geometry, such as gage, track straightness, grade or slope, and rail-to-rail elevation must be investigated when any of the following are found:

See Para 4.2.3 of NAVFACINST 11230.1E

1) Indications of abnormal wear on the rail heads or on wheel flanges.

Refer to Flange & Rail Wear Page 10

Normally, the rail surface appears to be shiny and the wear pattern is consistent along the length of the rail. Depending on the hardness of the wheels, a dull appearance (if different from one wheel to the next) may indicate a crane wheel alignment problem. **Remember to look closely at the equipment that is running on the rail to see if it relates to a rail problem.**

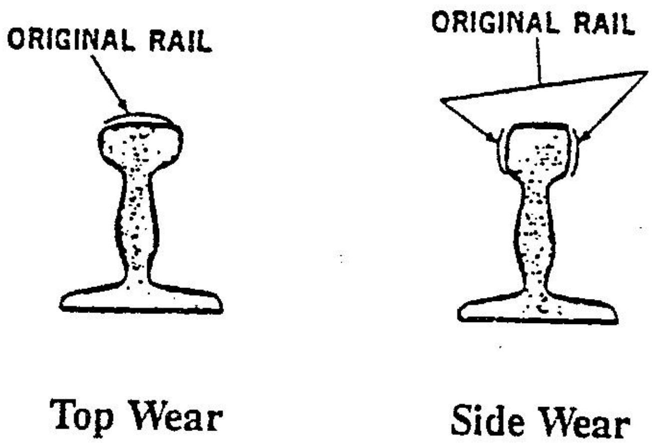


WEAR PATTERN INSPECTION

2) New rails installed or any portion of a rail is realigned.

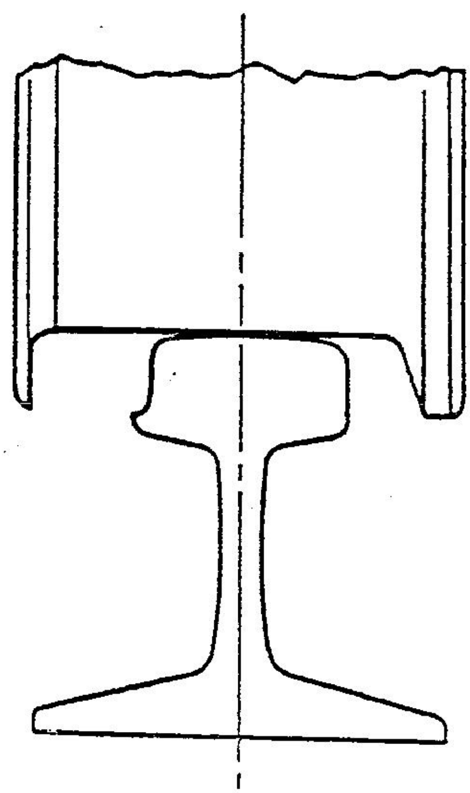
3) Operating crane binds on trackage, has difficulty in starting or has trouble with movement.

For criteria, see Summary of Defects.



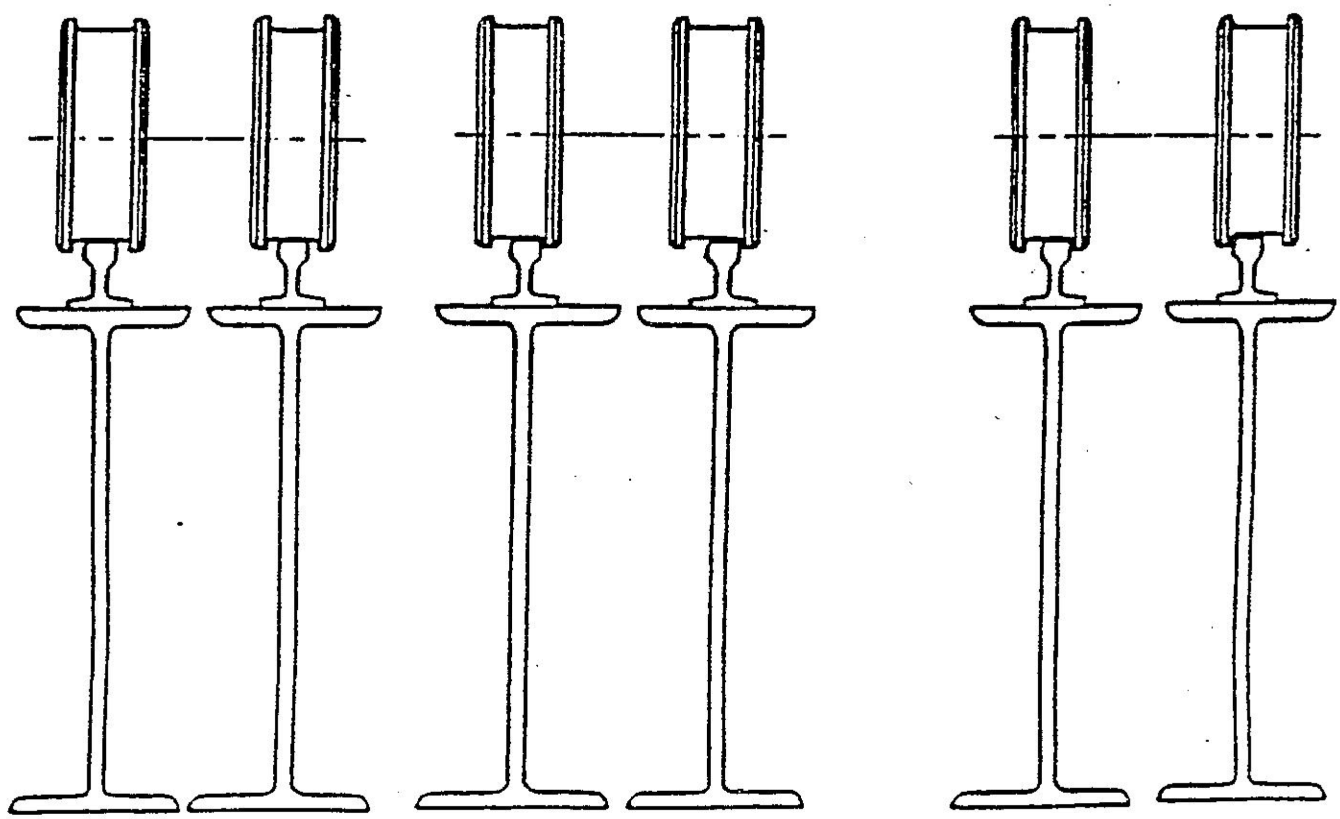
RAIL WEAR

An example of one cause of rail wear.



FLANGE & RAIL WEAR

CLASS INFORMATION	STUDENT NOTES
An indication of incorrect rail span or alignment problems. There may be evidence of excessive rail and wheel flange wear.	

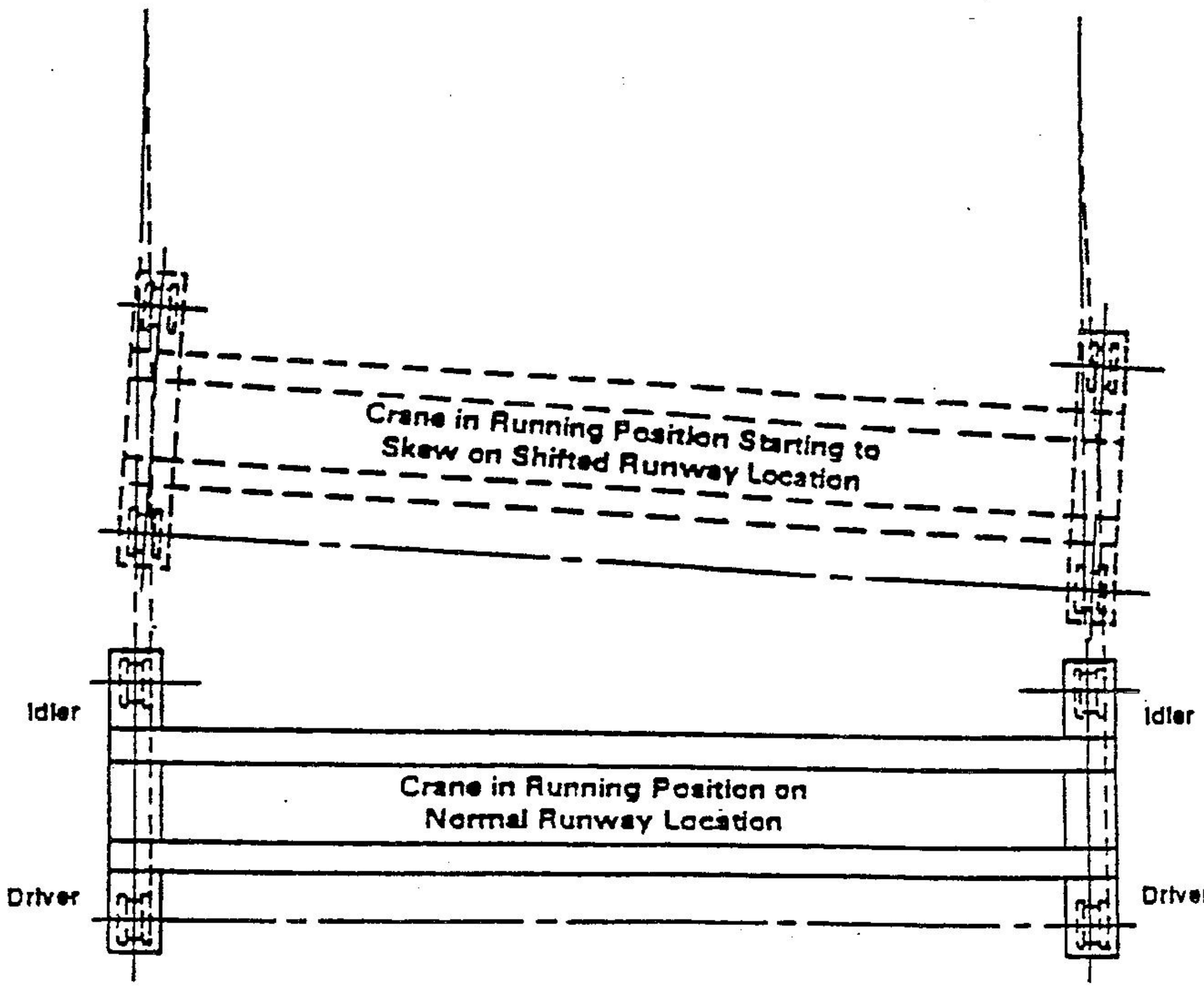


Normal

Potential Problem

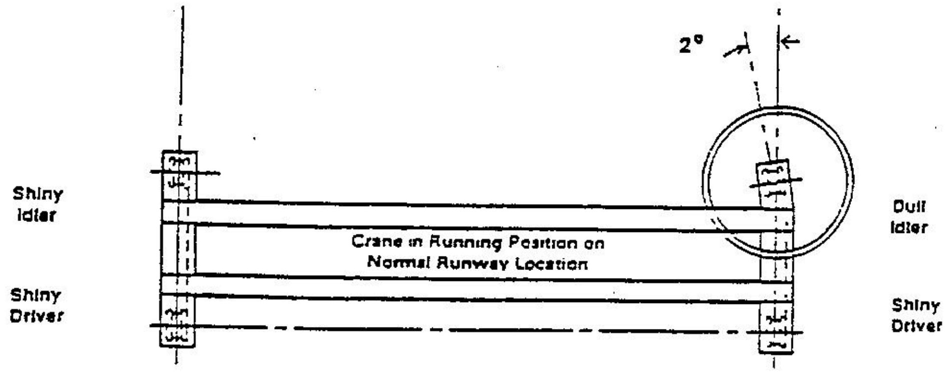
WHEEL TO RAIL RELATIONSHIPS

CLASS INFORMATION	STUDENT NOTES
Skewing could be a result of rail alignment problems or a crane caused problem.	

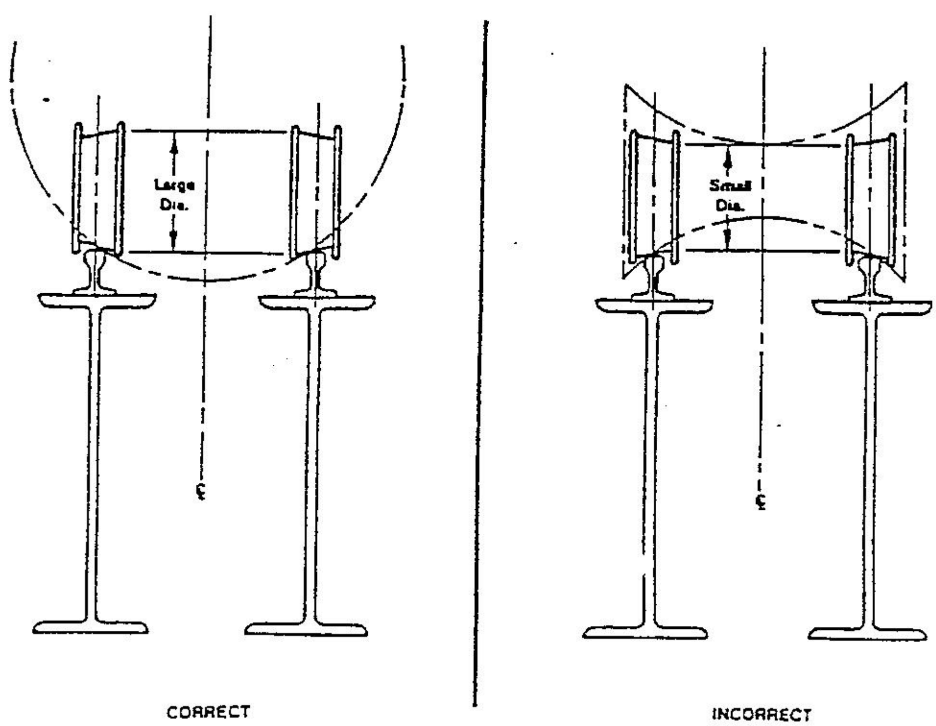


CRANE SKEWING

CLASS INFORMATION	STUDENT NOTES
Note again that the dull appearance of the wheel may indicate a wheel/truck alignment problem. Skewing can also be caused from improper installation of tapered drive wheels.	



COCKED BRIDGE WHEEL



TAPER TREAD WHEEL INSTALLATION

CLASS INFORMATION	STUDENT NOTES

4) When a potential deficiency of trackage can be observed, heard or felt.

5) There are indications of substructure settlement, failure or other structural changes.

6) Visual observations indicate that the acceptable limits may exceed those shown in Summary of Defects.

7) Tests, inspections, experience or engineering judgment indicate operation or rail alignment problems.

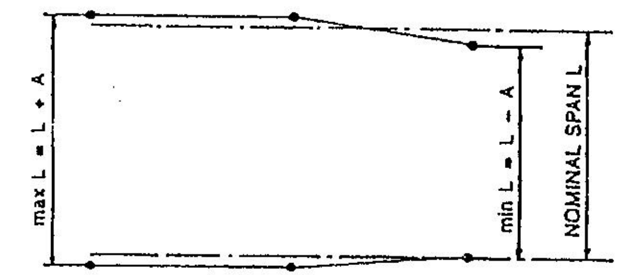
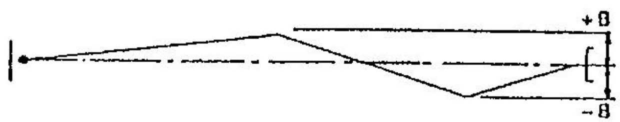
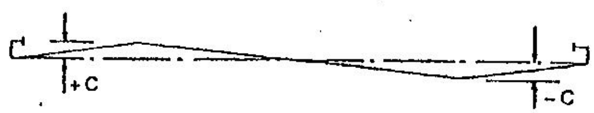
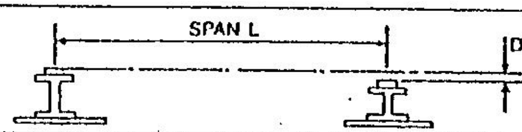
8) Cranes roll after stopping.

Aspects of track geometry should be checked annually, however, measurements are required only when conditions in paragraph ~~3.3~~ 4.2.3 exist.

GRADE

Elevated Crane Trackage should be kept near level grade. Grade must not cause the crane to roll freely or present problems in starting or stopping the crane.

Cross-sectional elevation differences should be checked when the conditions described in paragraph ~~3.3~~ 4.2.3 exist.

ITEM	FIGURE	OVERALL TOLERANCE	MAXIMUM RATE OF CHANGE
SPAN		L<50' A = 3/16" 3/16" L>50'<100' A = 1/4" 1/4" L>100' A = 3/8" 3/8"	1/4" 1/4" IN 20'-0"
STRAIGHTNESS		B = 3/8" 3/8"	1/4" 1/4" IN 20'-0"
ELEVATION		C = 3/8" 3/8"	1/4" 1/4" IN 20'-0"
RAIL-TO-RAIL ELEVATION		L<50' D = ± 3/16" 3/16" L>50'<100' D = ± 1/4" 1/4" L>100' D = ± 3/8" 3/8"	1/4" 1/4" IN 20'-0"

*CMAA Specification #70

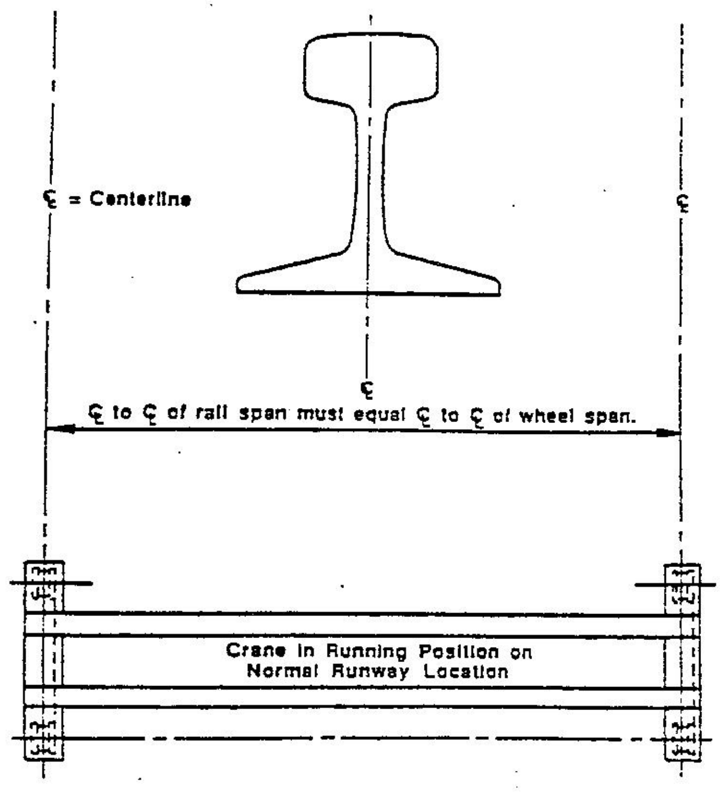
Rail Alignment

Span

CLASS INFORMATION | STUDENT NOTES

The ~~gage~~ of trackage shall be held within the tolerances specified by the crane manufacturer or as computed from the existing crane wheel spacing. Gage of elevated crane trackage only needs to be measured when circumstances listed in paragraph ~~3.3~~ 4.2.3 are not caused by other problems.

See Para 4.2.3.5 of NAVFACINST 11230.1E



BRIDGE SPAN

The correct method of measuring the gage on spans over the standard railroad gage.

MISCELLANEOUS

Classification of defects listed in this section shall be made based on evaluation by the Activity and appropriate action shall be taken.

See Para 4.2.4 of NAVFACINST 11230.1E

CLASS INFORMATION	STUDENT NOTES

Cracked, broken, loose or otherwise defective accessories that do not permit excessive rail movement may be considered as negligible (not serious) and repaired according to normal work schedules.

Safety features apply to all trackage systems and may also be included in the crane, building, or other inspection reports. There shall be no missing, loose or broken components, bad welds, accumulation of debris, heavy corrosion or severe deterioration of the following trackage appurtenances:

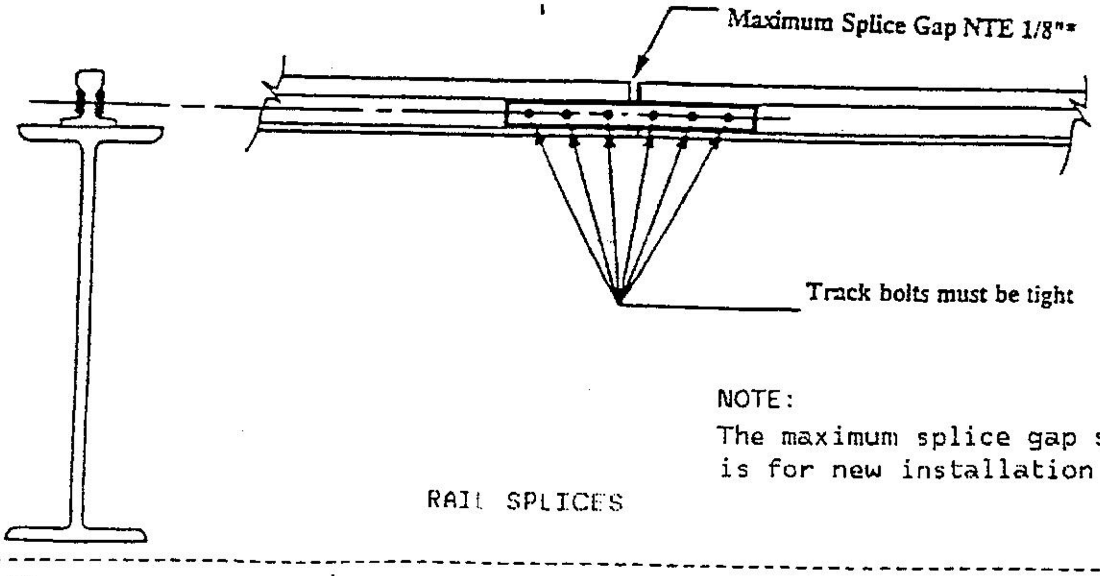
1) Ladders, Platforms, and Hand Rails.

2) Rail Stops.

3) Caution signs and other warning signs.

4) Any other features that could cause a mishap.

Missing, broken, deteriorated or worn bolts which permit movement of rails 1/4 inch or less may be considered "negligible" (not serious), provided that the criteria in attachment (3) is met.



NOTE:
The maximum splice gap shown is for new installation only.

RAIL SPLICES

SAFETY CONSIDERATIONS

Recommended practices in elevated rail inspection include, but are not limited to, the following:

1. When out on the rail supporting structure in areas where handrails are not available, or practical, safety belts must be used.
2. When possible, use a man-lift or a personnel lifting device to inspect elevated rail.
3. When using the bridge crane to access the rails, move the crane to the rail to be inspected, stop the crane, inspect the rail to the extent possible, then repeat the process to inspect the entire rail.
4. Use extreme caution when moving from the bridge crane end-truck to the rail supporting structure.
5. Avoid bending over to inspect the web. Use a large angled mirror mounted on a handle.
6. Avoid areas near energized crane power supply or "third rails".
7. Always inspect in teams. Use the buddy system for safety!
8. Remember: Safety is the #1 priority.

The following glossary has been taken from the NAVFAC MO-103, "Maintenance of Trackage".

GLOSSARY

BROKEN BASE - Any break in the base of a rail.

COMPOUND FISSURE - A progressive fracture originating in a horizontal split head which turns up or down in the head of the rail as a smooth, bright or dark surface, progressing until substantially at a right angle to the length of the rail. Compound fissures require examination of both faces of the fracture to locate the horizontal split head from which they originate.

CORROSION - The dissolving or eating away of the surface of metal through chemical action, either regularly and slowly as by rusting in air, or irregularly and rapidly as by pitting and grooving in the interior of boilers.

CRUSHED HEAD - A "flattening" or crushing down of the head of a rail.

DAMAGED RAIL - Any rail broken or injured by wrecks, broken, flat or unbalanced wheels, slipping or similar causes.

DETAIL FRACTURE - A progressive fracture originating at or near the surface of the rail head. These fractures should not be confused with transverse fissures, compound fissures, or other defects which have internal origins. Detail fractures usually have their origins in the following types of defects, and progress crosswise into the head of the rail.

Shell - Where a thin shell of metal becomes separated from the head, usually at the gage corner.

Head Checks - Usually at or close to the gage corner where movement or flow of surface metal is sufficient to start a hairline crack.

ENGINE BURN FRACTURE - A progressive fracture originating in spots where driving wheels have slipped on top of the rail head. In developing downward they frequently resemble the compound or even transverse fissure with which they should not be confused or classified.

FASTENINGS - Joint bars, bolts, and spikes.

Auxiliary - Nut locks, spring washers, tie plates, rail braces, and anti-creeping devices.

FLOWED HEAD - A rolling out of the metal on top of the head of a rail toward the sides without showing any indication of a breaking down of the head structure.

FOOTING - A structural unit used to distribute wall or column loads to the foundation materials.

FOUNDATION - Material, including piling or other special construction, which supports the structure and its loads.

GAGE (of Track) - The distance between the gage lines, measured at right angles thereto. (Standard gage is 4 feet 8 1/2 inches.)

HORIZONTAL SPLIT HEAD - A horizontal progressive defect originating inside of the rail head, usually 1/2 inch or more below the running surface and progressing horizontally in all directions, and generally accompanied by a flat spot on the running surface. The defect appears as a crack lengthwise of the rail when it reaches the side of the rail head. (See Compound Fissures).

JOINT, RAIL - A fastening designed to unite the abutting ends of contiguous rails.

Insulated - A rail joint designed to arrest the flow of electric current from rail to rail by means of insulation so placed as to separate the rail ends and other metal parts connecting them.

JOINT BAR - A steel member, embodying beam-strength and stiffness in its structural shape and material; commonly used in pairs for the purpose of joining rail ends together, and holding them accurately, evenly, and firmly in position with reference to surface and gage-side alignment.

JOINT GAP - The distance between the ends of contiguous rails in track, measured at a point 5/8 inch below the top of the rail on the outside of the head.

LAP - A surface defect on metal appearing as a seam caused from folding over hot metal, fins, or sharp corners and then rolling or forging, but not welding them to the surface.

LEVEL - The condition of the track in which the elevation of the two rails transversely is the same.

ORDINARY BREAK (Square or Angular Break) - Any partial or complete fracture in which there is no sign of a fissure, and in which none of the other defects or damage is visible.

PIPED RAIL - One with a vertical split, usually in the web, due to failure of the sides of the shrinkage cavity in the ingot to unite in rolling.

PROFILE - A line representing the ground surface or an established grade line, or both, in relation to the horizontal.

RAIL (Track) - A rolled steel shape, commonly a T-section, designed to be laid end to end in two parallel line on cross-ties or other suitable supports to form a track for railway rolling stock.

SETTLEMENT (Noun) - The term settlement as applied to grading material is the reduction in elevation of an embankment caused by shrinkage or subsidence.

SHATTER CRACKS - Minute cracks in the interior of rail heads, seldom closer than 1/2 inch from the surface, and visible only after deep etching or at high magnification. They may extend in any direction. They are caused by rapid (air) cooling, and may be prevented from forming by control cooling the rail. Shatter cracks also occur in other steel products.

SHIM - A small piece of wood or metal placed between two members of a structure to bring them to a desired relative elevation.

SKEW - Having an axis at any other angle than right.

Angle of - The angular deviation of one of two intersecting lines from a right angle to the other.

SPLIT WEB - A longitudinal or diagonal transverse crack in the web of a rail.

SURFACE (Track) - The condition of the track as to vertical evenness or smoothness.

TOLERANCE - An allowable variation from dimensions or requirements specified.

TRACK - An assembly of rails, ties, and fastenings over which cars, locomotives, and trains are moved.

TRACK BOLT - A bolt with a button head and oval, or elliptical, neck and a threaded nut designed to fasten together rails and joint bars.

TRANSVERSE DEFECT - For defects found by detector cars, a tentative group classification, applied prior to the breaking of the rails, of all types of rail defects which have transverse components, such as transverse fissures (TF), compound fissures (CF), and detail fractures (DF).

TRANSVERSE FISSURE - A progressive crosswise fracture starting from a crystalline center or nucleus inside the head from which it spreads outward as a smooth, bright or dark, round or oval surface substantially at a right angle to the length of the rail. The distinguishing features of a transverse fissure from other types of fractures or defects are the crystalline center or nucleus and the nearly smooth surface of the development which surrounds it.

TREAD - The top surface of the head of a rail which contacts wheels.

VERTICAL SPLIT HEAD - A split along or near middle of the head of a rail and extending into or through it. A crack or rust streak may show under the head close to the web, or pieces may be split off the side of the head.

WELDED RAIL - Two or more rails welded together to form a length less than 400 feet (CWR).

Tips for Avoiding Crane Runway Problems

DAVID T. RICKER

Mill and heavy industrial type buildings are usually designed with two main functions in mind: to provide a sheltered work area and to support lifting devices which serve to move loads from one location to another. Providing shelter involves fairly routine design procedures, utilizing well-known and tested guidelines. But supporting the transporting device, or crane system, is a more complicated and intricate task and efforts in this regard have not always been successful. In fact, many otherwise sound heavy industrial structures are plagued with problems which stem from the method of supporting the crane system.

There are several different types of cranes: overhead traveling, underslung, jib, gantry, and monorail are among the most common. A building may contain one or several of the above, either singly or in various combinations.

Although all of these cranes have their own special problems, this paper is concerned with the one which generally has the potential to deal the most punishment to its supporting system—the overhead traveling crane. This type of crane is available in a vast range of capacities from 1 ton to well over 300 tons.

An overhead traveling crane runway system consists of the following components:

1. The crane, comprising the bridge girder, end trucks, trolley, hoist, power transmitting devices, and usually a cab which houses the controls and operator. (See Fig. 1.)
2. The crane rails and their attachments.
3. The crane beams, girders, or trusses.
4. The crane columns, or bents.
5. The crane column bracing.
6. The crane column foundations.
7. The crane stops.
8. The conductor rail supports.

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The crane (or cranes) directly affects the other components of the structure. When the owner selects the crane, he must consider load capacity, space limitations, and the class of service which he requires. When designing the crane runway, the engineer takes into account these requirements plus other factors such as potential future changes in load capacity, the addition of other cranes, various load combinations, and the possible extension of the runway. Few other structures suffer such an extreme range of stresses and as high an incidence of maximum loadings and fatigue as crane runways, and this must also be considered by the engineer. In addition he must be aware of the infinite variety of abuses inflicted on crane systems, such as hoisting loads which exceed the crane capacity, swinging loads pendulum fashion, dragging loads longitudinally along the crane runway, dragging loads laterally from one crane aisle to another, dropping loads pile driver fashion (as when freeing heavy castings from their molds), and ramming the crane against the crane stops at excessive speed to realign the bridge (make it perpendicular to the rails). Murphy's Law is liberally applied in most plants with unbelievable ingenuity—if something *can* happen it *will* happen, sooner or later. The runway had best be able to handle it. An unsuspecting engineer, guided mainly by economics, may be lulled into designing a runway component as he would any other member in the structure; he is then often appalled by the rapid and violent deterioration of his handywork. The crane runway is often one of the most important parts of an industrial operation; significant "down time" required for repairs and maintenance can be disastrous to the owner.

AISC has established reduced allowable stresses for fatigue loadings (AISC Manual,[1] 8th Edition, Appendix B) and guidelines for impact and horizontal loads for crane runways (AISC Specification Sects. 1.3.3 and 1.3.4). References 2 and 3 (both available from AISC) contain much worthwhile information regarding crane runway design and performance and must be considered among the definitive references on the subject today.

This paper is intended to expose and discuss some of the problems associated with crane runways. It will examine each of the eight components of the crane runway, pointing

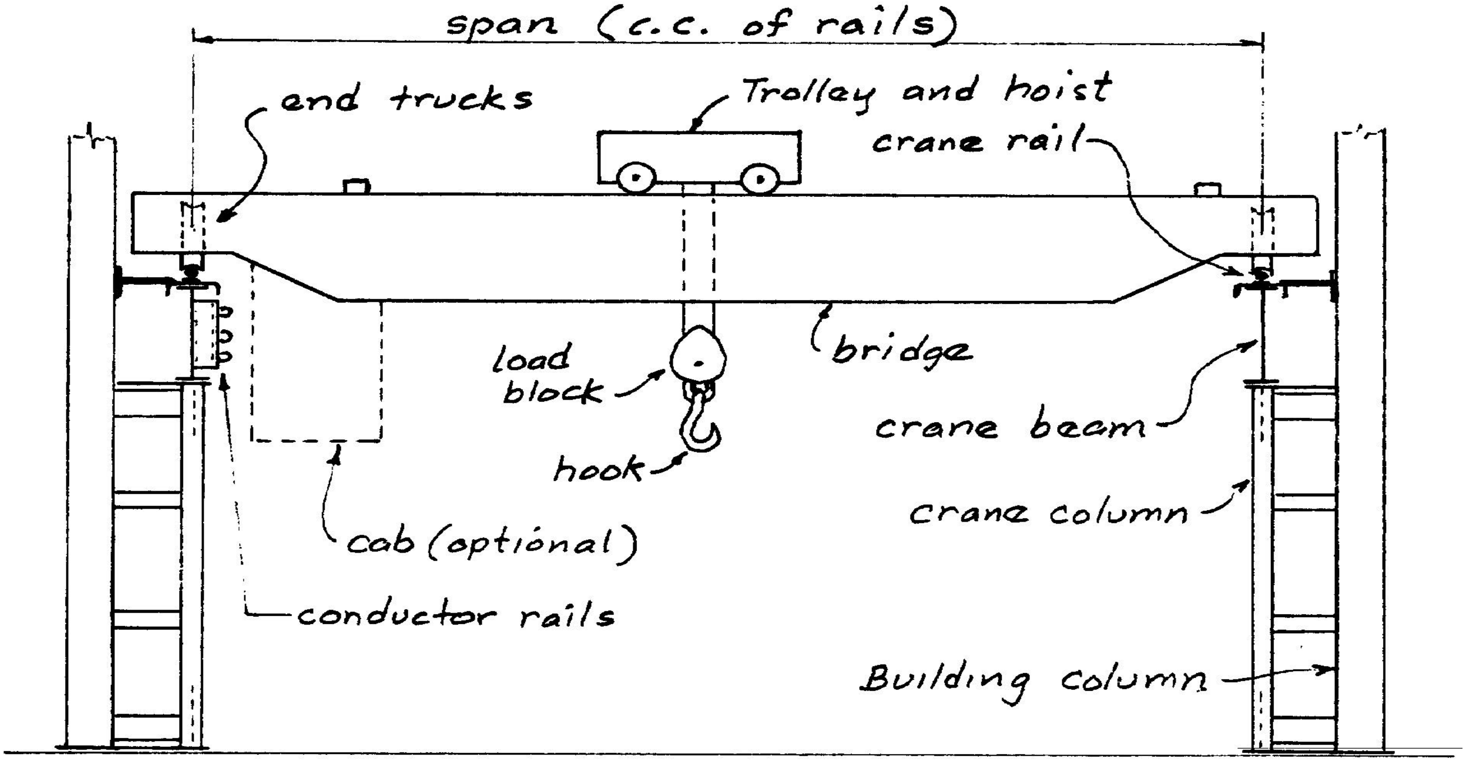


Figure 1

out pitfalls, dos-and-don'ts, suggested details and safeguards, and certain aspects which are considered good practice today. It is *not* the intent herein to instruct engineers in how to design a crane runway; this subject is amply covered in many texts, including the aforementioned references.

CRANE SERVICE CLASSIFICATIONS

The Crane Manufacturers Association of America (CMAA) has established service classifications[4] to aid a purchaser in selecting the most economical crane to satisfy his particular requirements. These classifications are as follows:

Class Al (Standby Service) —This service class covers cranes used in installations such as power houses, public utilities, turbine rooms, nuclear reactor buildings, motor rooms, nuclear fuel handling and transformer stations, where precise handling of valuable machinery at slow speeds (see Table 1 for representative bridge crane speeds) with long idle periods between lifts is required. Rated loads may be handled for initial installation of machinery and for infrequent maintenance.

Class A2 (Infrequent Use) —These cranes will be used in installations such as small maintenance shops, pump rooms, testing laboratories, and similar operations where loads are relatively light, speeds are slow, and a low degree of control accuracy is required. The loads may vary anywhere from no load to full rated load with a frequency of a few lifts per day or month.

Class B (Light Service) —This service covers cranes such as used in repair shops, light assembly operations, service buildings, light warehousing, etc., where service requirements are light and speed is slow. Loads may vary from no load to full rated load with an average load of 50% of rated load with 2 to 5 lifts per hour, averaging 15 ft, not over 50% of the lifts at rated load.

Class C (Moderate Service) —This service covers cranes such as used in machine shops, paper mill machine rooms, etc., where the service requirements are medium. In this type of service the crane will handle loads which average

Table 1. Representative Bridge Crane Speeds, ft/min. (Ref. 7)

Capacity (tons)	Slow	Medium	Fast
10	200	300	400
50	200	250	300
100	100	150	200
150	100	125	150
200	100	125	150
250	100	125	150

50% of the rated load with 5 to 10 lifts per hour, averaging 15 ft, not over 50% of the lifts at rated load.

Class D (Heavy Duty) —This service covers cranes, usually cab operated, such as are used in heavy machine shops, foundries, fabricating plants, steel warehouses, lumber mills, etc., and standard duty bucket and magnet operation, where heavy duty production is required but with no specific cycle of operation. Loads approaching 50% of the rated load will be handled constantly during the working period. High speeds are desirable for this type of service with 10 to 20 lifts per hour averaging 15 ft, not over 65% of the lifts at rated load.

Class E (Severe Duty Cycle Service) —This type of service requires a heavy duty crane capable of handling the rated load continuously, at high speed, in repetition throughout a stated period per day, in a predetermined cycle of operation. Applications include magnet, bucket, magnet-bucket combinations of cranes for scrap yards, cement mills, lumber mills, fertilizer plants, etc., with 20 or more lifts per hour at rated load. The complete cycle of operation should be specified.

Class F (Steel Mill, AISE Specification) —Cranes in this class are covered by the current issue of The Association of Iron and Steel Engineers' Standard No. 6 (rev. 1969), *Specification for Electric Overhead Traveling Cranes for Steel Mill Service.*[5] (The AISE is currently revising this standard, now referred to as Technical Report No. 6, which will include a scale of crane classifications ranging from D1 through D9. This report will probably be available within the coming year.)

CRANE RUNWAY DESIGN CONSIDERATIONS

In examining the performance histories of existing crane runways, it is interesting to note why they have or have not performed well. Several things become apparent. Some design aspects permitted on light crane runs should not be attempted on heavy crane runs; cranes with long bridge spans (over 50 ft) should be treated differently than those with shorter spans; fast, heavy service cranes require special considerations not required for slower, lighter cranes, etc. There are several conflicting schools of thought on certain aspects of runway design over which engineers have argued for years, such as hook bolts vs. clamps, tight clamps vs. floating clamps, stepped columns vs. separate crane columns, etc. Sometimes it happens that for a certain set of conditions both parties may be correct, but one solution may have an economic advantage whereas another might provide greater longevity. The client often has a difficult choice to make.

The important thing to remember is that, due to the large range of crane sizes and uses, it is virtually impossible to establish a single set of rules applicable to all. History has dealt harshly with those who blindly follow rules. Wars have been lost, catastrophes have struck, and crane runways have "beat themselves to death," because someone did not consider the factors from which the rule evolved and did not adjust the rule to compensate for a changing set of factors.

Loading Considerations —The following loading considerations must be taken under advisement by the designer:

1. Maximum wheel load and wheel spacing.
2. The effects of multiple cranes in the same aisle or in adjacent aisles.
3. Impact.
4. Traction and braking forces.
5. Impact forces on crane stops.
6. Cyclical loading and the effects of fatigue.
7. Lateral horizontal loads.

Many variations of single and multiple crane loadings are possible. It is better left to the designer's judgment and experience to determine what is most suitable for the particular set of parameters from which he must mold his design.

Fisher and Buettner,[2] pp. 59 through 66, is an excellent reference for various loading conditions and combinations, as is AISE Technical Report No. 13.[3]

During preliminary design studies, the specific crane information necessary for the final design may not be available. It is often necessary to estimate loadings. Table 2, taken from Merritt's *Structural Steel Designers' Handbook*,[6] p. 6-18, is helpful. When the crane information does become available, it should be carefully compared to the estimated loadings and adjustments made to the preliminary design as required.

Miscellaneous Considerations —The designer must consider the manner in which the crane runway attaches to the main structure. The runway girder flexes as it is stressed and means of connecting must be devised to minimize the transfer of this motion into the main part of the structure. However successful the connection may be, it must be assumed that a structure with a crane will receive more motion than one without, and the design of the other building components must be implemented with this in mind.

Occasionally a crane runway may extend beyond a building to service an outside area. Figure 2 shows several typical runway profiles commonly used.

Fabrication and construction tolerances also enter into crane runway design, and provisions must be made in the various components for vertical and horizontal alignment. Adjustments must be provided for such things as inaccuracies in foundation work, deviations in column plumbness, mill tolerances of rolled shapes, sweep in crane beams, and fabrication tolerances in the crane itself.

Crane manufacturers supply clearance data for their products. The clearance area must be clear of *everything:* gusset plates, connection angles, bolt or rivet projections,

Table 2. Assumed Minimum Load for Light to Medium Cranes (Ref. 6)

Capacity (tons)	Span c. to c. rails (ft)	Wheel base (ft)	Load at each wheel (kips)	Required*** clearance		Rail** weight (lb per yd)
				Vertical (ft)*	Side (in.)	
5	40	8.5	13	6	10	30
	60	9.0	15			
10	40	9.0	19	6	10	40
	60	9.5	21			
15	40	9.5	25	7	12	60
	60	10.0	29			
20	40	10.0	33	7	12	60
	60	10.5	36			
25	40	10.0	40	8	12	60
	60	10.5	44			
30	40	10.5	48	8	12	60
	60	11.0	52			
40	40	11.0	64	9	14	60
	60	12.0	70			
50	40	11.0	72	9	14	80
	60	12.0	80			
60	40	13.0	88	9	16	80
	60	14.0	94			

* Low headroom cranes are available; consult manufacturer.
** Also see Table 3.
*** With reference to top of rail.

roof trusses or rafters deflecting under full load, sagging horizontal roof bracing, pipes, conduits, and *all else*. Infringing on the clearance space in order to gain a few inches of hook height is poor policy, especially if it shuts down a crane operation after every heavy snow storm.

It has previously been mentioned that the crane characteristics govern other aspects of the runway design. Some of these characteristics are:

1. Hook capacity (amount of lifted load including lifting devices).
2. Crane weight.
3. Hoist and trolley weight.
4. Crane clearance and hook height.
5. Class of service.
6. Speed of travel, rates of acceleration and braking.
7. Span (center to center distance of rails).
8. Number of wheels and their spacing.
9. Maximum wheel load.
10. Type and location of collector rails (or other power source).
11. Size of runway rail.
12. Length of compression stroke of the bumper device.
13. Height of bumper above the top of the crane rail.

The hook capacity, crane weight, trolley and hoist weight, and lateral hook range determine the vertical wheel loads which are delivered to the runway via the crane rails. These wheel loads are included in the information which the crane manufacturer furnishes with his product. However, sometimes this information is required before a crane manufacturer is selected. Table 3 will be helpful as a general guide in selecting rail size.

RAILS

Rails are identified by initials and weight in pounds per *yard*. Rails are available in 30, 33 or 39 ft lengths, depending on size and manufacturer. Table 4 lists most of the common crane rail sizes.

The size of the crane rail is determined by wheel loads, type, and class of service. The crane manufacturer usually indicates the rail size for a new installation. If a new crane is purchased for an existing crane run, the crane manufacturer will supply wheels to match the existing rail, if the rail is of adequate size and configuration.

In addition to the direct load of the wheel, rails are subject to lateral forces due to horizontal hoist movement, mishandling of loads, skewing of the bridge, misalignment of the rails, and seismic influences. Crane bridges with long spans (over 50 ft c. to c. of rails) have a greater tendency to skew due to deformation of the bridge structure. Skewing accelerates wheel and rail wear and requires the use of more electric power. Longitudinal stresses in rails exist due to temperature differential, traction and braking, stretching in the area directly above the junction of adjacent deflected crane beams, and, in some cases, the impact of the crane bridge hitting rail-mounted wheel stops (one reason to avoid

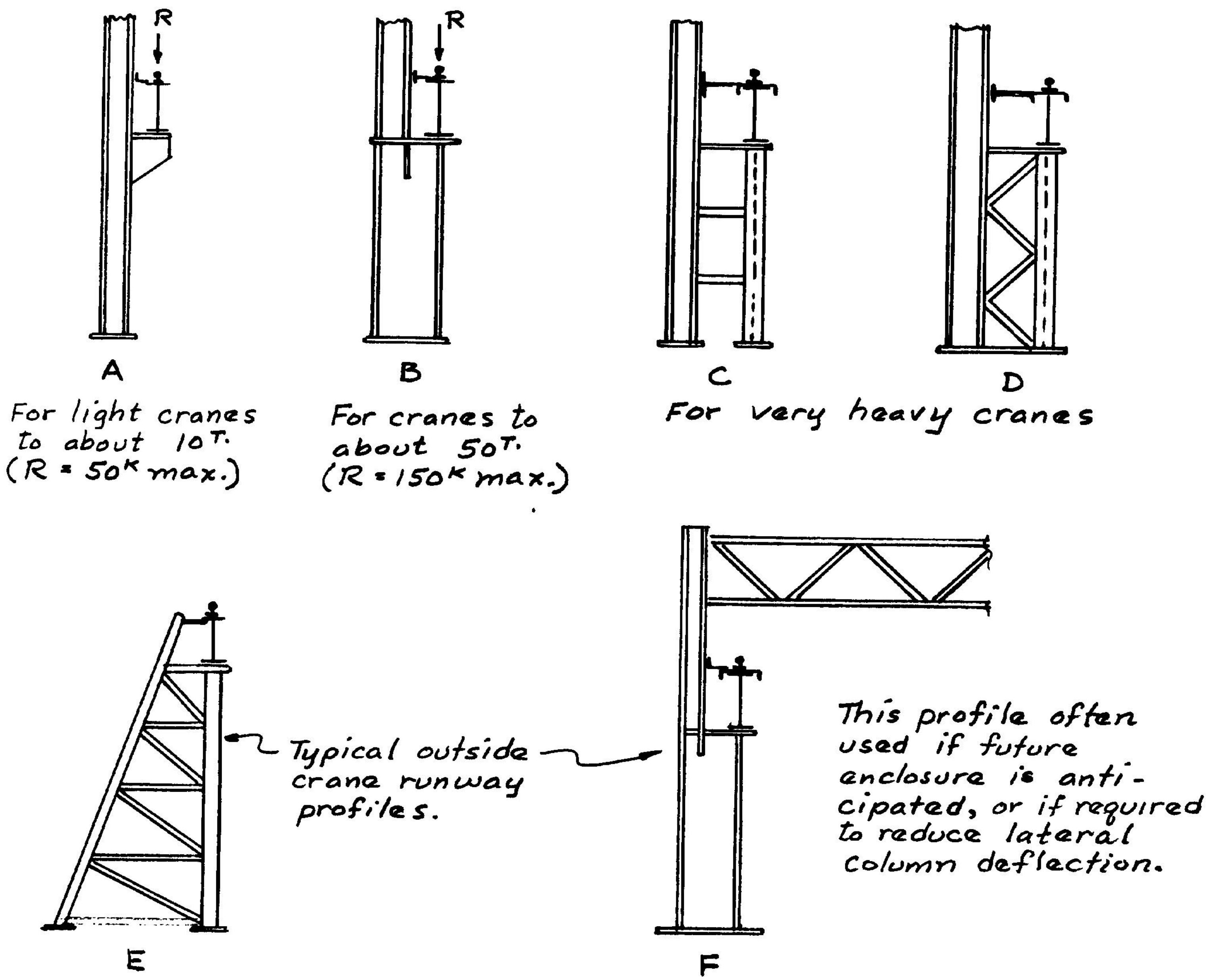


Fig. 2. Typical crane runway profiles

the use of this type of stop). Also, if rail splices are allowed to "open up" so that gaps exist, the rail ends are subject to a hammering action from the wheels, which can result in peening or chipping of the rail ends and may also inflict damage or speed the wear on the wheels.

Rails are generally spliced either by bolting or welding. The most common choice is bolting. Bolted splices are simple to install and relatively easy to dismantle if rails must be replaced or realigned. Welded splices provide a relatively smooth running surface if made properly, but require expensive preparation and welding techniques and make it difficult to repair or replace rails if the need arises. An example of a welded splice being justified might be where it is desired to have a very smooth running Class A1 crane on a short runway, with the life of the rail anticipated to outlast the life of the structure.

Rails for heavy service cranes (Class D, E, and F) should have tight splice joints and these rails should be ordered with milled ends and the splice bars should be indicated for a "tight fit." The size range for these rails is usually 104# and above. If requested, the rail manufacturer will drill the rails for the splice bar holes and also for hook bolts if that method of rail attachment is specified. The *Whiting Crane Handbook*[7] and the AISC Manual[2] recommend that, when ordering rails for use on crane runways, the order be noted "for crane service." However, two major rail manufacturers state that the phrase "for crane service" will net the purchaser a "control cooled" rail. A "control cooled" rail has

Table 3. Allowable Loads on Rails (lbs) (Ref. 7)

CMAA Service Class	Wheel diam. (*D*) in.	ASCE 30#	ASCE 40#	ARA-A 90#	ASCE 60 & 70#	ASCE 80 & 85# Beth 104# USS 105#	ASCE 100#	AISE 135#	AISE 175#	Beth 171#
Class Al & A2:	8	13610	16000							
Power House &	9	15310	18000	23900	25200					
Infrequent	10	17010	20000	26600	28000					
Service	12	20410	24000	31900	33600	36000	40800			
Class B:	15	25510	30000	39800	42000	45000	51000			
Light Service	18	30610	36000	47800	50400	54000	61200			
Class C:	21		42000	55800	58800	63000	71400	75600	105000	117600
Moderate	24			63800	67200	72000	81600	86400	120000	134400
Service	27					81000	91800	97200	135000	151200
P = 1600 *WD*	30					90000	102000	108000	150000	168000
	36						125000	130000	180000	202000
	8	11900	14000							
	9	13390	15750	20900	22050					
	10	14880	17500	23200	24500					
Class D:	12	17860	21000	27900	29400	31500	35700			
Heavy Duty	15	22320	26250	34900	36750	39380	44630			
Service	18	26790	31500	41800	44100	47250	53550			
P = 1400 *WD*	21		36750	48800	51450	55130	62480	66150	91880	102900
	24			55800	58800	63000	71400	75600	105000	117600
	27					70880	80330	85050	118130	132300
	30					78750	89250	94500	131250	147000
	36						107200	113600	157800	176500
	8	10200	12000							
	9	11480	13500	17900	18900					
Class E:	10	12760	15000	19900	21000					
Severe	12	15310	18000	23900	25200	27000	30600			
Duty-Cycle	15	19130	22500	29900	31500	33750	38250			
Service	18	22960	27000	35900	37800	40500	45900			
P = 1200 *WD*	21		31500	41800	44100	47250	53550	56700	78750	88200
	24			47800	50400	54000	61200	64800	90000	100800
	27					60750	68850	72900	101250	113400
	30					67500	76500	81000	112500	126000
	36						92000	97300	135000	151000

Notes: The loading limits for Class E are also recommended wherever travel speeds exceed 400 fpm.
W = effective width of rail head
D = diameter of wheels

a Brinnel Hardness range of about 240 to 280. A "heat treated" rail has a Brinnel Hardness range of about 321 thru 388. "Heat treated" rails will accept wheel loads about 20% greater than "control cooled" rails. An alternative to these two types of rails is to order the rails "control cooled" and with "ends hardened" (or "ends quenched"). Hardening the ends of the rails provides protection where the wear and abuse is likely to be the greatest. *Rails for heavy service cranes should be ordered "heat treated."*

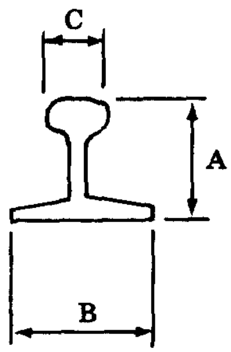
If rails and splice bars are not ordered for a "tight fit," the splice will generally have a small gap in the order of 1/16-in. to ⅛-in. The rail ends are sheared or sawed and then "dressed up" to varying degrees. These are suitable only for light service (Class A2, B) cranes operating at relatively low speeds. Plain unpunched rails are also available from rail manufacturers if custom fabrication such as special punching and/or end finishing is required.

Splice bars should be ordered from the same source as the rails so that the holes will properly line up. Splice bars are ordered in pairs and include the bolts, lock washers, and nuts (or lock nuts). The AISC Manual,[1] pp. 1-106 and 1-107, contains general information on rails and rail splices, but the catalogue of specific rail manufacturers should be consulted before ordering.

Rail joints on one side of a crane runway should be staggered so that they do not line up with those on the opposite

Table 4. Rail Sizes and Dimensions [7]

Type & weight per yard	A (in.)	B (in.)	C (in.)	Sect Mod. ($in.^3$)
ASCE 25	2¾	2¾	1½	1.76
ASCE 30	3⅛	3⅛	1 11/16	2.5
ASCE 40	3½	3½	1⅞	3.6
ASCE 60	4¼	4¼	2⅜	6.6
ASCE 70	4⅝	4⅝	2 7/16	8.2
ASCE 80	5	5	2½	10.1
ASCE 100	5¾	5¾	2¾	14.6
Beth 104	5	5	2½	10.7
USS 105	5 3/16	5 3/16	2 9/16	12.4
AISE 135*	5¾	5 3/16	3 7/16	17.2
AISE 175*	6	6	4¼	23.3
Beth 171	6	6	4 5/16	24.5



* Also known as USS 135, Beth 135, USS 175, Beth 175.

side. The amount of the stagger should be at least 1 ft, and should *not* be the same as the spacing of the crane wheels. Never locate a rail splice near a crane beam splice. Do not use pieces of rail shorter than approximately 10 ft if avoidable.

There are three methods of attaching rails to the supporting members:

1. Hook bolts
2. Clamps
3. Welding (not recommended)

Hook bolts are satisfactory for fastening the rails for slow moving cranes of Class A2 or B service where the capacity is not over approximately 5 tons and the bridge span is under about 50 ft. Properly made hook bolts provide good adjustment and hold down forces for these light service installations. They can be used for wide-flange crane beams and also those with channel caps (see Fig. 3), and they are useful on beams with flanges too narrow for clamps. Hook bolts are installed alternately in pairs, each bolt about 3 or 4 in. apart and each pair about 2 ft apart. Hook bolts do have a tendency to loosen up, even though they are installed with lock washers or lock nuts. Broken hook bolts sometimes result if they were not properly heated during their manufacture.

Clamp plates are a more positive method of attachment and there are several types in common use: steel plates with fillers, and steel forgings in many patterns with single- and two-hole versions. There are also several ingenious patented rail clamp devices now available on the market. Clamps are available in either fixed or floating types (Fig. 3). A "fixed" clamp holds the rail tightly to the supporting member, with alignment being accomplished through eccentric punching of the filler plates. A "floating" clamp permits controlled longitudinal and transverse rail movement. Adjustment is by means of eccentrically punched fillers the same as with "fixed" clamps. Clamps should be spaced 2 to 3 ft apart on each side of the rail and may be installed in opposing pairs or staggered.

Single-hole clamps should be avoided. Although most are designed not to rotate, they have been known to do exactly this, resulting in a camming action which tends to force and keep the rails out of alignment. Two-hole clamps do not have this problem and should be used on all but the most insignificant crane system.

The decision of whether to specify a "fixed" or "floating" rail system is one which has been argued hotly for many years. Both have been used successfully and both have been accused of causing problems. AISE Technical Report No. 13[3] recommends "floating" rails. (It should be mentioned that the AISE places emphasis on heavy service steel mill cranes.) Crane manufacturers generally prefer "fixed" rails. The AISC is neutral.

A "floating" rail is harder on rail splices which are not ordered for a "tight fit." In time the splices tend to open up due to thermal contraction and longitudinal, braking and

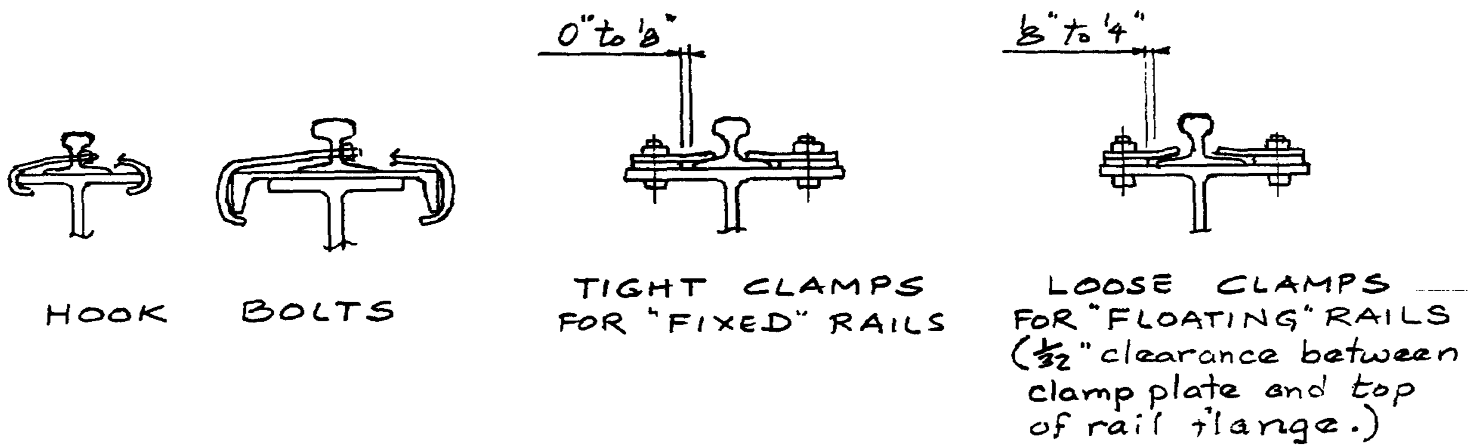


Figure 3

traction loads (similar to a string of boxcars leaving a railroad yard). The movement is almost imperceptible, but in time can wear grooves in the supporting crane beam. Grooving is most prevalent in outside runways. The deeper the grooves the sloppier the rail becomes and the problems associated with misalignment become more frequent. This can lead to the requirement that a wear plate be installed beneath the rail.

If a steel wear plate is utilized it should preferably be made easily replaceable, that is, attached by bolting. Often a channel cap can be utilized for a wearing surface and replaced when the amount of wear becomes objectionable. This loss of section should be considered when determining the channel size. Some wear plates are limited to a width equal to the base width of the rail. This requires extra fills under the clamp plates to compensate for the wear plate thickness. This type of wear plate requires occasional checking to see that the "creep" is taking place between the rail and wear plate, as it should and usually does, and not between the bottom of the wear plate and the girder top.

If a quiet, vibration-free crane service is required, fiber pads can be used below the rails. These are not recommended for a "floating" rail system unless a scheme is devised to keep the pads from working their way out from under the rails.

To address the problem of excessive rail "creep," at some installations the owners have tried welding the clamp plates to the rails for a short distance about mid-way of the crane runway length to provide an "anchor zone," thus reducing the amount of creep. This of course prevents future adjustments and may induce forces of unknown magnitude in those crane beams in the anchored areas. Caution, laced with apprehension, should be used when welding *any* rail to its supporting member. The AISC Manual,[1] p. 1-106, also has negative thoughts on the topic of welding rail, and this is good advice.

"Floating" rails on outside crane runs exposed to the weather seem to wear faster, probably because water is held beneath the rail by capillary action and tends to rust between periods of use. However, "floating" rails are sometimes preferred on exterior crane runways which are supported on isolated bents (such as sketch E in Fig. 2), due to the difficulty in keeping this type of runway in horizontal alignment.

We have mentioned several disadvantages with "floating" rails. What are the advantages? "Floating" rails do allow for thermal and other longitudinal movement. (It is generally conceded that building an expansion joint into a *rail* does not warrant the expense.) However, for crane runways over 400-ft long, the crane runway *beams* usually *do* require an expansion joint and the use of a "floating" rail system is advised in this case. For cranes classified for "heavy service" (CMAA Classes D, E, and F), it is advisable to use "floating" rails in order to minimize wear on the rails, wheels, and wheel bearings. Also, "floating" rails should be used if rail splices are ordered for a "tight fit." In general, this will encompass 104# rails and heavier for the above CMAA Classes.

"Fixed" rails do not have the drawbacks of "floating" rails nor do they have the advantages. However, unless there is a reason for using a "floating" rail the nod should go to a "fixed" rail. Most rail installations today are of the "fixed" variety, mainly because there are many more light to medium cranes in service today than there are heavy cranes, and for most of these moderate size cranes a "fixed" rail is suitable and proper.

Fastening a rail to its supporting member by welding is rare and should be avoided unless circumstances dictate otherwise. Once welded, a rail cannot be realigned if the building shifts or settles, and replacement is very difficult. Welding the rail to the crane beam may cause cracking due to the fatigue stresses.

Rail clamps and hook bolts are shown on p. 1-108 of the AISC Manual.[1]

The current *Whiting Crane Handbook*, *4th Edition*,[7] gives the following tolerances for rail alignment: span dimension (c. to c. rails) ±⅛-in., elevation of rails at points opposite each other ±⅛-in., elevation of a rail within the length of the wheelbase ±⅛-in. These figures may seem a bit idealistic, but will none-the-less help to attain a smooth running and problem-free crane system. In actual field conditions the matchup of wheel to rail and certain types of wheel bearings allow for lateral wheel "float" which will usually accommodate a larger tolerance than 1/6-in. A more realistic span tolerance might be ±¼-in. for spans up to 100 ft and ±5/16-in. for spans 100 ft and over, as given in the *3rd Edition* of the *Whiting Crane Handbook*. Runway elevations are subject to greater deviations due to differential settlements of the foundations, especially in long runways which may cover several areas of varied foundation conditions. It is advisable, as we shall see a little later on, to have some means of vertically adjusting the crane runway beams. The magnitude of vertical tolerance allowed is often dependent on what the individual crane can tolerate, and this varies from crane to crane—some being very stiff and others quite limber.

AISE Technical Report No. 13[3] gives the following crane runway tolerances:

Maximum sweep in crane runway girders ¼-in. per 50-ft length of girder span. Camber not to exceed ¼-in. per 50-ft length of girder span over that indicated on the design drawings. Center-to-center of crane rails not to exceed ¼-in. from theoretical dimension. Horizontal misalignment of crane rails not to exceed ¼-in. per 50-ft length of runway with a maximum of ½-in. total deviation from the theoretical location. Vertical misalignment of crane rails measured at the center lines of columns shall not exceed ¼-in. per 50-ft length of runway, with a maximum total deviation of ½-in. from the theoretical location. Crane rails shall be centered on the crane girders wherever possible, but in no case should the eccentricity be greater than three-fourths the thickness of the girder webs.

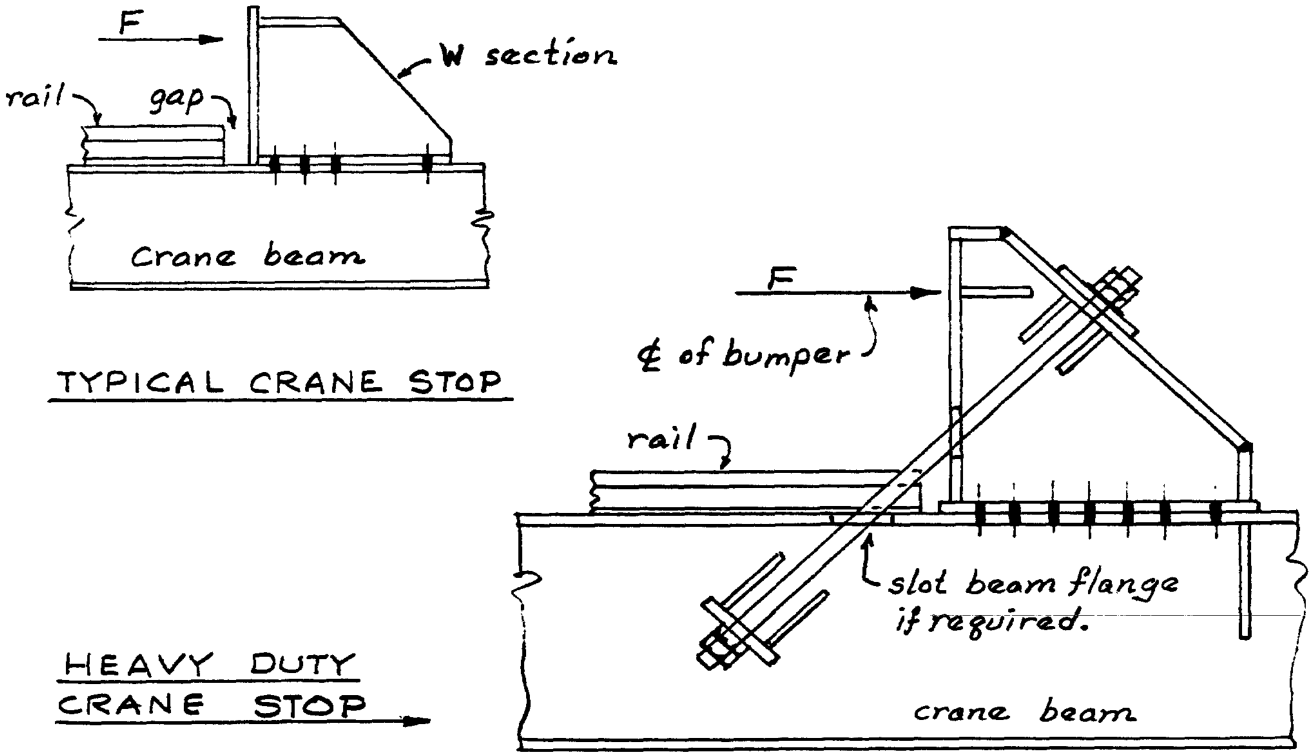


Figure 4

These AISE tolerances seem practical and within the scope of the real world of fabrication and erection.

CRANE STOPS

Crane stops prevent the crane from falling off the end of a runway. They can also be mounted at any location along a runway to keep a crane from advancing beyond that point. This type of crane stop preferably should straddle the rail and connect to the beam, although trolley stops can be used for very light cranes. Crane stops are mounted directly on top of the crane girders. (See Fig. 4.) They should not be confused with trolley stops (or wheel stops) which are attached directly to the crane rail by bolting through the web of the rail. Trolley stops should only be used for the very lightest and slow moving cranes, as they are prone to inflict damage on the wheel bearings.

Figure 4 shows a typical crane stop and a heavy duty stop. Any workable combination of shapes and plates can be used to construct a crane stop. A gap should be provided between the end of the rail and the face of the stop to accommodate expansion and "creep." Allow about 1 in. for each 100 ft of rail, with a maximum of 4 in. The height of the crane stop should be made to suit the height of the crane bumper—generally about 1 ft-6 in. to 2 ft-6 in. above the top of the rail. The crane bumpers are mounted on the bridge trucks directly in line with the center of each rail. Most modern cranes have bumpers which have some energy absorbing feature, such as rubber padding, springs, or hydraulic or pneumatic cylinders. These absorb some of the shock and are less abusive to the runway structure and the crane itself.

Crane stops are commonly used to realign (square up) the crane bridge in respect to the runway and it is important that the crane stops be in true alignment.

The crane stop must be designed to resist the impact force *F* shown in Fig. 4.

The following formula is used to compute the approximate force *F*, in kips, at *each* stop for cranes with energy absorbing springs or cylinders:

$$F = \frac{WV^2}{2gT}$$

where

W = total weight of crane, in kips, *excluding* the lifted load

V = crane speed in ft/*second*. The value of V is taken as 50% of the full load rated speed according to AISE Technical Report No. 6.[5] (See Table 1, which gives velocity in ft per *minute*.)

g = acceleration of gravity = 32.2 fps^2

T = length of travel, in ft, of spring or plunger required to stop crane, usually about 0.15 ft.

The *Whiting Crane Handbook*[7] suggests a value of 40% of the rated load bridge speed in accordance with ANSI Standard B30. Take your choice. The real problem in the above formula is the dimension T. This dimension is not listed in the *Whiting Crane Handbook* and it is doubtful that an engineer could obtain this dimension at the time he is doing his design unless he knows exactly the crane being purchased.

The above formula assumes that each stop shares the load equally (that the resultant inertia force due to the weight of bridge and trolley is located at midspan). This is a common approach. If it can be determined that the resultant inertia force is appreciably off-center, then the force directed against the face of the crane stop should be increased proportionately.

Outside cranes are subject to wind forces which have caused problems over the years. Several cases have been recorded where a crane's brakes were inadequate to resist the force of the wind, causing the crane to ride through the crane stops and fall to the ground. Once, this wind force was estimated by calculating the vertical projected area of the crane and multiplying by a force of about 10 psf. Today, the process is a bit more complicated. Refer to pgs. 92 and 93 of the *Whiting Crane Handbook*,[7] wherein a method of calculating wind pressure is explained based on ANSI recommendations.

When reviewing your calculations for the impact load on a crane stop, it is well to add a good pinch of common sense and judgment.

CRANE BEAMS

The work horse of the crane runway is the crane beam or crane girder or, in some special cases, the crane truss. The crane beam is subject to vertical loading including impact, lateral loading, and longitudinal loading from traction, braking, and impact on crane stops. In addition the crane beams must withstand local buckling under the wheel loads and at the bottom flange over the column (in the common case where the beam bears on a column cap plate).

In this discussion the terms crane beam and crane girder will be considered synonomous and refer to a horizontal load-carrying member, not necessarily a wide-flange section as opposed to a plate girder.

Figure 5 shows several common profiles for crane beams.

The profiles in Fig. 5 can be combined with other shapes to form horizontal trusses and walkways (See Fig. 6.) Observe all appropriate safety codes and considerations when utilizing horizontal surfaces as walkways or platforms.

Simple span crane beams are desirable. Two-span crane beams have dubious benefits. The initial modest cost saving due to the lesser weight of a two-span girder is usually negated by greater labor costs and the inevitable costly maintenance required. The effect of fatigue and prolonged reversal of stress takes its toll on this and other members in the structure. Two-span crane beams can result in uplift on columns at certain loading positions, and differential settlement of columns may result in undesirable additional stresses. A two-span girder makes reinforcement or replacement of the crane beam more complicated and costly. Perhaps the greatest advantage of a two-span girder is the slightly reduced deflection and end rotation.

Crane beams should be designed elastically, *not* plastically. Avoid abrupt changes in cross sections of crane girders.

Crane girders or trusses over approximately 75 ft in length should be cambered for the deflection due to dead load plus one-half the live load without impact.[6] The dead load consists of the weight of the girder or truss. The live load consists of that maximum load delivered to the girder or truss by the crane wheels, exclusive of impact.

Avoid cantilevered crane beams if possible.

In order to gain more stiffness, use ASTM A36 steel for crane beams. If, for any reason, higher strength steel is used, the deflection should be investigated.

Which brings us to a very important subject. The major cause of problems in crane runs is the deflection of crane beams and the accompanying end rotation. This troublesome characteristic transmits motion to other components of the crane runway. The cyclical nature of this movement causes fatigue stresses which may lead to weakening and eventual failure of the parts affected. Stretching of rails, opening of splice joints, column bending, skewing of the crane bridge, and undulating crane motion are among the undesirable side effects.

One of the engineer's principal objectives in the design of a crane runway is to limit the vertical deflection of the crane beam. Many of the most successful crane runways owe their performance record to the fact that someone had the foresight to limit the deflection, although other factors sometimes get the credit. In general, keep the spans as short as possible and the beam depths as large as possible. The design profession is not in total agreement as to the degree of stiffness which is desirable in a crane beam. The following is a brief sampling:

Source	Maximum Vertical Deflection(in.)
Fisher & Buettner[2]	L/600 for Light & Medium Cranes
	L/1000 for Mill Cranes
Merritt[6]	L/750
Gaylord & Gaylord[8]	L/960 for Light Slow Cranes
	L/1200 for Heavy Fast Cranes
AISE Technical Report 13[3]	L/1000

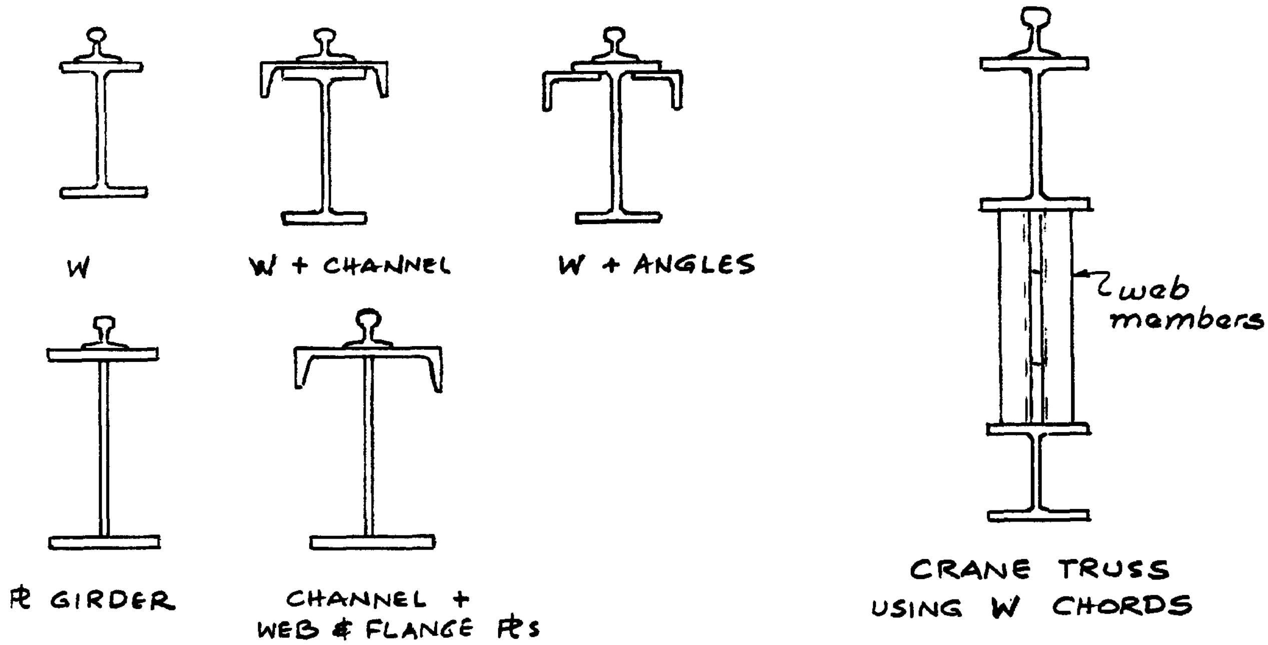


Figure 5

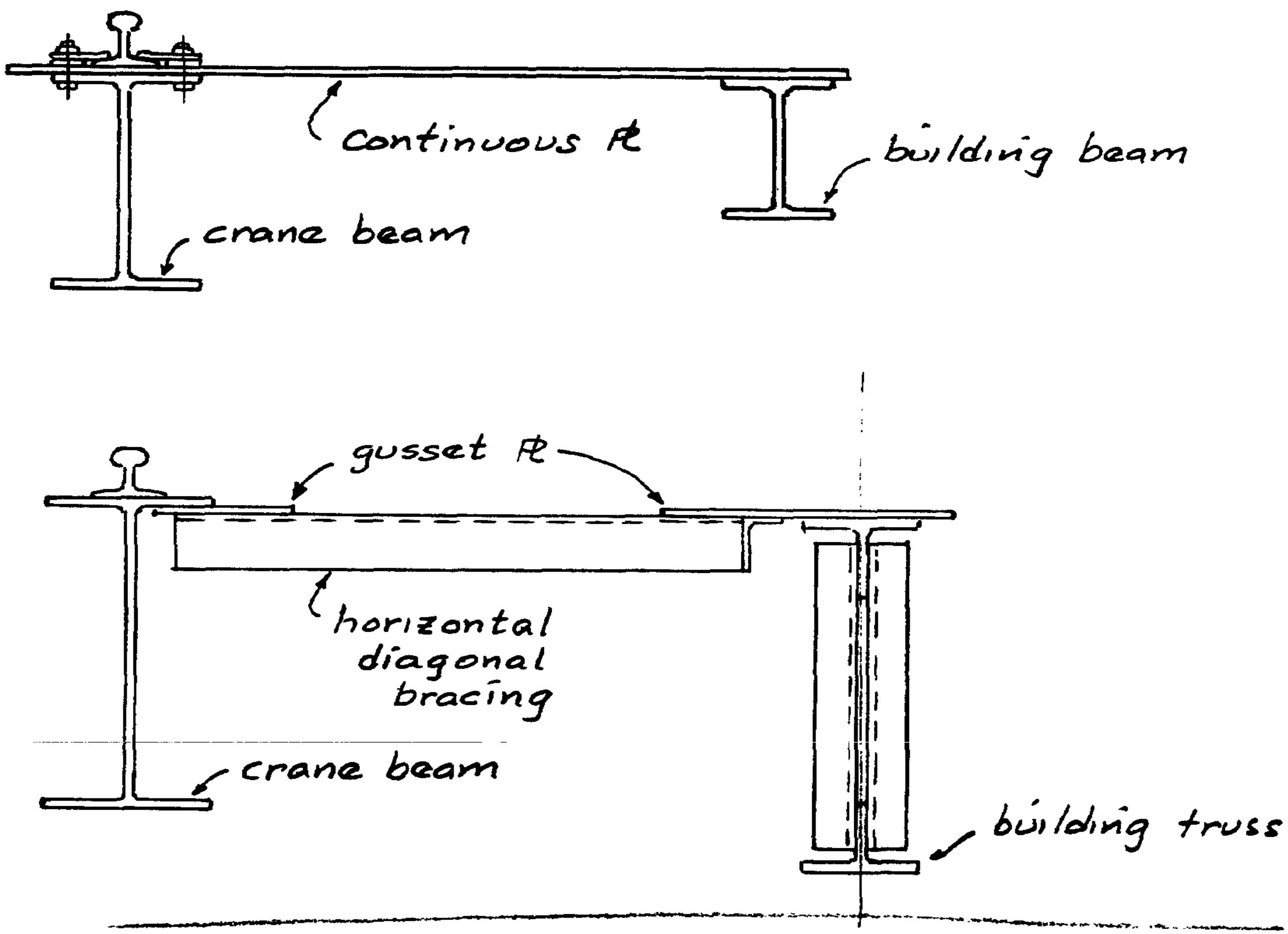


Figure 6

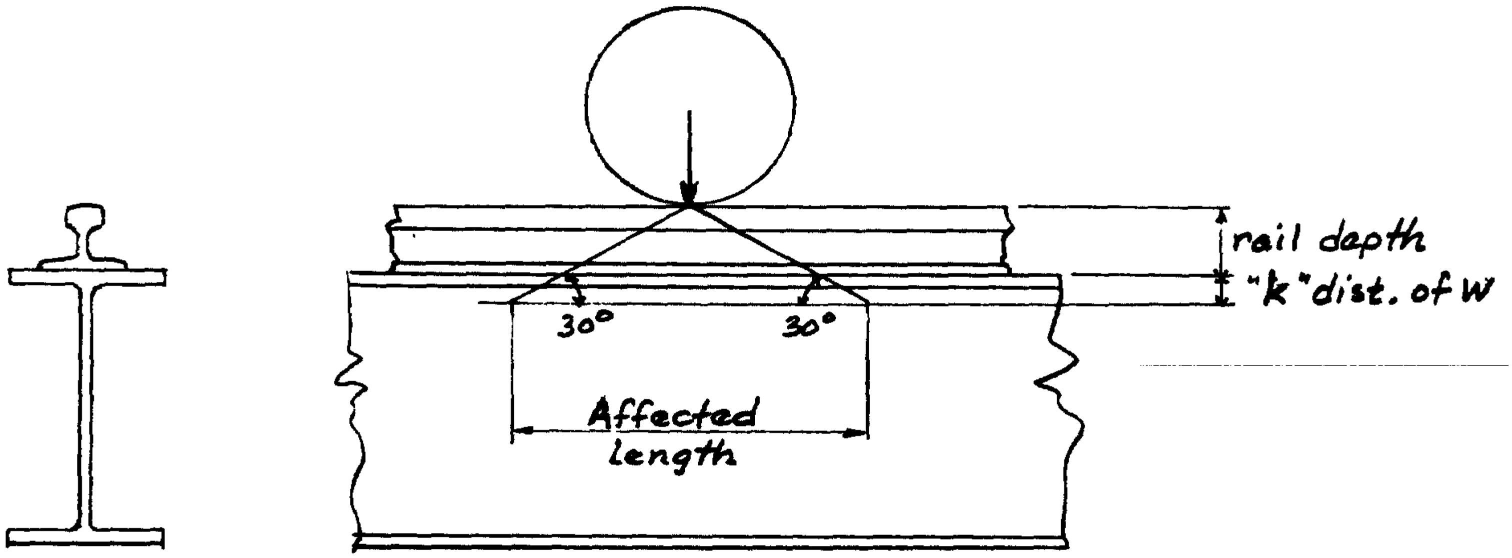


Figure 7

Having viewed the effects of many limber crane beams, this writer recommends that the maximum vertical deflections be limited to $L/1000$ for light to medium cranes and $L/1200$ for heavy cranes. It's the nicest thing you could do for your client and his crane run.

Vertical loads are delivered to the crane beam via the crane rail. The beam web must be capable of withstanding this localized load. The AISE recommends that a full penetration (groove) weld be used between the web and top flange plate of welded plate crane girders in order to maximize the fatigue life of the member.

There has been some conjecture over the years as to what length of web is affected by the concentrated wheel load. The angle of 30° shown in Fig. 7 is a logical average between the 45° pure shear angle and the 22° angle familiar in column stiffener analysis. This reflects the thinking of such notables of a generation ago as C. Earl Webb, Russell Chew, C. T. Bishop, Thomas Shield, and H. H. Shannon, as reported in an article by J. C. Arntzen.[9] This was during the era when most girders were made up of riveted plates and angles. Using this angle of 30°, the affected length can be calculated as follows:

Affected length = 3.5 × (rail depth + k). In the case of a plate girder the formula becomes: Affected length = 3.5 × (rail depth + flange thickness). AISE Technical Report No. 13[3] recommends the more conservative 45° angle rather than the 30° suggested above, which would change the value 3.5 in the above formulas to 2. Since web crushing is hardly ever critical, we have probably used too much verbiage on the subject already.

The above formula has more significance when investigating "built-up" plate girders (girders composed of flange angles riveted to a web plate), especially those of ancient vintage. Designers in the past were not always careful to make sure that the web plate bore full length on the underside of the top cover plate. In the event that it didn't bear, the wheel load was delivered to the web plate via the connecting rivets and the affected zone did not always contain enough rivets to withstand this load. Anyone investigating these old members should check this bearing condition carefully, often difficult for those of us not blessed with X-ray vision. In Fig. 8, the affected length formula for a riveted or bolted member becomes: affected length = 3.5 × (rail depth + cover plate thickness + angle gage).

The wheel load should always be increased for vertical impact when designing crane beams. The AISC Manual[1] p. 5-15, recommends 25% for cab-operated traveling cranes and 10% for hand-operated cranes. Table 5, taken from the *Whiting Crane Handbook*,[7] gives their recommendations for runway design factors, related to classes of service.

The effects of an off-center crane rail must be considered. Excessive rail eccentricity must be avoided, as it will cause local flange bending and subject the crane beams to torsional moments. Excessive sweep in crane beams, which is a contributing factor to rail eccentricity, should be removed at the time of fabrication. The AISE suggests a limit for this eccentricity of $0.75t_w$ for both wide-flange beams and plate girders. (See Fig. 9.)

To counteract the effects of rail eccentricity, the engineer may consider the addition of intermediate stiffeners to the crane beams or girders. These should bear and be welded to the underside of the top flange and down the web with continuous welds.

Lateral forces can be caused by mishandling of loads, misalignment of the runway, crane skew, and seismic loads. For design purposes this force is considered to act at the top of the rail and perpendicular to the rail. The AISC formula for determining lateral force is as follows:

Lateral force at *each* rail = 0.10 × (lifted loads + trolley weight). Other organizations, notably the AISE Technical Reports 6 and 13, have similar rules, and these should be examined as the case may dictate. Also see Table 5.

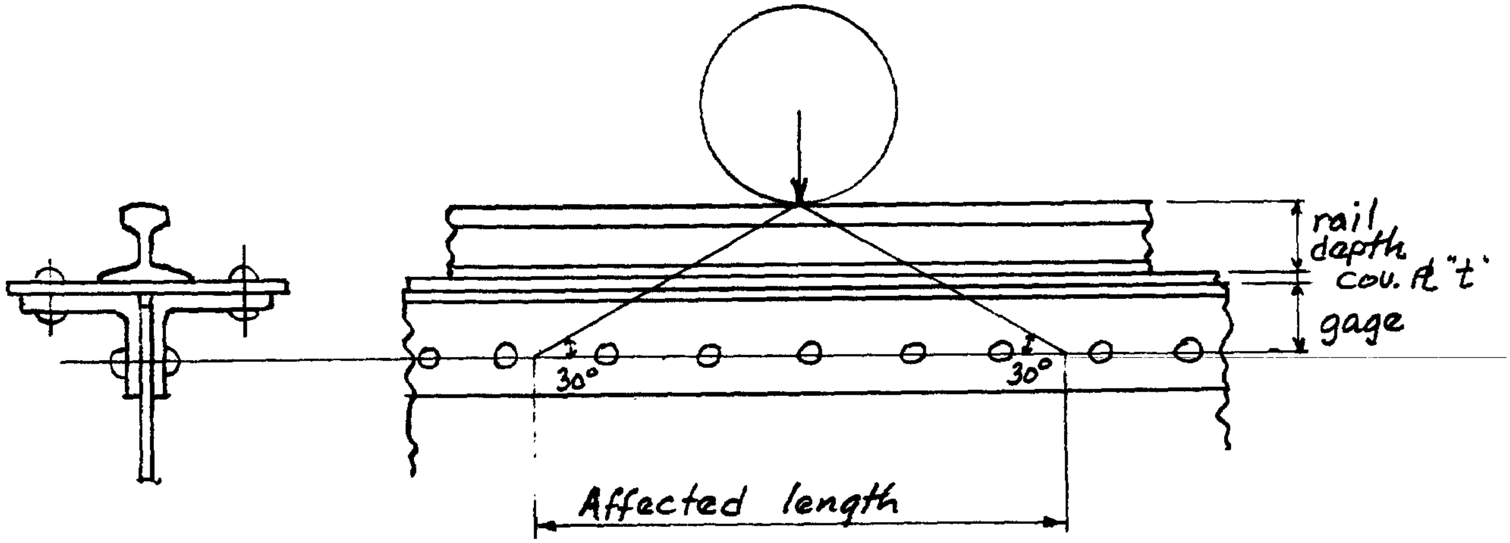


Figure 8

Lateral deflection should be limited to about $L/400$.

AISE Technical Report No. 13[3] requires crane girders of over 36-ft span to have their bottom flanges stiffened by a lateral bracing system connected to an adjacent girder or stiffening truss.

When examining a crane beam for resistance to lateral loading, only the section modulus of the top flange should be considered. If the strength of the section proves to be inadequate, it can be reinforced by adding a channel, plate, or angles, or by making a horizontal truss or girder in the case of large lateral loads. (See Figs. 5 and 6.)

These reinforcing members are often attached by welding. Due to the fatigue factor associated with intermittent welding, it is wise to consider using continuous welds (AISC stress category B vs. E) for these members, even though strength alone does not warrant their use. As a general guide when selecting the type of crane beams to use, consider the following suggestions. (See Fig. 5.)

For light cranes and short spans: use wide-flange.

For medium cranes and moderate spans: use wide-flange reinforced with a channel cap or angles.

For heavy cranes and long spans: use a plate girder with adequate provision for resisting lateral forces.

For extreme spans, trusses have been used. The Crane Service Classifications described earlier in this paper should also be considered, along with judgment and experience, when determining which kind of beam to use.

Reduced allowable stresses due to cyclical loading factors must be applied to all crane runway components when applicable. Refer to AISC Manual Appendix B.

In designing crane beams which require channels, plates, or angles to resist lateral loads, a practice which simplifies design and yields conservative but uneconomical results is to consider that vertical forces are resisted only by the beam and that lateral forces are resisted only by the channel, plates, or angles. Most designers assume the lateral load is resisted by the channel (or plates or angles) plus the top flange of the beam, and that the vertical load is resisted by the combined beam and channel (or plate or angles).

When sizing crane beams with added channels and if clamps are used to fasten the rails in place, it is necessary to select member sizes which will accept the required hole spacing. (See Fig. 10.) Threaded studs may be used in place of the bolts if a proper gage cannot be utilized.

Table 5. Runway Design Factors[7]

	Forces on Crane Runways (% of Wheel Load)		
CMAA Service Class	Vertical Impact, %	Longitudinal, %	Lateral, %*
A	10	5	10
B	10–15	5	10
C	15–25	5–10	15–20
D	25	10	20
E	25–50	10–15	20–25
F	25–50	15–20	20–30

* Given as % of rated load plus trolley weight with one half applied to each rail.

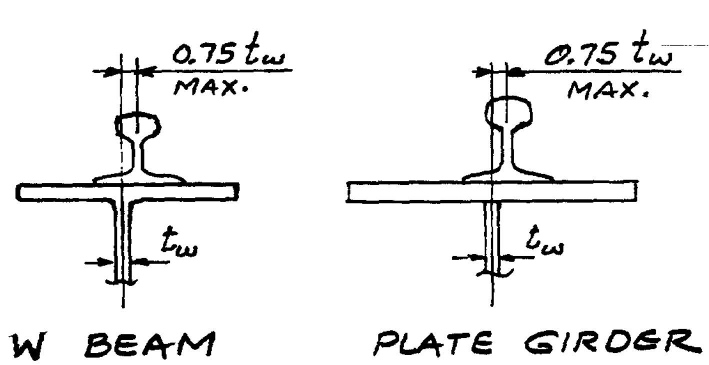


Figure 9

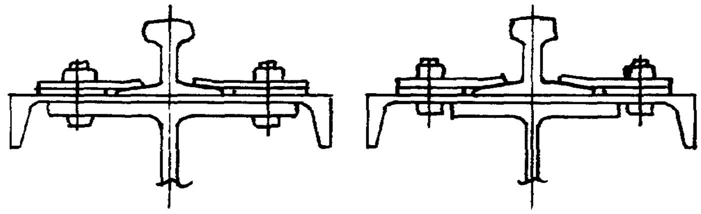


Figure 10

The fabricator of the crane girders should take precautions to see that the webs are perpendicular to the bottom flanges for a distance of about 1 ft-6 in. from each end. This will help to prevent lateral misalignment of the tops of two crane beams which share the same column cap plate.

Longitudinal loads are also present in a crane runway due to traction, braking, impact against crane stops, and wind. For design purposes the AISC gives the following:

Longitudinal Force = 0.10 × (total wheel loads each rail)

Also see Table 5. Longitudinal forces are hardly ever critical, but their existence should not be ignored, especially when considering the connection of the crane beam to the column cap plate, and when designing the bracing and foundations.

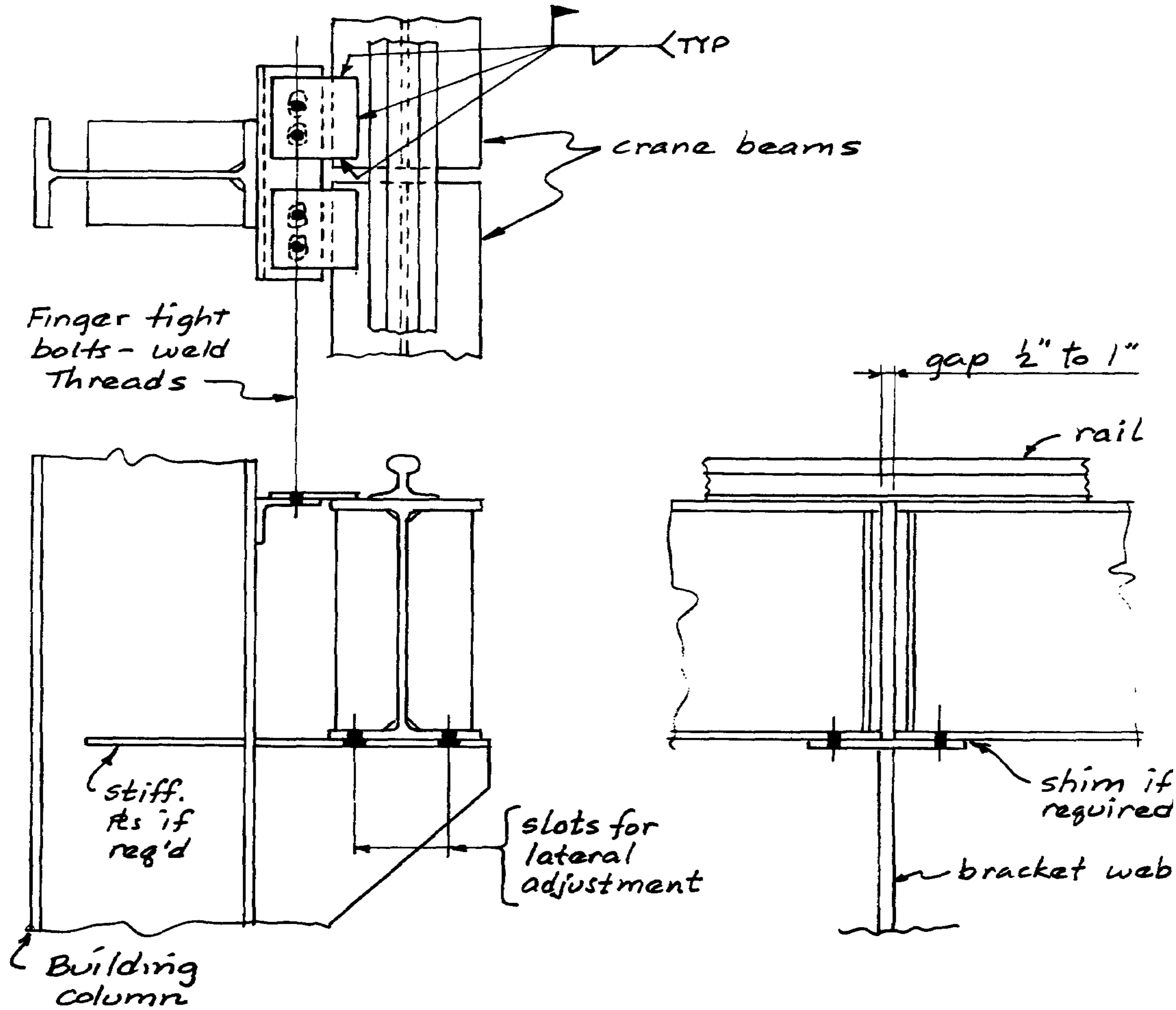


Figure 11

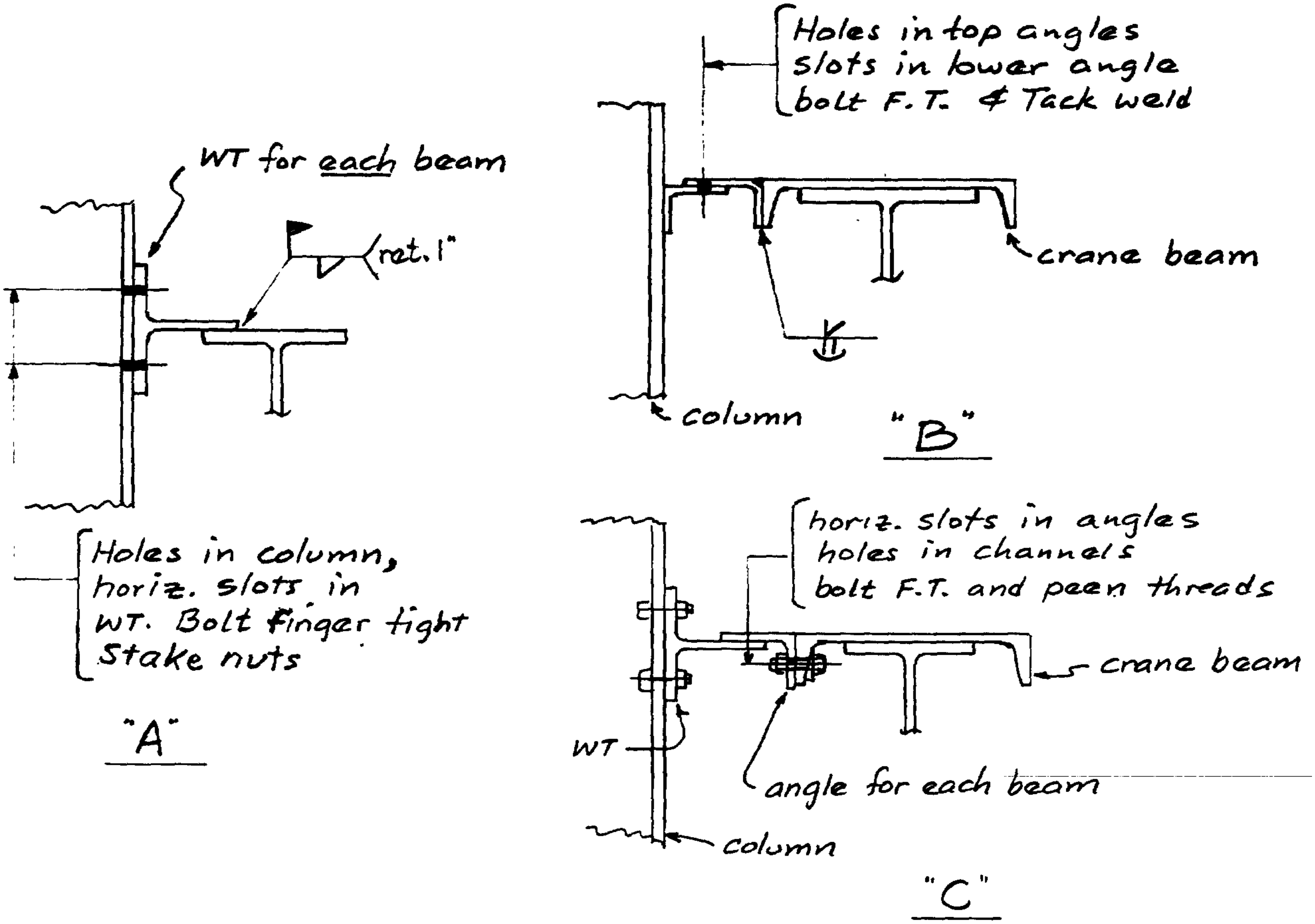


Figure 12

COLUMNS

Figure 2 shows several crane column profiles for various crane size categories.

AISE Technical Report No. 13 requires that impact be considered in crane columns when one crane is the governing criterion. The AISC does not require this. However, if the crane beam is supported on a bracket attached to a column, then impact must be considered in the design of the bracket.

Figure 11 shows a column bracket. This type of crane beam support should be limited to relatively light crane loads and light service cranes (max. reaction = 50 kips).

Slots are provided in the bracket seat plate for lateral adjustment. Stiffeners are placed at the end of the beam to prevent web buckling and to lead the reaction toward the bracket web. The bolts connecting the beam to the bracket must be adequate to resist the longitudinal forces. Note that stiffeners are *not* shown in the bracket web plate directly below the crane beam web. Omission of these stiffeners allows the seat plate to flex with the beam end as the crane passes along the runway. But stiffeners may be required for certain other bracket configurations. The lateral forces are resisted at the top flange.

Figure 11 shows an angle, shop welded to the column flange (it could be bolted), containing longitudinal slots. The connecting plates must be individually fastened to each beam. The plates have holes and may be bolted or welded to the beams either in the shop or field. Note that the slots should be placed in the lower of the two members, so that they will not fill up with dirt or debris. The bolts at this connection should be snugged up, then backed off about ½ turn and the bolt peened or threads nicked or welded. To determine the number of bolts required, the bearing of the bolt against the side of the slot must be checked. If the building settles and it is necessary to raise the crane beam to relevel the runway, note that this is easily done with shims inserted between bracket and bottom flange of beam and between the angle and the plate at the top flange. Figure 12 shows other combinations of lateral load resisting

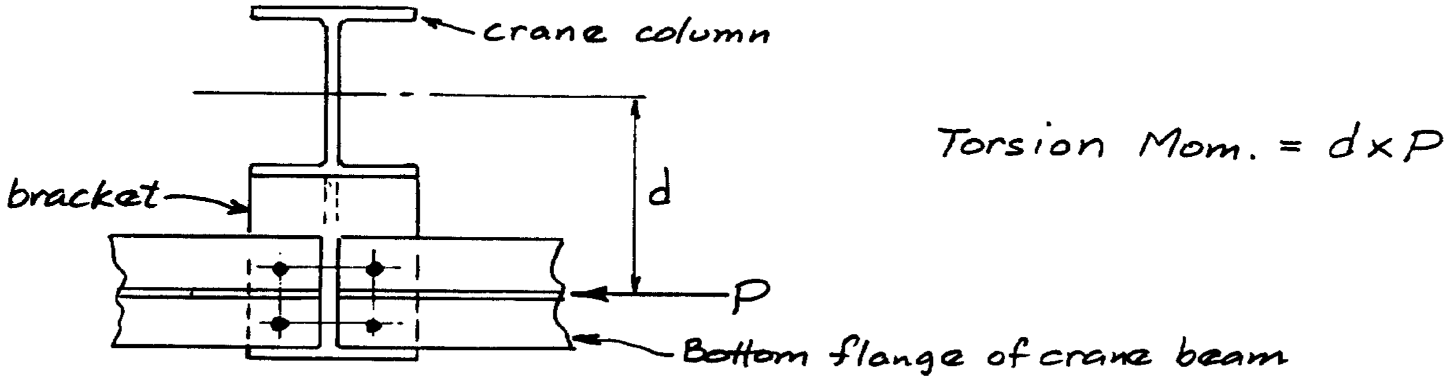


Figure 13

connections. In sketch C of Fig. 12, note that if the lateral load is directed *away* from the column, the vertical leg of the angle is subject to bending and the bolt is in tension at a time when it is trying to slide along the slot, certainly not an ideal situation. There should be a beveled washer on the inside of the channel flange and this washer must be welded to keep it from rotating and binding. All-in-all, sketch C might better be your last resort, if nothing else works.

Longitudinal forces cause torque on columns which have crane brackets. (See Fig. 13.) If this proves to be too great for the column, the effects of the torsion can be significantly reduced by adding horizontal struts. (See Fig. 14.)

The braces shown in Fig. 14 are not required at every column, but should be located near the center of the runway at as many columns as the loads and judgment dictate.

When it becomes uneconomical, inconvenient, or unwise to use a bracket to support the crane beam, then a "stepped" column should be considered. (Stepped columns can also be used for lighter cranes. Figure 15 shows a typical detail of a crane beam connecting to a stepped column.)

Notice that as the deflected beam delivers its load to the column the fulcrum is near the edge of the column flange, which is not desirable. This portion of the column flange and the beam web above it are subject to stress concentrations. In some instances it may prove beneficial to add reinforcing to the column. (See Fig. 16.) However, when this is required the load is delivered more eccentrically to the column, so in this situation it is probably wiser to consider the ultimate in crane beam support, which is a separate crane column. Crane beams for heavy service are best

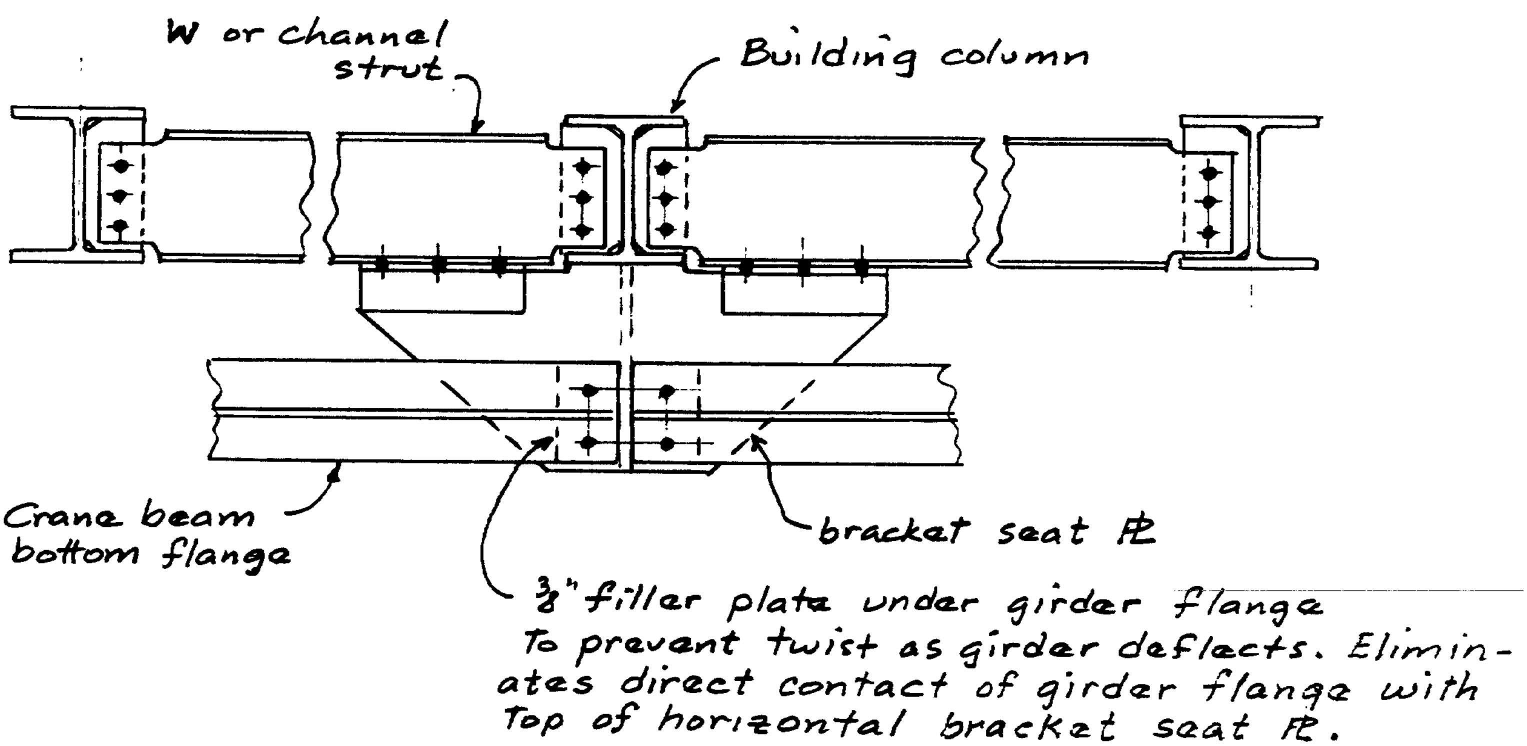


Figure 14

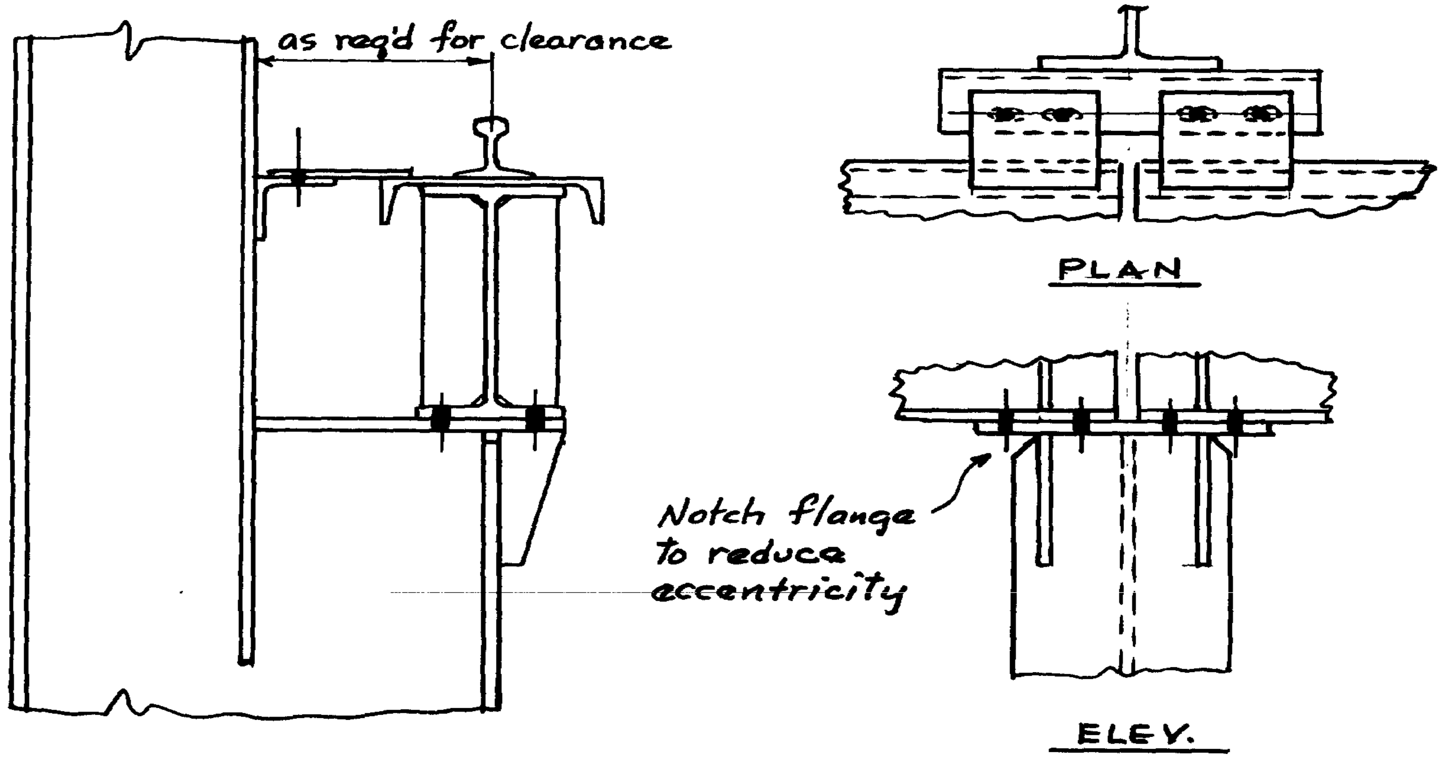


Figure 15

supported by their own columns. Refer to Fig. 2.

The usual and logical orientation of these columns is shown in Fig. 17.

The building column is oriented so that its strong axis will withstand the lateral wind and seismic loads on the building and the lateral crane loads. The crane column is oriented so its strong axis is able to resist the longitudinal forces on the runway. The crane column flanges also act as a fulcrum on which the crane beam will pivot as it deflects.

Keep the depth of a crane column as small as practical—do not use a W14 if a W12 will do, etc., in order to keep the load eccentricity as small as possible. (See Fig. 18.)

In Fig. 18, note the caution about not adding stiffener plates below the cap plate. This would increase the eccentricity of the load delivered by a deflecting beam. Even without the stiffeners, *this region of the column is subjected to severe cyclical loading conditions.* As the crane passes along the runway, the load is delivered first to one flange and then the other. Occasionally cracking is observed in the

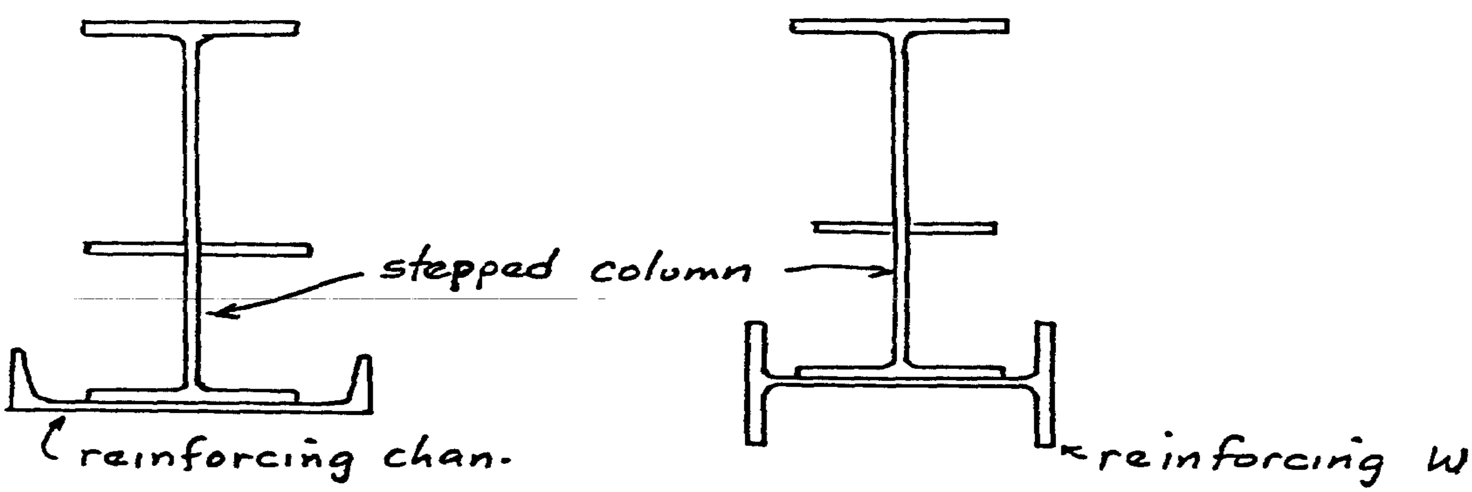


Figure 16

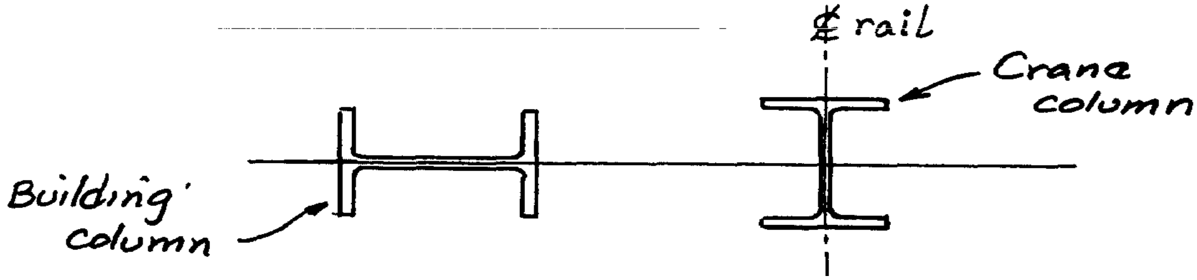


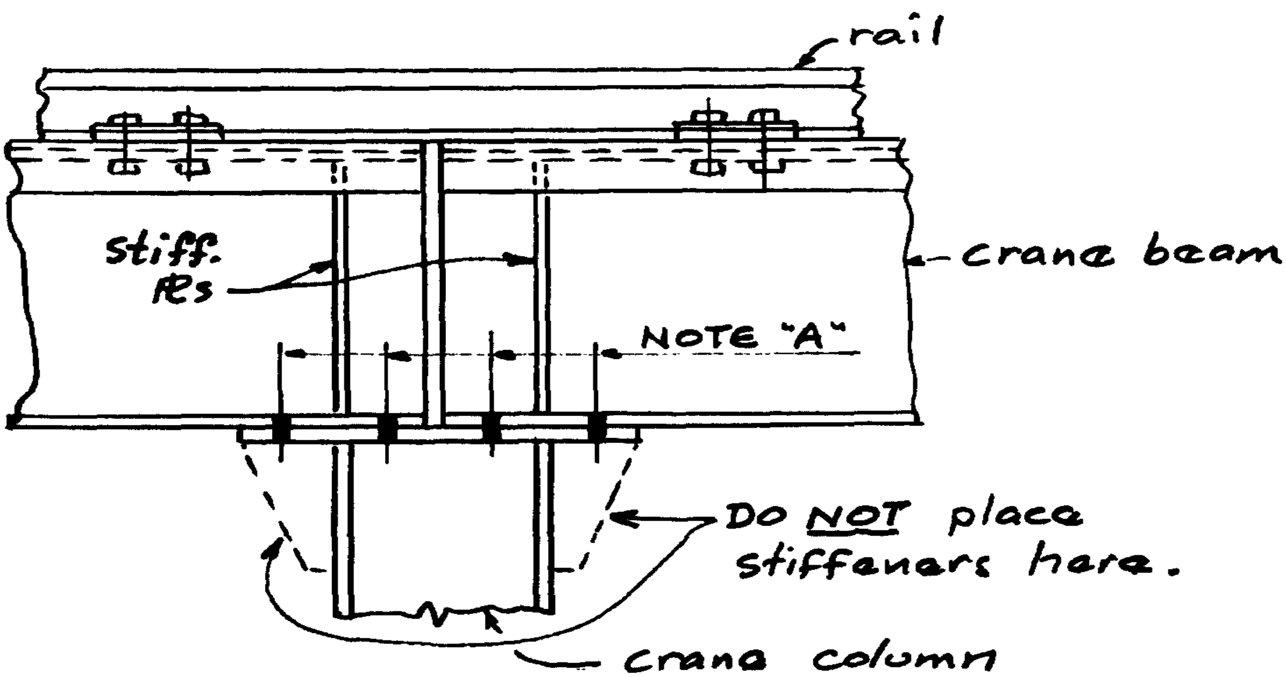
Figure 17

region below the cap plate. Note that the stiffeners in the crane beam are placed directly over the crane column flanges.

Note also that in none of the previous discussions have we mentioned anything about connecting the ends of two neighboring crane beams together. It should *not* be done. Likewise, the ends of two adjacent *horizontal* crane girder bracing members should not be tied (connected) together but should be attached separately to the column or bent by individual plates (see Fig. 19). Refer to Fig. 20 which shows exaggerated end rotation due to beam deflection. It is obvious that a plate connecting these members would find itself in a lot of trouble. Note also that a rail splice in the area above the beam gap would be under severe tension. It is advantageous to keep the gage in the bottom flange of the crane beam as large as practical, to permit the flange to yield locally as the end rotates.

You may also have noted that none of the previous sketches have shown a diaphragm connecting the beam *web* to the column. This detail should be avoided; a web diaphragm localizes stresses in the beam web just below the top flange, which quite often leads to fatigue failure, cracks and loss of strength. (See Fig. 21.)

Now, after suggesting that you not use a "vertical diaphragm" for lateral bracing, it must be pointed out that it is permissible under certain conditions, but that precautions must be taken. On very heavy crane runs, where top flange lateral bracing cannot be made of adequate strength, a diaphragm can be added. Consider this a safety feature in case the horizontal thrust connection fails or is inadvertently weakened or destroyed by subsequent alterations. If diaphragms must be used, the crane girder end rotation should



NOTE "A": *these bolts must be capable of withstanding the longitudinal forces.*

Figure 18

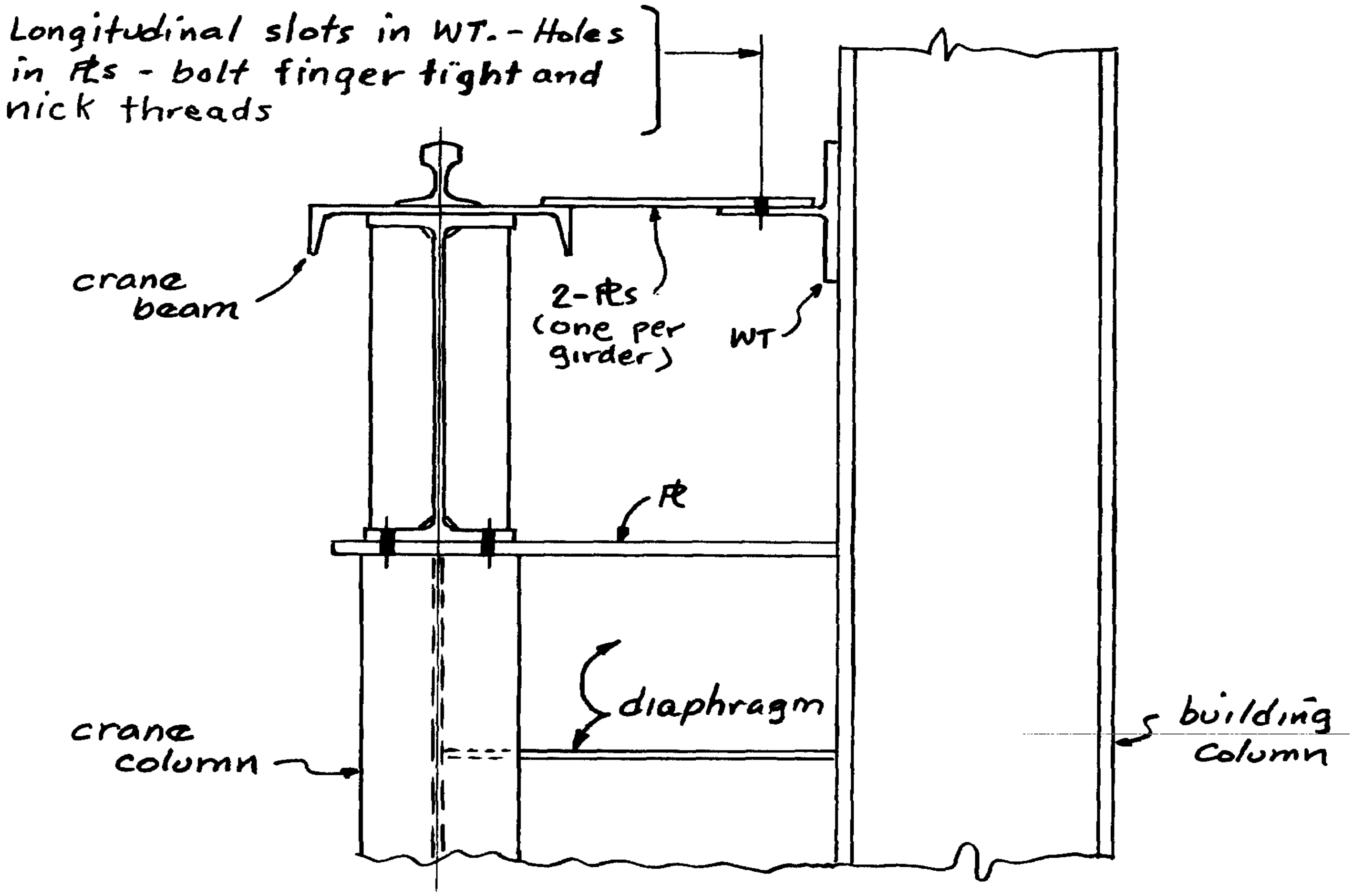
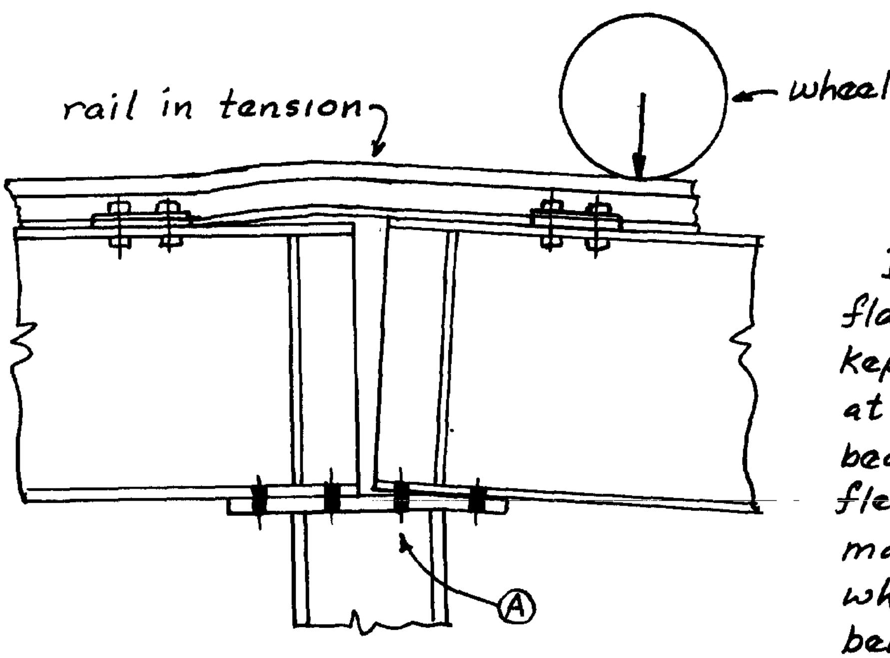


Figure 19



If the gage in the bottom flange of the crane beam is kept reasonably large the bolts at Ⓐ will <u>not</u> stretch. The beam flange and cap Pl will flex slightly but probably maintain contact. Any gap which occurs will be directly below the beam web.

Figure 20

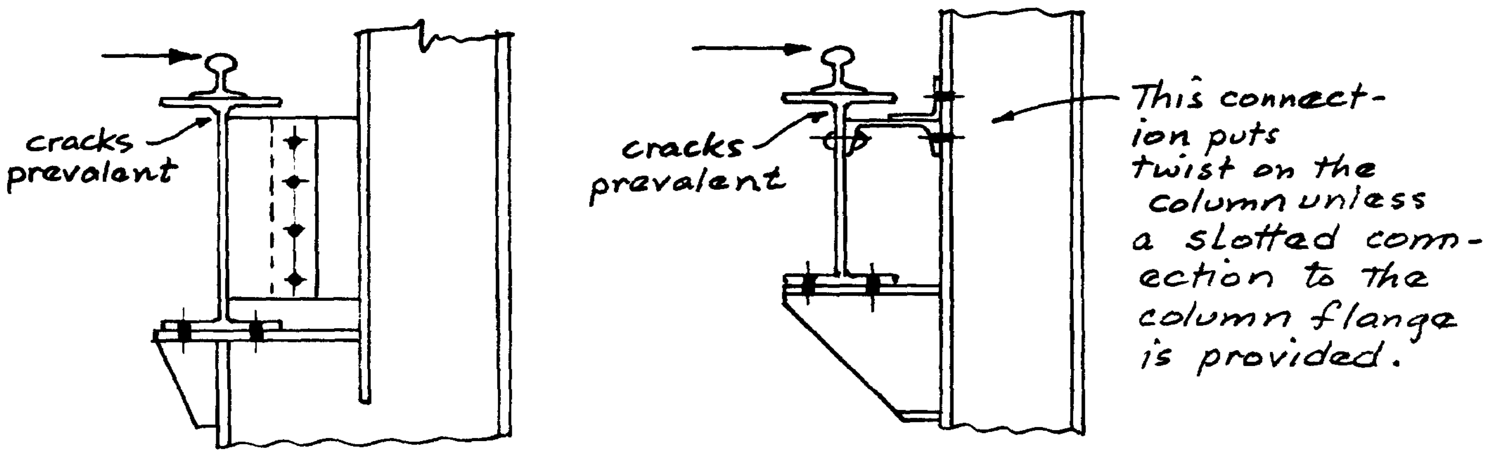


Figure 21

be kept very small. A single diaphragm should *not* serve two crane beams—a diaphragm should be supplied for each beam end. (See Fig. 22.)

It is probably a good idea to run these diaphragms full depth of the crane beam, and the plate thickness should be kept as thin as practical, say in the $\frac{5}{16}$-in. to $\frac{3}{8}$-in. range, to maintain flexibility.

Another case of where a diaphragm may be used is between two parallel crane beams or between a crane beam and a bracing girder, but this diaphragm should be horizontal and may be utilized as a walking surface or work platform if all due safety precautions and codes are observed. This diaphragm should be also kept flexible, to permit unequal deflections between the two members.

We have rambled on concerning crane beam deflection, end rotation, and associated headaches. Figure 23 is a design example that will give you an idea of the magnitude of this motion.

As this example shows, the magnitudes of these movements are relatively small. But the magnitude of the forces causing the motion are large. It is futile and uneconomical to attempt to restrain the motion, so we must use connections which permit the motion while maintaining their strength.

Whereas we have previously stated that expansion joints are not required or desirable in crane *rails*, such is not the case in the crane run. Expansion joints should be supplied at intervals coinciding with those in the main structure. The maximum distance between expansion joints should be about 400 ft (up to 500 ft in a building where the temperature range is not extreme.) Expansion joints for exterior crane runways should generally be closer, due to the probability of a greater temperature range. Where possible, use dual columns rather than a slide bearing.

If a slide bearing is used beneath the bottom flange of the crane girder, it must be made of a type of material which will permit rotation. "Floating" rail clamps should be used if a crane runway contains expansion joints. Crane runways subject to concentrations of high heat, such as smelters, soaking pits, and furnaces, should be examined for abnormal expansion joint requirements. Heat shields are sometimes required to protect the exposed members.

Each segment of runway between expansion joints should be independently braced longitudinally.

Column bases must be designed to properly deliver the horizontal loads to the foundation, both lateral and longitudinal. Column bases sometimes are subject to uplift forces from the vertical component of diagonal bracing and from certain loading positions on two-span or cantilevered girders.

Column bases subject to rotation, such as the case where the crane column is attached to the building column in such a way as to form a vertical truss, should be designed so that the moment forces are delivered to the foundation.

FOUNDATIONS

The crane column foundations must be designed to adequately resist all of the vertical, horizontal, and rotational forces previously referred to. The magnitude of the forces is dependent upon the design of the superstructure and especially the bracing. Column bases should be kept above grade to minimize corrosion damage and so their condition may be easily monitored.

BRACING

Crane runways must be braced laterally and longitudinally. Lateral bracing is usually attained by providing either some degree of column base fixity, by utilizing the roof trusses or rafters, or by providing a vertical bent in conjunction with the main building column or an adjacent runway column.

Longitudinal runway bracing can take several different forms. Refer to Fig. 24, which shows several types. The simplest bracing to design and the most effective is the diagonal

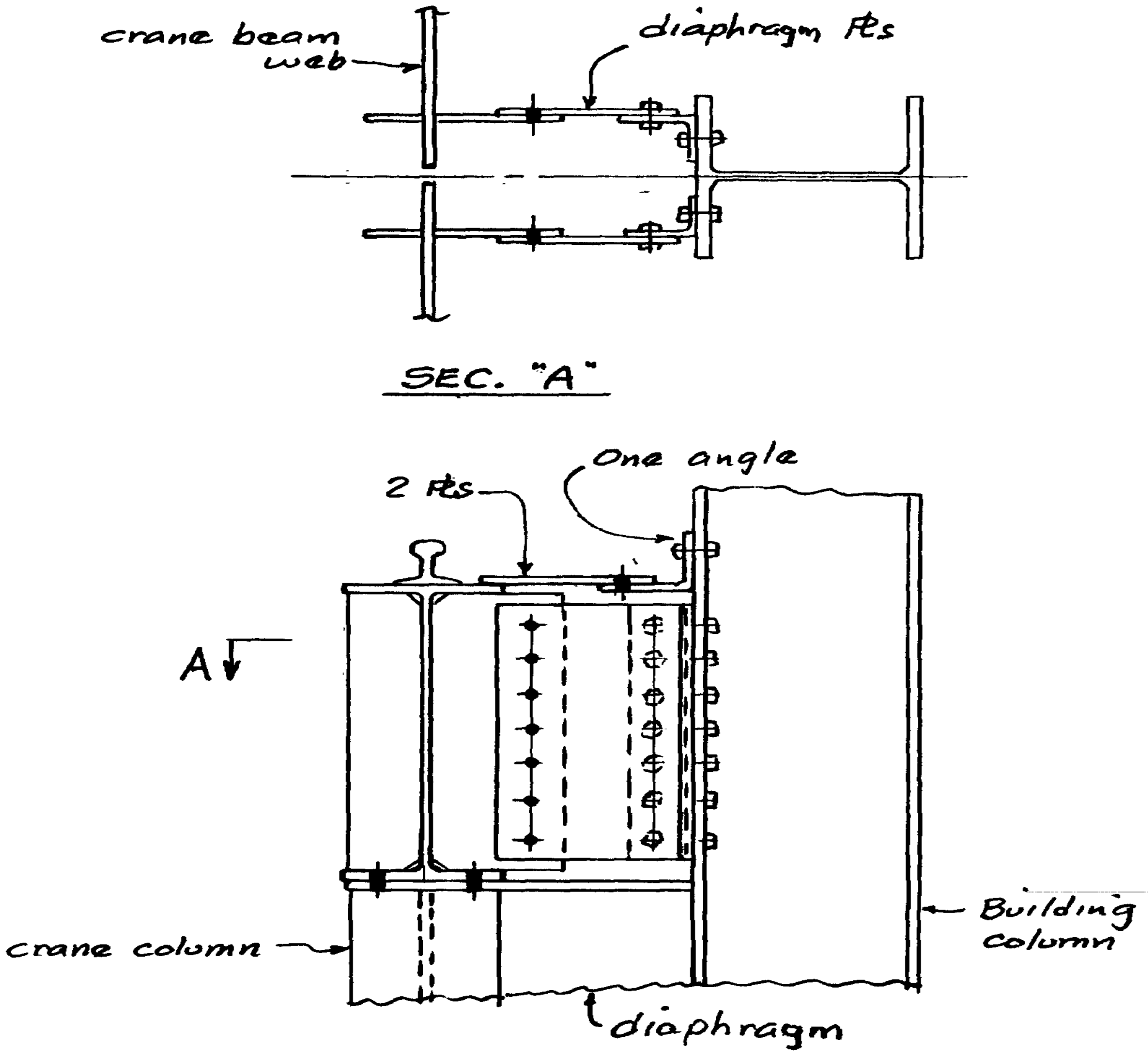
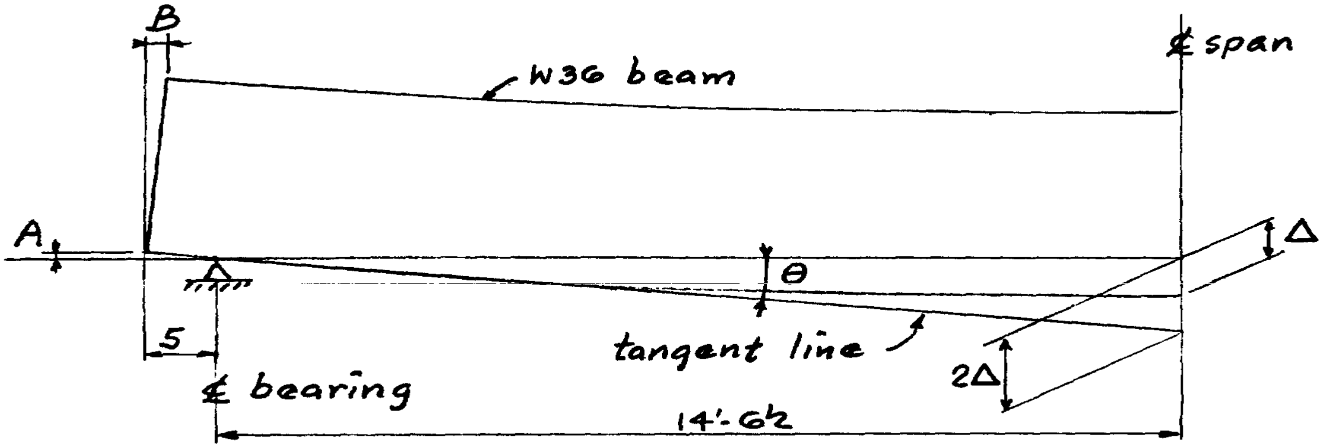


Figure 22

X-brace shown in Figure 21A. It is suggested that the engineer limit the *L/r* ratio of tension crane runway bracing to about 200, due to the abrupt reversal of stresses which are characteristic of crane runs. Bracing members should be constructed of efficient sections, such as double-angle members, wide-flange, tube, or pipe sections. Never use rods and limit single angle bracing to light service crane runs. "Slack" bracing members are a disconcerting sight in any structure. Never connect bracing directly to the underside of the crane beams.

If headroom is a problem either of the schemes in Fig. 24B or 24C can be used. The moment induced in the columns in Fig. 24C must be accounted for in the design of those columns. Foundations must be designed to handle the vertical and horizontal load components delivered by the bracing.

The bracing shown in Fig. 24 should be located on the center line of the crane columns. If stepped columns or columns with brackets are used, the bracing is generally located near the center line of the column and serves to



GIVEN: *W36 beam 30'-0 c.c. crane columns. Max.* $\Delta = L/1000.$

REQUIRED: *Dimensions A & B.*

PROCEDURE: $max.\ \Delta = \frac{29.08(12)}{1000} = 0.35"$ $\tan\theta = \frac{2(0.35)}{14.54(12)} = 0.004012$

$DIM."A" = 0.004012(5) = 0.02".$ (*less than* 1/32")

$DIM."B" = 0.004012(36) = 0.144".$ (*less than* 5/32")

Figure 23

brace the structure from wind and other external forces, as well as from the crane system.

Crane columns and crane bracing are often subjected to damage or abuse due to their proximity to moving loads. It is false economy to "skimp" on these members (or any crane runway members for that matter!)

The location of longitudinal bracing has always been a source of design conjecture. Consider the runway in Fig. 25.

Some designers start out by placing a braced bay on either side of, and adjacent to, the expansion joint, to try to "contain" the runway and keep it plumb. But this tends to defeat the purpose of the expansion joint by preventing or restraining movement in the adjacent bays. It is proper *not* to brace near the end of the runway, but rather to locate the bracing near the center of the runway. This will allow thermal expansion and contraction to advance or retreat from a centrally "anchored" area of the runway towards the ends.

In order to keep as many bays as possible clear for access to neighboring crane aisles, the crane bracing location often must coincide with that of the building bracing. However more crane bracing is often required than building bracing, and it may be necessary to provide crane run bracing in adjacent bays, but near the centrally anchored area. See Fig. 25. Experience has shown that, if a braced bay becomes objectionable to the mill operation, it may mysteriously disappear. It is comforting to know that an occasional brace can be eliminated without jeopardizing the performance of the runway. The number of braced bays is usually up to the judgment of the engineer, but the following should be kept in mind. The length of each bay changes with temperature and, when under load, the bottom flange of the loaded girder will elongate. See Fig. 26 for an exaggerated portrayal of the cumulative effects of these movements.

For example, consider the following conditions with reference to Fig. 26:

Given: Bay length = 25′-0″
Bay 2-3 is loaded to cause a 3/16″ elongation of the beam bottom flange.
Temp. = 100° F (30° above normal).

Required: Find the relative movement of the top of Column 1 in reference to Column 4 (an "anchored" column).

Solution: Temp. $\Delta = 30 \times (0.0000065)(75)(12)$
$= 0.17″$ (about 3/16″)

Total movement =3/16″ +3/16″=⅜″

Comment: If a diagonal X-brace were contemplated for bay 1-2 and if its angle with the horizontal were about 45°, then the required stretch in this member would be about 0.707 (0.375) = 0.27

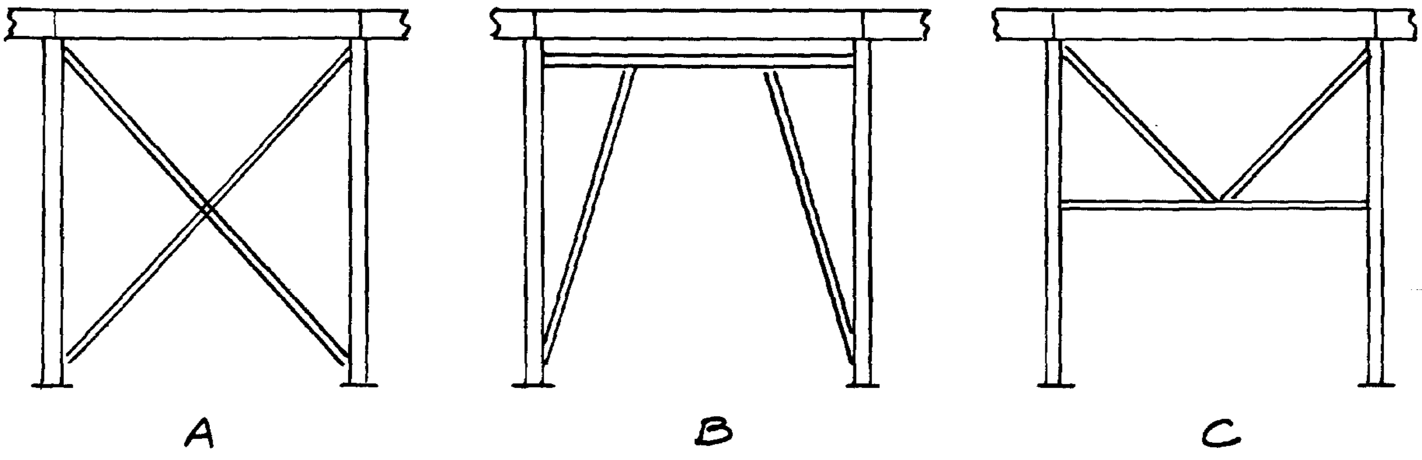


Figure 24

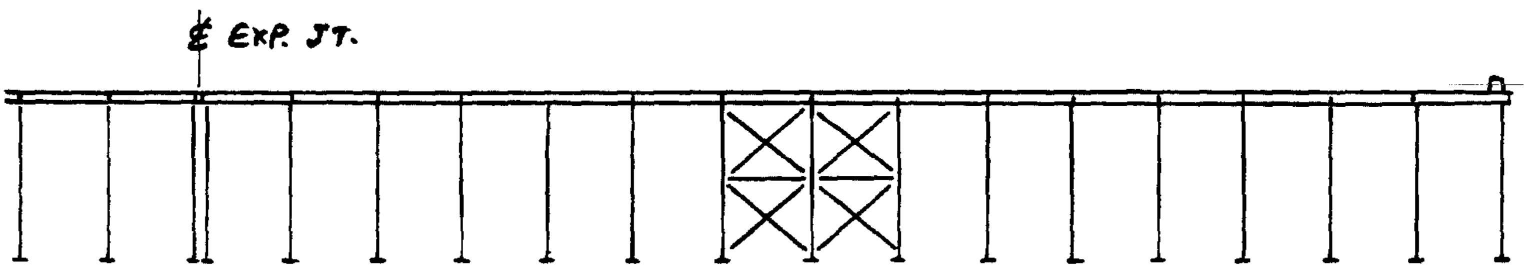


Figure 25

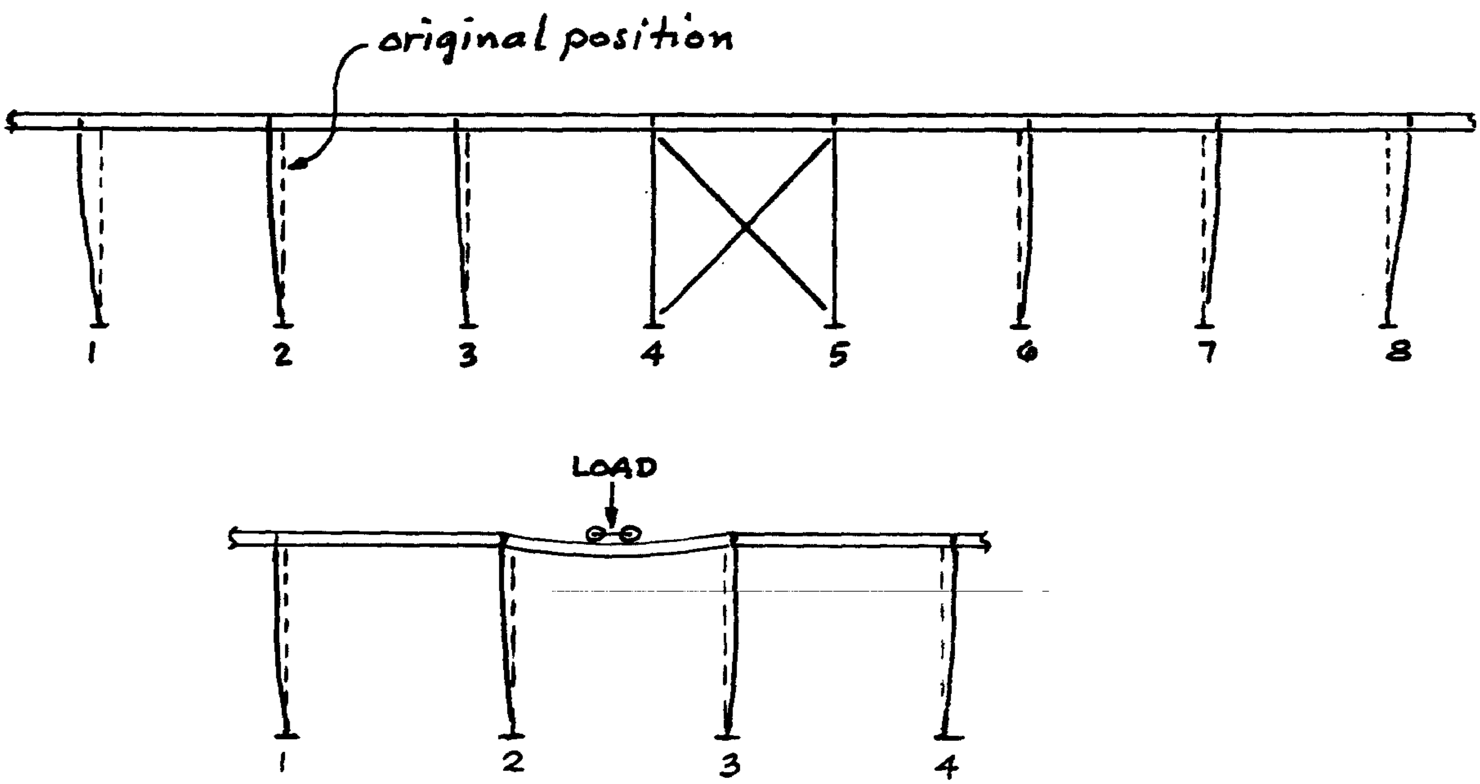


Figure 26

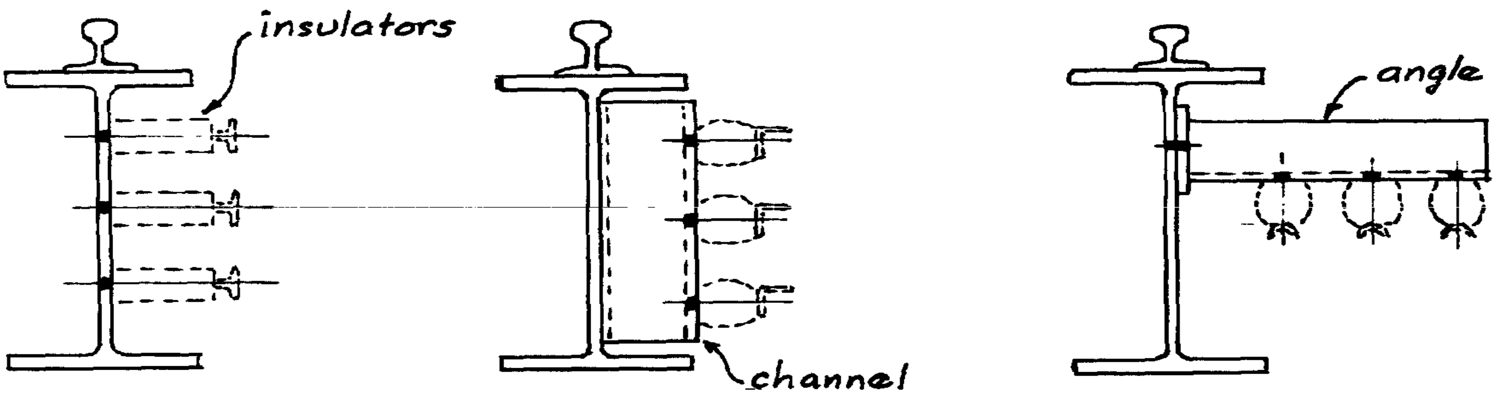


Figure 27

in. If the bracing member were 35 ft long and had an area of 4 in.^{2}, the force from this increment alone would be:

$$P = \frac{A\,E\,e}{L} = \frac{4(29 \times 10^3)\,0.27}{35 \times 12} = 73 \text{ kips}$$

Obviously, if it were A36 steel the brace would be stressed near the working limit and might not be able to withstand the other longitudinal runway loads to which it would be subjected. And no self-respecting foundation would stand for this sort of nonsense. Actually, there is no point in attempting to return the top of Column 1 to its original position. If we did attempt to pull it back, other yielding would occur and it would not be necessary for this diagonal brace to realize the full 70-kip theoretical load.

It is interesting to observe bracing behavior while a crane is operating on a runway. The effects of impact, braking, traction and reversing directions can be witnessed when the crane is often several bays away.

Notice that we have *not* mentioned knee bracing (angle or diaphram type) as a means of stabilizing a crane run. Knee braces should *not* be used. They are the source of many crane run problems, causing undesirable restraint, column bending, and secondary stresses. They may transmit unwanted forces into the foundation. An engineer who does investigations of existing crane runways should take a long hard look at any knee braces and assess their effect on other members of the runway. Replacement with X or portal bracing may be justified. There are case histories of satisfactory knee bracing, but there are usually mitigating circumstances which are responsible for their longevity, such as a favorable depth/span ratio (very small crane beam deflection) or a reduced crane capacity.

More on this topic can be garnered from a 1965 AISC *Engineering Journal* paper by John E. Muller.[10]

Parallel crane girders in adjacent crane aisles should not be relied on to brace each other, except to be utilized to form a horizontal truss or girder, or box member. This member should be designed to withstand the maximum lateral loads of both cranes simultaneously.

CONDUCTORS

Crane runway conductors are the means by which the crane receives its electrical power. The rigid type is generally used, although occasionally a festoon type is found.

Usually the fabricator of the runway steel need supply only holes or a bracket with holes in it for mounting the conductor insulators. In some cases, the crane supplier will furnish the entire runway power system as part of a package deal. In cases where he doesn't, he will generally recommend the power system to be used in order to assure that it is compatible with his crane components.

Figure 27 shows several different typical schemes. The conductor supports are spaced usually about 4 to 15 ft apart, depending on the size and type of conductor rails.

CONCLUSION

The pros and cons of the several components and details of construction, as well as the various design approaches, can be argued indefinitely. The bottom line is that the crane runway performs satisfactorily over its desired term of service with least cost to the owner.

The "life" of a mill building is commonly figured to be about 50 years. A crane runway which "lives" half that long without major reconstruction should delight its owner.

What may work well for one set of conditions may not work at all for a different set. The vast range of crane capacities and classes of service make one set of rules virtually impossible to apply to all runways. This is where the experience, judgment, and discretion of the designing engineer is important.

This paper had dealt almost exclusively with crane runways, with only occasional reference to the other parts of the building. The author has discussed certain design criteria, construction methods, has called attention to things that are sometimes overlooked, and has attempted to point out certain aspects that are considered good practice today. The actual methods of design have not been discussed, as these are amply covered in numerous texts on the subject.

Among the best design sources are the 1979 AISC publication *Light and Heavy Industrial Buildings*[2] and the AISE Technical Reports No. 6[5] and No. 13.[3] Anyone contemplating the design of a crane runway would do well to examine these texts.

Another excellent source of crane information is the *Whiting Crane Handbook, 4th Edition.*[7]

The following suggestions will help to assure better crane runways:

1. Limit the deflection of the crane beams.
2. Avoid the use of cantilever crane beams or two-span crane beams if possible.
3. Don't use knee braces for longitudinal runway bracing.
4. Connect the *top flange* of the crane beams to the column to resist lateral loads. Do *not* connect the webs.
5. Remember to use reduced allowable stresses where cyclical loading would result in structural fatigue. (AISC Specification Appendix B).
6. Crane runway field connections should be made with properly tensioned high-strength bolts (using friction values) except where sliding connections are required. High-strength bolts (finger-tight) are preferable for sliding connections because of their toughness and greater resistance to abrasion.
7. Anticipate the worst possible operating conditions because these are sure to happen sometime.
8. Keep in mind that dealing with crane runways can be likened to stamping on red ants with golf shoes— the best intentions and earnest efforts are often only about 50% effective. Be conservative!!!

DISCLAIMER

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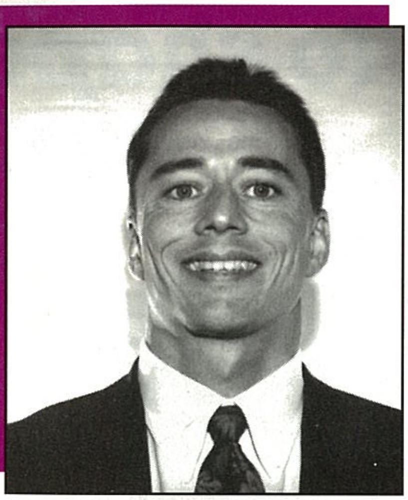
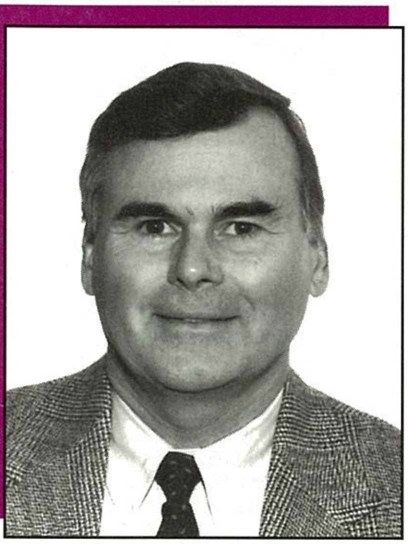
CRANE GIRDER DESIGN

An examination of design and fatigue considerations





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PROPER FUNCTIONING OF OVERHEAD BRIDGE CRANES IS DEPENDENT upon proper crane runway girder design and detailing. The runway design must account for the fatigue effects caused by the repeated passing of the crane, and the details must not create restraints that limit the girders ability to deflect under the applied crane loads. The runway girders should be thought of as a part of a system comprised of the crane rails, rail attachments, electrification support, crane stop, crane column attachment, tie back and the girder itself. All of these items should be incorporated into the design and detailing of the crane runway girder system.

Stiffer elements of a structural assembly tend to attract load. This holds true for crane girders. In a statically loaded member, the tendency for an attachment to "draw" load can often be neglected. However, with the repeated application of loads this condition can lead to fatigue damage. Relative deflections between adjacent members may often be neglected in statically loaded structures. In dynamically loaded structures these relative movements can result in some form of fatigue damage. It has been estimated that 90% of crane girder problems are associated with fatigue cracking. To address these conditions, this paper will briefly discuss the phenomena of fatigue damage, then the nature of crane loads will be discussed followed with a discussion of typical connections and details, lastly a design example will be provided.

The basic phenomena of fatigue damage has been understood for may years. Engineers have designed crane runway girders that have performed with minimal problems while being subjected to millions of cycles of loading. The girders that are performing successfully have been properly designed and detailed to:

- limit the applied stress range to acceptable levels.
- avoid unexpected restraints at the attachments and supports
- avoid stress concentrations at critical locations
- avoid eccentricities due to rail misalignment or crane travel
- minimize residual stresses

Runway systems that have performed well have been properly maintained by keeping the rails and girders aligned and level.

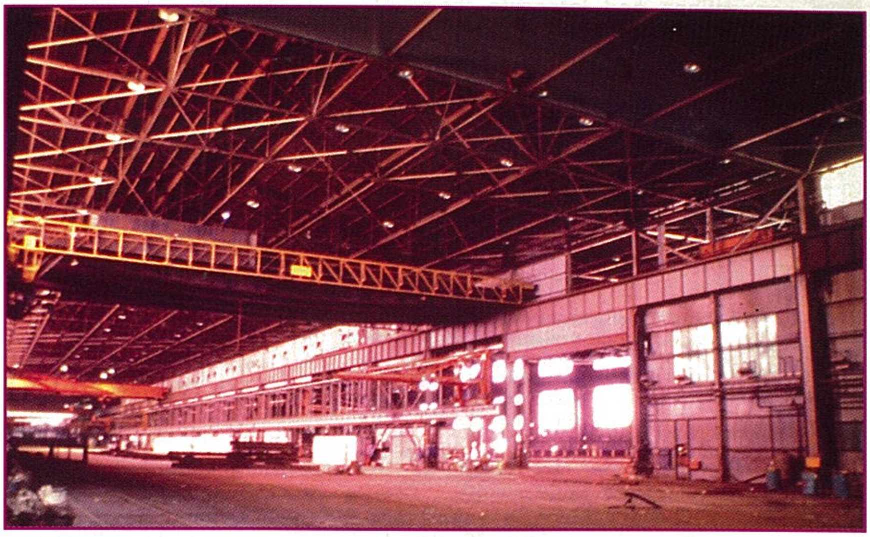
FATIGUE DAMAGE

Fatigue damage can be characterized as progressive crack growth due to fluctuating stress on the member. Fatigue cracks initiate at small defects or imperfections in the base material or weld metal. The imperfections act as stress risers that magnify the applied elastic stresses into small regions of plastic stress. As load cycles are applied, the plastic strain in the small plastic region advances until the material separates and the crack advances. At that point, the plastic stress region moves to the new tip of the crack and the process repeats itself. Eventually, the crack size becomes large enough that the combined effect of the crack size and the applied stress exceed the toughness of the material and a final fracture occurs. Common grades of structural steel and common sizes of members used in interior applications are not prone to brittle fracture. The typical situation occurs when cracks reach a noticeable size and are repaired before catastrophic failure occurs. A damaged girder can be evaluated for fitness for purpose using various fatigue life prediction techniques and fracture mechanics. These methods are outside the scope of this discussion.

The phenomena of fatigue damage or crack growth is considered to occur in three stages: initiation; propagation; and final fracture. The ***crack initiation*** is affected by the initial flaw size, the amount of residual stress, the presence of corrosion and the applied stress range. Most of the fatigue life of an unwelded or unnotched member is taken up in the initiation of the crack. Fabricated members typically will have small defects from the welding process that can be considered as initiated cracks. In this case, the entire useful life of the section is taken up in crack propagation. The useful life of the element is usually met when the crack reaches an objectionable size.

Crack propagation occurs when the applied loads fluctuate in tension or in reversal from tension to compression. Fluctuating compressive stress will not cause cracks to propagate. However, fluctuating compressive stresses in a region of residual tensile stress will cause cracks to propagate. In this case, the cracks will stop growing after the residual stress is released or the crack extends out of the tensile region.

The general design solutions to ensure adequate service life of members subject to repeated loads are to limit the buildup of residual stress, limit the size of initial imperfections, and to limit the magnitude of the applied stress range. The AISC Specification limits the allowable stress range for a given service life based on the anticipated severity of the stress riser for a given fabricated condition. In addition, it requires conformance with Chapter 9 of the AWS D1.1 *Structural Welding Code* ("Dynamicallv Loaded Structures"), which provides criteria for limiting the severity of stress risers found in weld metal and the adjacent base metal.



It should be noted that higher strength steel does not have a longer fatigue service life than A36 steel. That is, *the rate of crack growth is independent of the yield strength of the material.* Similarly, the rate of crack growth is not effected by the toughness of the material. A given cross section of higher toughness will be able to resist the effect of a larger crack with out fracture. However, at this stage of the service life of the member, only a few additional cycles would be gained by having a material of greater toughness. Thus, the AISC Specification provisions regarding fatigue conditions are independent of material strength and toughness. The material design requirements for strength and toughness are the same for crane runway girders as for statically loaded girders.

Crane Loads

Each runway is designed to support a specific crane or group of cranes. The weight of the crane bridge and trolley and the wheel spacing for the specific crane should be obtained from the crane manufacturer. The crane weight can vary significantly depending on the manufacturer and the classification of the crane. Based on the manufacturer's data, forces are: determined to account for impact, lateral loads, and longitudinal loads. The AISC Specification, and most model building codes address crane loads and set minimum standards for these loads. The AISE Technical Report No. 13 *Guide for the Design and Construction of Mill Buildings* also sets minimum requirements for impact, lateral and longitudinal crane loads. The AISE requirements are used when the engineer and owner determine that the level of quality set by the AISE Guide is appropriate for a given project. It should be noted that the latest edition of the BOCA *National Building Code* has adopted the AISE Guide for the purpose of determining crane loads.

Vertical crane loads are termed as wheel loads. The magnitude of the wheel load is at its maximum when the crane is lifting its rated capacity load, and the trolley is located at the end of the bridge directly adjacent to the girder. In addition to shear and bending stresses in the girder cross section, the wheel loads result in localized stresses under the wheel. AISE Technical Report No. 13 provides an equation for calculating this localized stress. The method is based on considering the top flange and rail as beams on an idealized elastic foundation. The axial stiffness of the web determines the stiffness of the elastic foundation. The compressive stress is oriented parallel to the axis of the member and can be added to the flexural compressive stress. Localized bending stresses at the top flange to web juncture can also occur when the rail is not aligned directly over the girder web. To minimize fatigue cracking at the junction of the web to the top flange the AISE Technical Report No. 13 requires a full penetration weld plus contoured fillet welds between the web and top flange. It should be noted that the localized wheel loads will occur with each passage of the wheel. A girder supporting a four wheel end truck will experience four stress fluctuations for each passage of the crane.

The vertical wheel loads are typically factored using the same impact factor. It accounts for the effect of acceleration in hoisting the loads and impact caused by the wheels jumping over irregularities in the rail. Bolted rail splices tend to cause greater impact than welded splices. In the U.S., most codes require a 25% increase in loads for cab and radio operated cranes and a 10% increase for pendant operated cranes.

Lateral crane loads are oriented perpendicular to the crane runway and are applied at the top of the rails. Lateral loads are caused by:

- acceleration and deceleration of the trolley and loads
- non vertical lifting
- unbalanced drive mechanisms
- oblique or skewed travel of the bridge

Except for the case of the trolley running into the end stops, the magnitude of lateral load due to trolley movement and nonvertical lifting is limited by the coefficient of friction between the end truck wheels and rails. Drive mechanisms are either equal on each side of the crane or they are balanced to align the center of the tractive force with the center of gravity of the crane and lifted load. If the drive mechanism is not balanced, acceleration and deceleration of the bridge crane results in skewing of the bridge relative to the runways. The skewing imparts lateral loads onto the crane girder. Oblique travel refers to the fact that bridge cranes can not travel in a perfectly straight line down the center of runway. It may be thought of as similar to the motion of an automobile with one tire under inflated. The tendency of the crane to wander can be minimized by properly maintaining the end trucks and the rails. The wheels should be parallel and the should be in similar condition. The rails should be kept aligned and the surfaces should be smooth and level. A poorly aligned and maintained runway can result in larger lateral loads. The larger lateral loads will in turn reduce the service life of the crane girder.

The AISC Specification and most model building codes set the magnitude of lateral loads at 20% of the sum of the weights of the trolley and the lifted load. The AISE Technical Report varies the magnitude of the lateral load based on the function of the crane (see Table 1).

Longitudinal crane forces are due to either acceleration and deceleration of the bridge crane or the crane impacting the bumper. The tractive forces are

Table 1: AISE Crane Side Thrusts

Crane Type	Total Side thrust % of lifted load
Mill crane	40
Ladle cranes	40
Clamshell bucket & magnet cranes (including slab & billet yard cranes)	100
Soaking pit cranes	100
Stripping cranes	100
Motor room maintenance cranes, ect.	30
Stacker cranes (cab-operated)	200

limited by the coefficient of friction of the steel wheel on the rails. The force imparted by impact with hydraulic or spring type bumpers is a function of the length of stroke of the bumper and the velocity of the crane upon impact with the crane stop. The longitudinal forces should be obtained from the crane manufacturer. If this information is not available, the AISE Technical Report provides equations that can be used for determining the bumper force.

Consideration of fatigue requires that the designer determine the anticipated number of load cycles. It is a common practice for the crane girder to be designed for a service life that is consistent with the crane classification. The correlation between the CMAA crane designations and the AISC loading conditions can be seen in Table 2. The MBMA *Low-Rise Building Systems Manual* provides a design method for reducing the AISC loading condition for the girder. This method accounts for the fact that for many cranes the loading that is applied on a regular basis is less than the maximum wheel load.

Table 2: Crane Loading Conditions

CMAA Crane Classification	AISC Loading Condition
A, B	1
C,D	2
E	3
F	4

For cranes with scheduled production tasks, the number of cycles can be directly calculated based on anticipated use.

DETAILING & FABRICATION CONSIDERATIONS

Welding

The vast majority of stress risers that lead to crack propagation are weld defects. Common weld defects are: lack of fusion or penetration, slag inclusions, undercut, and porosity. Lack of fusion and penetration or cracks are severe stress risers. Slag inclusions and undercut are significant defects in areas of relatively high stress. It should be noted that surface defects are far more harmful than buried defects. Also, the orientation of the defects is important. Planer defects normal to the line of applied stress are more critical than defects parallel to the line of stress.

Visual inspection during fabrication is the most useful method of ensuring adequate quality control of the fabricated elements. It should be noted that visual inspection is mandatory (per AWS, for the contractor) for both statically and dynamically loaded structures.

The fabrication sequence should be controlled to limit restraint during welding so as to reduce the residual stresses created by the welding process. For example, when fabricating a plate girder, the splices of the flange and web plates should be made before the flanges and web plates are welded together.

Tiebacks

Tiebacks are provided at the end of the crane runway girders to transfer lateral forces from the girder top flange into the crane column and to laterally restrain the top flange of the crane girder against buckling. The tiebacks must have adequate strength to transfer the lateral crane loads. However, the tiebacks must also be flexible enough to allow for longitudinal movement of the top of the girder caused by girder end rotation. The amount of longitudinal movement due to the end rotation of the girder can be significant. The end rotation of a 40 foot girder that has undergone a deflection of span over 600 is about .005 radians. For a 36 inch deep girder this results in .2" of horizontal movement at the top flange. The tieback must also allow for vertical movement due to axial shortening of the crane column. This vertical movement can be in the range of $^1/_4$ in. In general, the tie back should be attached directly to the top flange of the girder. Attachment to the web of the girder with a diaphragm plate should be avoided. The lateral load path for this detail causes bending stresses in the girder web perpendicular to the girder cross section. The diaphragm plate also tends to resist movement due to the axial shortening of the crane column.

Bearing Stiffeners

Bearing stiffeners should be provided at the ends of the girders as required by the AISC Specification paragraphs K1.3 and K1.4. The AISE Guide requires that full penetration welds be used to connect the top of the bearing stiffeners to the top flange of the girder. Fillet welds are considered to be inadequate to transfer the concentrated wheel load stresses into the bearing stiffener. The bottom of the bearing stiffeners may be fitted (preferred) or fillet welded to the bottom flange. All stiffener to girder welds should be continuous. Horizontal cracks have been observed in the webs of crane girders with partial height bearing stiffeners. The cracks start between the bearing stiffener and the top flange and run longitudinally along the web of the girder. There are many possible causes for the propagation of these cracks. One possible explanation is that eccentricity in the placement of the rail on the girder causes distortion of the girder cross section and rotation of the girder cross section. At the support, the girder can not rotate, and the cross sectional distortion is concentrated into web bending above the stiffener. Cracking might also occur if the tie back detail holds up one edge of the crane girder restricting the movement caused by axial shortening of the crane column.

Intermediate Stiffeners

If intermediate stiffeners are used, the AISE Guide also requires that the intermediate stiffeners be welded to the top flange with full penetration welds, the stiffeners should be stopped short of the tension flange in accordance with the AISC Specification provisions contained in Chapter G. The AISE Guide also requires continuous stiffener to web welds for intermediate stiffeners.

Cap Channels

Channel caps or cap plates are frequently used to provide adequate top flange capacity to transfer lateral loads to the crane columns. The common heuristic is that a wide flange reinforced with a cap channel will be economical if it is 20 pounds a foot lighter than a unreinforced wide flange member. It should be noted that the cap channel or plate does not fit perfectly with 100% bearing on the top of the wide flange. The tolerances given in ASTM A6 allow the wide flange member to have some flange tilt along its length, or the plate may be cupped or slightly warped, or the channel may have some twist along its length. These conditions will leave small gaps between the top flange of the girder and the top plate or charmed The passage of the crane wheel over these gaps will tend to distress the channel or plate to top flange welds. Because of this phenomena, cap plates or channels should not be used with class E or F cranes. The Channel or plate welds to the top flange can be continuous or intermittent. However, the AISC Allowable stress for the base metal is reduced from Category B for continuous welds to Category E for intermittent welds.

Column Cap Plate

The crane column cap plate should be detailed so as to not restrain the end rotation of the girder. If the cap plate girder bolts are placed between the column flanges, the girder end rotation is resisted by a force couple between the column flange and the bolts. This detail has been known to cause bolt failures. Preferably, the girder should be bolted to the cap plate outside of the column flanges. The column cap plate should be extended outside of the column flange with the bolts to the girder placed outside of the column flanges. The column cap plate should not be made overly thick as this detail requires the cap plate to distort to allow for the end rotation of the girder. The girder to cap plate bolts should be adequate to transfer the tractive or bumper forces to the longitudinal crane bracing. The engineer should consider using slotted holes perpendicular to the runway or oversize holes to allow tolerance for aligning the girders atop the crane columns.

Lacing

A horizontal truss can be used to resist the crane lateral forces, The truss is designed to span between the crane columns. Typically, the top flange of the girder acts as one chord of the truss while a back up beam acts as the other chord. The diagonal members are typically angles. Preferably, the angles should be bolted rather than welded. The crane girder will deflect downward when the crane passes, the back up beam will not. The design of the diagonal members should account for the fixed end moments that will be generated by this relative movement.

Walkways can be designed and detailed as a beam to transfer lateral loads to the crane columns. The lacing design may need to be incorporated into the walkway design. Similar to the crane lacing, the walkway connection to the crane girder needs to account for the vertical deflection of the crane girder. If the walkway is not intended to act a beam, then the designer must isolate the walkway from the crane girder.

The AISE Guide requires that crane runway girders with spans of 36 feet and over for building classifications A, B, and C or runway girder spans 40 feet and over in class D buildings shall have bottom flange bracing. This lacing is to be designed for $2^1/_2$% of the maximum bottom flange force, and is not to be welded to the bottom flange. Cross braces or diaphragms should not be added to this bracing so as to allow for the deflection of the crane beam relative to the back-up beam.

Sidesway Web Buckling

Crane runway girders should be checked to ensure adequate capacity to resist sidesway web buckling. Equation K1-7 contained in the AISC Specification should be used to perform this check. This criteria is likely to control the member size for crane runway girders with cap plates, welded girders with larger top flanges and girders with braced compression flanges. It seems likely that the foregoing AISE limitations on the length of unbraced tension flanges were created to address the sidesway web buckling phenomena. The sidesway web buckling criteria was introduced into the AISC Specification in the Ninth Edition. Runway girders designed prior to this time would not have been checked for this criteria.

At present, the AISC method does not address the condition of multiple wheel loads on a single span.

Knee Braces or K Braces

The longitudinal crane forces are typically resisted by vertical X-bracing in the plane of the crane girder. The use of knee braces to create a rigid frame to resist longitudinal crane forces should be avoided. The knee brace picks up the vertical wheel load each time the wheel passes over the brace. K braces are subject to the same behavior. If a lacing system is used to resist lateral loads, this same system could be used to transfer longitudinal forces to the plane of the building columns. Then the crane vertical bracing could be incorporated into the building bracing at the building column.

Rail Attachments

The rail to girder attachments must perform the following functions:

- transfer the lateral loads from the top of the rail to the top of the girder.
- allow the rail to float longitudinally relative to the top flange of the girder
- hold the rail in place laterally.
- allow for lateral adjustment or alignment of the rail.

The relative longitudinal movement of the crane rail to the top flange of crane girder is caused by longitudinal expansion and contraction of the rail in response to changes in temperature and shortening of the girder compression flange due to the applied vertical load of the crane.

There are four commonly accepted methods of attaching crane rails to crane girders. These are: hook bolts, rail clips, rail clamps, and patented rail clips. To varying degrees these four methods perform the functions previously mentioned. The authors are aware of installations that have the rails welded directly to the top flanges of the girders. This method is not recommended. The rails may lack the controlled chemistry that would ensure good quality welds, and there is no provision for longitudinal movement or lateral adjustment of the crane rails.

Hook bolts are only appropriate for attaching light rails supporting relatively small and light duty cranes. Hook bolts should be limited to CMAA Class A, B. and C cranes with a maximum capacity of approximately 20 tons. Hook bolts work well for smaller crane girders that do not have adequate space on the top flange for rail clips or clamps. Longitudinal motion of the crane rail relative to the runway girder may cause the hook bolts to loosen or elongate Therefore, crane runways with hook bolts should be regularly inspected and maintained. AISC recommends that hook bolts be installed in pairs at a maximum spacing of 24 in. on center. The use of hook bolts eliminates the need to drill the top flange of the girder. However, these savings are offset by the need to drill the rails.

Rail clips are one piece castings or forgings that are usually bolted to the top of the girder flange. Many clips are held in place with a single bolt. The single bolt type of clip is susceptible to twisting due to longitudinal movement of the rail. This twisting of the clip causes a camming action that will tend to push the rail out of alignment.

There are two types of rail clamps, tight and floating. Rail clamps are two part forgings or pressed steel assemblies that are bolted to the top flange of the girder. The AISE Technical Report No. 13 requires that rail clips allow for longitudinal float of the rail and that the clips restrict the lateral movement to 0.25 in. inward or outward. When crane rails are installed with resilient pads between the rail and the girder, the amount of lateral movement should be restricted to $^{1}/_{32}$-in. to reduce the tendency of the pad to work out from under the rail.

Patented rail clips are typically two part castings or forgings that are bolted or welded to the top flange of the crane girder. The patented rail clips have been engineered to address the complex requirements of successfully attaching the crane rail to the crane girder. Compared to traditional clips, the patented clips provide greater ease in installation and adjustment and provide the needed performance with regard to allowing longitudinal movement and restraining lateral movement The appropriate size and spacing of the patented clips can be determined from the manufacturer's literature.

ELEVATED CRANE TRACKAGE QUIZ

PART I

Name: ____

Activity: ____

Circle either the "T" or "F" alongside the following statements to indicate whether they are True or False.

T F Typical defects for monorails are included in the section of the instruction for elevated crane trackage.

T F The tread of a rail is the running surface.

T F Traffic should not be allowed on trackage with critical defects.

T F A profile of the rail shows the grade.

T F A contractor maintaining rail should use the criteria established in NAVFACINST 11230.1 to check his work

T F A 100 pound rail, 30 feet in length weighs about 3,000 pounds.

T F Burning of bolt holes with a torch is not permitted.

T F Track bolts in newly installed joint bars frequently become loose faster than those which have been in track for longer period of time.

T F Wheel flange wear on the inside corner of a rail head on tangent track may indicate the presence of tight gage.

T F Some track defects can develop over a period of time, even if the track is not used.

T F The web and base of the rail should be sounded when using a hammer to non-destructively test rail.

T F Crane rail hold down clips allow ¼ inch lateral movement of rail for equalization.

T F If a catastrophic defect is found, will that cancel certification over the entire trackage system?

T F The minimum distance between non-defective fastenings on either side of the crane rail is 60 in.

Answer the following multiple choice questions by circling the letters for ALL correct statements. Questions may have every statement true or no correct answer shown; therefore, there may be from zero to six circles for each question.

Track geometry should be investigated when:

A based on engineering judgement
B elevated cranes roll after stopping
C the pavement adjacent several columns is deteriorated and appears to be sinking
D flanges on the crane are showing significant wear

An operator tells you there is funny feel to a short section of trackage you have just inspected and found satisfactory. You should:

A ignore it and continue your work
B record it and continue your work
C has him run the crane over the area again
D immediately make another detailed examination of the section of track

The responsibility of the Certifying Official for trackage is:

A to approve all track certifications
B to insure safety and visual supervision of each operation over non-certified track
C determine if non-certified track can be used for emergencies or temporary traffic
D immediately make another detailed examination of the section of track

In jointed rail the bolt holes in the rail ends are larger than the bolts:

A to keep the bolts from supporting the rail
B to allow for expansion
C to prevent rail pull apart

Ultrasonic inspection is a non-destructive test method using acoustic waves of frequencies above the audible range to reveal ___________ defects in dense homogeneous materials.

A surface
B internal

"J" bolts or hook bolts should only be used on

A Low capacity bridge cranes
B High capacity bridge cranes
C Not at all

What is included in the term "trackage"?

A Rails
B Foundations
C Support Structures
D Markings
E Signs
F Rail Accessories

The minimum rail length to be maintained between joints in elevated track is

A 20 feet
B 13 feet
C 10 feet

When sounding with a hammer to perform non-destructive testing, the weight of the hammer should be:

A 10 ounces
B 18 ounces
C 36 ounces

The following are track defect classifications:

A Negligible
B Marginal
C Serious
D Catastrophic
E Critical

ELEVATED CRANE TRACKAGE QUIZ

PART II

Name: ____

Activity: ____

REFERENCES MAY BE USED

Place a check in one column to show the proper hazard category for track for each defect identified below.

DESCRIPTION	CATASTROPHIC	CRITICAL	MARGINAL	NO DEFECT
Fully bolted joint bars applied to an ordinary break.				
Vertical split head broken out on the gage side.				
A six hole joint bar cracked between the second hole from one end and the top of the bar.				
A broken rail with movement.				
Missing fastener on outside of rail, inside fastener in place – fastener spacing 24 inches on center				
The deviation in profile elevation in the center of a 62 ft section of crane rail measures 1-1/4 inches.				
The roll on a flowed rail measures 1/4 inch from the gage face.				
During an operational inspection on elevated crane rail, a wheel tread on one corner of the crane lifts from the top of the rail.				

DESCRIPTION	CATASTROPHIC	CRITICAL	MARGINAL	NO DEFECT
The edge on one side of the base of the rail, below a tightly bolted six hole splice bar, has an eight inch moon shaped piece broken off.				
Electrical conduit installed on column supporting runway girder. 1 inch clearance between crane bridge and conduit.				
Weld irregularities.				
Surface cracks on the rail tread caused by a cold rolling or working by elevated crane wheels.				
A torch cut hole 1 inch in diameter is found 10 foot from the rail end in the center of the web.				
Loose rail stops on an elevated crane track system				
An ultrasonic inspection indicates a horizontal split head measuring 2 inches.				
Missing fastener on inside of rail, outside fastener in place – intended fastener spacing 30 inches on center.				
Gap between two rails at joint bar measures 7/16 inch.				
An ultrasonic inspection includes a defective joint weld with 50 % of the rail head cross sectional area weakened by defect.				

DESCRIPTION	CATASTROPHIC	CRITICAL	MARGINAL	NO DEFECT
One bolt is missing from a 4 hole joint bar.				
During inspection of runway rails, it is noted that rail joints are directly opposite each other.				
Shelling depth approximately 1/8 inch deep.				
Broken hand rail support on top of ladder to elevated crane rail.				
One joint bar at rail joint is found to have been torch cut modified to fit web of rail.				
The temperature is normal or average, between 45º and 65º F, the following joint gaps are measured.				
1/8”				
1/4”				

½”				
¾”				
<u>Alignment Deviation</u> Stations Mid-Offset to 31 Foot a 62 foot line Spacing on Tangent Track				
1 0	Tangent Track - review alignment measurements and provide overall defect classification for this section of track in the space above			
2 -1/2”				
3 +1/2”				
4 -1”				
5 -1/2”				
6 +1/2”				
7 0				